NUMBER GAMES IN EARLY CHILDHOOD CENTRES

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ABSTRACT

Experiences provided at Early Childhood Centres can play an important role in influencing children's dispositions towards mathematical learning. This study examined the use of number games in promoting the development of number skills in young children. Specifically this study explored whether or not raising the profile of mathematical activity through the provision of number games within the centre would increase the children's number knowledge and skills.

Early differences in children's understanding about number have been found to influence their later levels of achievement in mathematics. Children who are initially ahead tend to stay ahead, while those who are initially behind tend to stay behind. Within Early Childhood Centres programmes of learning are developed within the children's range of interests. This raises concerns that children less confident in mathematics, and with little domain knowledge are not necessarily encouraged to develop in areas of mathematics. If children do not experience the early number skills crucial to broadening their domain knowledge then 'closing the gap' between children who are more, and those who are less, confident in number may not be possible.

A case study approach involving ten children, aged between four and five years, from the morning session of a city kindergarten formed the basis of the study. For each of three consecutive fortnights the teachers introduced three new number games to the children. Teachers and the researcher, using scheduled observations, monitored game usage to determine which children played the games and which games were played. Initial and final interviews of consenting children were undertaken to determine number knowledge development. Parallel to the introduction of the games, teachers undertook a six-week professional development programme consisting of three two-hour sessions focussing on the early development of number skills and knowledge in young children. Teachers were then interviewed to determine changes in teaching practice regarding number development and game usage.

There were improvements in all ten children's number knowledge within the six-week period. However, game usage varied greatly between children and there was no significant relationship between high game usage and children's improvement levels in number knowledge. It was assumed that other influences were also occurring to contribute to the children's development of number skills. Game usage was higher when an adult was present. The role played by the teacher in using appropriate mathematical domain and pedagogical knowledge appeared to be vital in the development of early number knowledge. This area of teacher interaction warrants further investigation.

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CHAPTER ONE: INTRODUCTION

1.1. EMPHASIS ON NUMERACY

Recent studies have shown that New Zealand children are scoring well below international averages in tests of their mathematical competency at nine years of age (Garden, 1997). This fact is particularly disturbing when we consider that our children have had at least one more year of formal schooling than other children surveyed and 80% of New Zealand children experience some form of early childhood education. Research by Young-Loveridge (1989b) has provided clear evidence that children who begin school confident in their number skills continue to do well in mathematics. Wylie, Thompson and Lythe (1999) have confirmed this stability of achievement in their study of competent children. They found that children who start school lacking in mathematics skills are unlikely to catch up. After the first year at school, those children who were least capable were not yet achieving knowledge that the high achieving children had upon school entry. The gap between the least and most capable children continues to widen - not close - during the first three years at school.

Much research has been undertaken to determine the levels of mathematics understanding which children have on entry to school. In New Zealand the research by Young-Loveridge (1993) focussed on the number skills and spatial understanding of five-year-olds. Young-Loveridge, Carr and Peters (1995) completed *The Enhancing Mathematics of Four Year Olds Study* (EMI-4s*)* which focussed on an intervention programme in mathematics at kindergartens; in particular to find how the mathematical concepts and skills of four-year-olds are enhanced at the pre-school level. Results highlight two important facets of early childhood education: firstly, that there was very little mathematics going on at kindergarten, and secondly, that early childhood centres potentially have an important role in reducing the high degree of variability evident among the children in terms of their numeracy skills and concepts.

Young-Loveridge (1989b) in her earlier work was able to identify five key competencies that appeared to predict later success in mathematics. These are the ability to:

- rote count,
- form a group of objects of a specified number,
- recognise numerals,
- subitize. i.e. instantly recognise how many objects there are in a collection without having to count them,
- add and subtract imaginary objects to 14.

The work of Young-Loveridge (1989b) has highlighted the influential role which adults have in the development of early number skills. The mathematics knowledge of the teacher is crucial in the development of mathematics understanding in children. In order to provide the necessary scaffolding support teachers must have a sound grasp of subject matter and organisation. What teachers know will affect the kinds of learning experiences they offer to children.

1.2. SITUATION IN EARLY CHILDHOOD CENTRES

In Early Childhood Centres mathematical thinking is embedded in a range of social situations linking the relationship between context and language. Examples of the interrelated experiences include the opportunity to indicate comparative status (e.g., I'm bigger than you, I'm four), to rehearse culturally significant sequences (counting out loud to 20 for grandma), to recognise culturally significant symbols (e.g., knowing the numeral '4' represents their age), and to solve interesting problems (Carr, 1992).

More commonly, experiences which lead to the development of mathematical ideas tend to happen rather than being planned (Davies, 1999; Hill, 1995; Young-Loveridge et al., 1995). In kindergartens these experiences are found in such contexts as puzzles, water play, dough, sand pit, art/collage, blocks, library, table-top activities (activities are put out on some days at the teacher's discretion and are not always available), and the morning tea table (Young-Loveridge et al., 1995). The teaching of mathematics concepts also is incidental rather than formal and occurs more frequently as part of the normal centre routine e.g., cutting up fruit, counting steps, during the reading of stories. Young-Loveridge and colleagues note that there was very little mathematics going on at kindergarten and suggested the need for more formal, purposeful planning of mathematical activities.

1.3. THE USE OF GAMES FOR LEARNING

Playing games is a natural part of a child's life. In their work with four- to six-year-olds, Kamii and de Vries (1980) used games *to develop confidence in ones own ability to figure things out* (p. 20). In playing number games children learn, practise and reinforce number learning. Jones (1982) suggests that *well designed number games can encourage children to think about numbers, properties and quantities and to compare numbers and develop networks of number relationships* (p. 616). Games can prompt the exploration of mathematical ideas and the use of mathematical knowledge, by encouraging discussion between children as they talk over the moves, and discuss the correctness of answers and different strategies (Baroody, 1998). However, Ainley (1988) cautions that while a well-designed game may create a good learning environment, it will not automatically ensure that the children learn the mathematics. The teacher's role in stimulating learning during the playing of the game and monitoring the learning is vital (Burgess, 1999). There are issues to be considered when regarding the value of number games as independent activities, and the teacher's role in the use of games for number knowledge development and reinforcement must be acknowledged.

1.4. RESEARCH OBJECTIVES

The purpose of this study was to examine the usage and success of a range of number games in fostering children's early number skills and knowledge development within an Early Childhood Centre environment. This study uses information gathered from children and their teachers on levels of participation, usage of the mathematical games, and number knowledge and progress to answer the following questions:

1. Does the use of number games enhance the development of number knowledge and skills in young children?
2. Are the number games used more by particular groups of children?
3. Did game playing induce interaction with other adults or children?

In order to situate the introduction of games in a supportive and purposeful learning environment the teachers in the centre were involved in a professional development package that focussed on the development of early number knowledge and skills. This allowed the researcher to explore wider issues regarding teacher domain knowledge and pedagogical content knowledge - specifically:

4. What do teachers recognise as important number knowledge and skills in young children?
5. How effective is this type of short-term workplace centred professional development in relation to children's number development and game implementation?

1.5. OVERVIEW

Chapter Two reviews the recent literature focussing on the following aspects: how children learn, trends in early childhood education today, the role of teacher knowledge, the development of early number understanding, and playing games. In Chapter Three the methodology for this study is discussed. Details of the setting and time frames are included.

The following three chapters report the results of the study. Chapter Four deals with the responses to the games from teachers' and children's perspectives. Chapter Five describes the development of number skills and knowledge during the research period. Raising teacher awareness of children's number knowledge development is the focus of Chapter Six.

Chapter Seven discusses the results and draws conclusions. Implications for successful number development in early childhood centres are presented suggestions for further professional development for teachers are made and directions for further research are highlighted.

CHAPTER TWO: LITERATURE REVIEW

In order to provide a background to the key issues related to the research objectives this chapter weaves together four key threads; of game play, how children learn, early childhood philosophies of learning and teaching, and early number development as outlined in current research and literature. An initial focus on play and the use of games for learning draws together the current teaching and learning philosophies in New Zealand early childhood education. By amplifying past and present theories of learning, empathy for the early childhood philosophy of learning is advanced. The crucial role and influence of the teacher in the learning process are examined thus highlighting the importance of teacher content knowledge. Finally, a review of early number skills with reference to the curriculum document and recognition of the current place of mathematics in early childhood education completes the literature review.

2.1. CHILDREN'S PLAY AND GAME PLAYING

Play contributes significantly to cognitive development. As an essential social activity children commonly use play to make sense of the world around them. Play situations provide an environment rich in experiences and exploration, and allow the child to develop knowledge which is personally meaningful (Burnett, 1992). Piaget identified three successive systems in the evolution of children's play: practice play, symbolic play, and play with rules (Bodrova & Leong, 1996). In this latter stage, play activities become collective and acquire rules that mark the transition to the more adult activities of the socialised individual. Piaget distinguished two categories of rules, some rules are formal, set and handed down by others, and others are generated and negotiated during the play as children invent the game. External rules are used to initiate, regulate, maintain and terminate social interaction (Bodrova & Leong, 1996).

Games are an important learning medium in childhood, that are strongly associated with play (Mannigel, 1998). When a distinction is made between games and play the dimension generally used is the existence, or the lack, of rules and the nature of the competitive element (Inbar & Stoll, 1970). Games are generally played according to a set of rules and though more structured than free play, they include a playfulness and fun (Mannigel, 1998). Children learn through play that achieving their own desires requires voluntary obedience to self-chosen rules and that their individual satisfaction can be enhanced by co-operation in rule-governed activities (Nicolopoulou, 1993). Play and games are initially learned by young children in a social context under the supportive guidance of caretakers who at first act out both roles (i.e., the adult also pretends to be the child) until the children start to assume the roles of active participants.

Game playing is a regular activity in most children's lives especially those of school age. Numerous researchers (Booker, 1996; Bright, Harvey, & Wheeler, 1985; Ernest, 1986; Gough, 1999a; Inbar & Stoll, 1970; Jones, 1982; Kamii, 1986) have identified the following benefits as learners participate in the playing of games:

1. Motivation and development of positive attitudes to mathematics.
2. Development of mental processes and strategy development.
3. Development of social skills.

The motivational aspect of games, whether they are competitive or not, is well-documented (Bright et al., 1985; Ernest, 1986). Games provide opportunities for a hands-on approach where students are actively involved in the learning activity (Jones, 1982). Additional to participant involvement games naturally generate excitement, enthusiasm and enjoyment resulting in children becoming highly motivated and totally immersed in the activity (Gough, 1999a). The fun element of games not only provides motivation but also encourages full engagement thus supporting a constructive learning environment. It has been found that children participate more willingly in order to interact with their peers in a socially rewarding activity (Booker, 1996; Ellington, Gordon, & Fowlie, 1998). Because games are removed from the serious consequences of every-day life they provide the opportunities for children to 'make a fools of themselves' without serious consequences when taking a risk (Inbar & Stoll, 1970).

Mental processing and strategy development are encouraged through the playing of games. In game playing children have to think hard and critically, and co-ordinate different viewpoints in a game, and it is this mental activity that is important in the construction of logico-mathematical knowledge (Bright et al., 1985; Kamii, 1986). In some games children can work at their own pace and make mistakes without penalty, thus providing opportunity for self assessment and development of autonomy and meta-cognitive skills (Inbar & Stoll, 1970). Through continued playing of games self-corrections are made and children can see the results of this change in thinking or strategy. Meaningful, intuitive learning is also fostered as one child's knowledge is influenced by that of another. Children are more willing to try out new ideas which they must justify in a meaningful way to those against whom they are playing (Booker, 1996). Feedback from their playing partners is more immediate compared with delayed teacher feedback in class or group instruction (Booker, 1996; Mannigel, 1998). Furthermore, children acquire an understanding of the processes and concepts in a meaningful and purposeful way as they are fully engaged in an act of sense making (Burnett, 1992). Because they have ownership of the learning process they are more likely to remember and readily retrieve information.

The competitive nature of games can be beneficial to children as in competitive games children are highly motivated to decenter and plan strategies at their own level of cognitive development. According to Piaget's theory of learning, competitive games help the child to move from egocentricity to increasing ability to decenter and co-ordinate points of view (Kamii & De Vries, 1980). One could assume that in an early childhood setting the provision of games may provide opportunities for children to decenter.

An advantage of games in an instructional setting is that children of differing mathematical abilities can often play games together, especially if the game has the appropriate mixture of chance and skill (Coleman, 1976). Inbar and Stoll (1970) concluded from their meta-analysis of research on games that games are especially valuable for the underachiever as there appeared to be no strong relationship between performance in a game and prior academic performance. The work carried out by Jones (1982) led her to believe that games helped develop positive self-concepts in underachieving children.

Development of effective communication skills in both listening and speaking is encouraged during game play due to the strong incentive to check or challenge the mathematics of the other players (Booker, 1996). Within the context of discussion, explanations and justifications of conjectures amongst themselves provide children with a means of clarifying and modifying their own understanding. Kamii (1986) contends that when groups of children play mathematics games they talk over the moves and discuss the correctness of answers and different strategies. This language that stems from the games facilitates learning (Burnett, 1992).

Social interaction plays a central role for children's learning in a social constructivist environment.

> *There is some evidence that these games play an important part in the emergence of the early communicative role of language, the development of turn taking, the learning of conversation conventions, and the acquisition of other social skills.* (Nicolopoulou, 1993, p. 12)

As games often involve peers in the learning process they lend themselves to co-operative learning that encourages active involvement (Ernest, 1986). As such, games are extremely effective vehicles for developing social skills; encouraging pupils to listen to others' points of view, co-operation, talking about what is happening, assisting others to understand, and perseverance in completing the task are critical play behaviours (Booker, 1996; Ellington et al., 1998). The socializing function of games is summarized by Inbar and Stoll (1970) to include the following components: *moral development, willingness to co-operate with the group, perception of roles of others, practice in situations and strategy use, achievement values, sex-role identity, efficacy and lastly orientation to competition* (p. 55).

The provision of mathematical games for children also benefits the teacher. Games more readily allow a teacher to make judgements about child understanding. Children are less disposed to provide an answer or reason which they think will match the teacher's expectations (Booker, 1996). When working with teachers involved in the Primary Mathematics Project, Ainley (1990) found games offered teachers an opportunity to work closely with a small group of children and to assess children's progress and understanding. Teachers found that when children were playing games their thinking became more readily transparent and their actions revealed much about their thinking strategies (Ainley, 1990; Bright et al., 1985). Within the context of a game it is easy for teachers to question children about their thinking and the children's ways of thinking become more apparent during game playing. Assessment of the quality and level of children's understanding of mathematics is more easily facilitated without the potentially intimidating atmosphere of a more obvious assessment (Ainley, 1988; Jones, 1982). Thus the teacher's role as judge and jury is diminished during game playing with the reversion to a more natural role for the teacher as helper and coach rather than focusing on the evaluation of the learner (Coleman, 1976; Inbar & Stoll, 1970).

2.2. TENSIONS WHEN USING GAMES FOR LEARNING

While the benefits to young children from playing mathematical games are numerous, Ainley (1990) cautions that what children are able to learn when playing games will vary enormously. Care is needed to ensure that children do not learn incorrect lessons. For example, children waiting to roll a six before they start to play a game can mis-learn that a six is harder to roll than any of the other numbers (Amir & Williams, 1994). While a well-designed game may create a good environment for learning some mathematics it will not guarantee that the children learn the desired mathematics. Using mathematics games to reinforce or practise a concept is a common objective within the classroom, however, children may be so distracted by their natural interest in winning that they fail to focus on the mathematics (Gough, 1999b). Also, care must be taken in ensuring that the game is properly matched to the abilities and needs of the children (Ellington et al., 1998).

A well-designed game may create a good environment for learning mathematics but should not be regarded as a replacement for the teacher. The teacher has an important role in stimulating learning during the playing of the game and monitoring the learning outcomes (Ainley, 1988; 1990; Burgess, 1999). Young-Loveridge and Peters (1994), in their NZ study *Enhancing the Mathematics of Five Year Olds* (EMI-5s), found that the teacher's role in monitoring, encouraging and modelling for the children was vital. Likewise, Burgess (1999), in his study with ten- and eleven-year-olds, noted that *the role of the teacher in the process* (using games to help the learning of probability) *is absolutely vital, through questioning, challenging, explaining, supporting and encouraging the children* (p. 81). However, within a specific instructional episode, Young-Loveridge and Peters (1994) suggest that the teacher's role may be a diminishing one as the teacher can withdraw support as the children acquire increasing competence and understanding.

Teachers of young children are rightfully concerned about the kind of competition that breeds rivalry and feelings of failure and rejection (Kamii & De Vries, 1980). Competition in game playing concerns the comparison of one's performance with that of another. However, because competition between children is inevitable an effective teacher needs strategies to deal with it positively - rather than avoid it. Kamii and De Vries stress that the teacher has an important role in educating children to handle the competitive aspects of games: *developing an attitude that winning is nothing more than winning and that losing does not mean inferiority or incompetence* (p. 191). Ainley (1988) suggests that as children mature and increase their game playing, so their awareness of the types of games and the competitive element increases. Some games you win simply because of luck or skill, and other games you enhance your chances of winning by hindering the opposition or adopting a winning strategy.

2.3. GAMES IN AN EARLY CHILDHOOD SETTING

The earlier work of Kamii and De Vries (1980) focused very specifically on the use of group games in early education, and they concluded that *children develop not only socially, morally, and cognitively but also politically and emotionally through games involving rules* (p. 27). Their work, based on Piaget's theory of learning, suggests that although two-year-olds cannot decenter and co-ordinate points of view required in a group game this does not need to deter them from playing games. As children mature by the age of four and five years they become more able to play games. This increasing ability to play games is due to their increasing ability to decenter and co-ordinate the points of view of others. However, despite the work of Kamii and De Vries promoting game playing, some early childhood educators believe that because of the 'direct' teaching required for games they are not appropriate in an early childhood setting. Closer focus on the learning philosophy of early childhood education highlights the appropriateness of games within the approach to learning and teaching currently promoted.

2.4. INTERNATIONAL TRENDS IN EARLY CHILDHOOD CURRICULUM DEVELOPMENT

In recent times early childhood educators have used the phrase Developmentally Appropriate Practice (DAP) to describe educational practice and care in early childhood. The concept of appropriateness has two dimensions: *age appropriateness* and *individual appropriateness* (Bredekamp, 1987). DAP was developed as a concerned response to the growing practice of 'pushing down' the school curriculum to encourage more formal academic instruction with younger and younger children (Perry, 2000; Steffe, 1990). This 'pushing down', especially prevalent in the United States, prompted the writing of Bredekamp's (1987) influential document on developmentally appropriate practice for The National Association of Education of Young Children. The document provides guidelines to assist teachers in making appropriate decisions regarding teaching approaches. The influence of developmentally appropriate practice has been reflected in many of the early childhood institutions both nationally (Cullen, 1994; Smith, 1996) and internationally (Catherwood, 1994; Dockett & Perry, 1996).

Age Appropriateness

The age appropriate dimension assumes the universal predictable changes in children's development at particular ages and stages, regardless of context and is strongly related to Piaget's theory of cognitive development that has dominated over the past 20 years (Fleer, 1992). Cognitive development deals with the recall or recognition of knowledge and the development of intellectual abilities and skills (Bright et al., 1985). Through observational work and later experimental work Piaget developed a theory of how children acquire and develop knowledge. His work was concerned with normative development in children by systematically describing and explaining growth and the development of internal structures and knowledge. Piaget identified specific characteristics of children's thinking at different ages. His theory is characterised by four stages of development: sensori-motor (birth-2 years); pre-operational (2-6 years); concrete operations (6-12 years) and formal operations (12 years onwards) (Westwood, 2000).

Piaget argued that knowledge develops little by little through a laborious process of individuals acting on their environment. For Piaget every act of intelligence is characterised by equilibrium between *assimilation* and *accommodation.* In *assimilation,* the subject incorporates events, or objects, or situations into existing ways of thinking, which constitute organised mental structures or schema. In *accommodation,* the existing mental structures reorganise to incorporate new aspects of the external environment. Learners filter, interpret and adjust information in terms of what they already know (Baroody, 1987). When new learning does not fit in with prior knowledge (i.e., it is not accommodated) it remains a fragment of experience that is easily forgotten, or is difficult to recall and use when needed. For example, if a child is taught to recognise the numeral for 'three' when they cannot visualise a set of three objects, then the numeral for 'three' makes little sense and is quickly forgotten. In acquiring numeracy skills this fragmentation can occur when children are taught new facts or rules out of context with little understanding (Westwood, 2000).

However, despite the dominance of Piaget's theories for over 20 years, the accuracy and relevance has in recent times been debated (Donaldson, 1978; Fleer, 1992; Nicolopoulou, 1993). Several learning theorists have suggested that in all areas of learning the Piagetian framework pays insufficient attention to social and cultural factors (Nicolopoulou, 1993; Westwood, 2000). Moreover, replications of Piaget's work on classification, number concepts, arithmetic, and measurement using different methodologies have generated data which conflict with those of Piaget (Donaldson, 1978; Fleer, 1992; Fuson & Hall, 1983; Inagaki, 1992). Wood (1988) suggested that *there is now a significant body of opinion which holds that Piaget's methodology and demonstration led him to underestimate or misconstrue the nature of children's thinking* (p. 45). The general consensus is that young children's capacities have been considerably underestimated and misrepresented in past accounts of cognitive development (Catherwood, 1994; Donaldson, 1978). In light of this criticism many post-piagetian psychologists have revised Piaget's stages of developmental theory while still accepting his constructivist view that knowledge is constructed as individuals interpret and seek to make sense of their experiences (Inagaki, 1992).

Developmentally age appropriate practice in early childhood education reflects Piaget's stages of learning the discovery of the world by children spontaneously through their own self-directed play within a resource-rich environment. Play, it is suggested, enables children to progress along Piaget's developmental sequence from the sensori-motor to the pre-operational stage. Within developmentally age-appropriate practice teachers serve primarily as resources for children's self-initiated activities including play experiences, and providing open-ended opportunities for children to explore concrete materials and to interact with one another. Within such an environment the foundational basic skills required for numeracy and literacy are embedded in everyday, meaningful activities. This constellation of practices is referred to as 'child-centred' (Stipek & Byler, 1997). In child-centred practices young children construct their intellectual competencies by directly experiencing and manipulating concrete objects.

However, a single focus on the age appropriateness dimension of developmentally appropriate practice has caused much concern among early childhood researchers (Catherwood, 1994). Catherwood stresses that sole reliance on an age appropriate approach is no longer acceptable or useful; to simply characterize young children as being 'pre-operational' is simplistic. The emerging picture of early cognitive growth demands greater acknowledgement of social and cultural influences on individual children's cognitive capacities as encapsulated in the second dimension of DAP.

Individual Appropriateness

The second dimension of developmentally appropriate practice is individual appropriateness. The concept of *individual appropriateness promotes a more dynamic perspective on development by acknowledging the individual experiences in families, communities and societies* (Cullen, 1996, p. 115). Here the focus is on the social and cultural contexts of children's learning.

Vygotsky, a major influence on individually appropriate programmes, has contributed to new theories about how children learn most effectively. His approach provides a viable alternative to Piaget's cognitive theory; informing and unifying post-Piagetian researchers' concerns about the social formation of the mind (Inagaki, 1992). Vygotsky's starting point is that cultural practice and the systems of ideas of the community in which children find themselves shape their capabilities. The central role in the creation and development of higher psychological functions is given to culture and to its transmission through interaction and communication (Nicolopoulou, 1993; Rogoff, 1993). Vygotsky emphasises the fact that children do not develop in isolation but through the interconnection of two key elements:

> *On one hand, the systems of social relationships and interactions shaped by the social organisation of the society as a whole ... and, on the other hand, by collectively elaborated conceptual and symbolic systems that are the cultural heritage of the society.* (Nicolopoulou, 1993, p.8)

A central concept in Vygotsky's theory is the 'zone of proximal development':

> *the difference between the child's actual development level as an independent problem solver and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.* (Nicolopoulou, 1993, p. 8)

The actualisation of the 'zone of proximal development' depends on social interaction within a shared cultural framework. Learning activities that fall within a child's zone of potential development have a high probability of success, whereas activities beyond the zone are often too difficult and may result in failure and frustration (Reys, Suydam, Lindquist, & Smith, 1998).

Although Piaget and Vygotsky share a common emphasis on the importance of interacting partners, they differ in viewing shared thinking as an individual process versus a collective process. In Piaget's view individuals work on each other's ideas with independence and equality. Social influence is expected to foster change through the induction of cognitive conflict - whereas in Vygotsky's view, people share joint endeavours and think in common. Learning takes place often through the scaffolding of ideas by a more knowledgeable participant. With some guidance or suggestion from an adult or peer the learner can master the knowledge, skill or strategy. This help may be through observation, from being stimulated through relevant questions or by direct instruction. Gradually the scaffolding or support is phased out so the learner deals with the task independently (Westwood, 2000). If children receive ineffective scaffolding or support to broaden or deepen their understanding then their impressions and experiences remain superficial and ineffective. Klugman and Smilansky (1990) suggested that when unsupported, children could look but not see; more importantly, many did not understand what they saw. Effective instruction should thus provide children with support to understand what they have discovered, or foster the development of learning strategies for exploring, enquiring and investigating (Wood & Attfield, 1996).

Knowledge acquisition can be achieved collectively by interactions with one another in a group, such as a group of children working together playing a game, even when there is no adult guidance. However, often an adult can play an important intervening role; they can stimulate children's thinking through deadlock and set up situations in which a group of children are able to engage in inquiry (Inagaki, 1992). The influence of the social context on early learning stresses *the significance of 'experts' – parents, teachers, siblings, peers – whose assistance enables the child to achieve a more competent level of performance than if acting alone* (Cullen, 1994, p. 59). From early infancy, children seek and share meaning with their caregivers and other learning partners. Children's participation in communicative processes is the foundation on which they build understanding.

Children are assumed to be involved in collaboration in which they may internalise shared thinking produced in the interaction (Rogoff, 1993). For Vygotsky, children come to understand and participate in the skilled activities of their culture through guided participation with others.

> *Interaction with people assists children in their development by guiding their participation in relevant activities, helping them adapt their understanding to new situations, structuring their problem-solving attempts, and assisting them in assuming responsibility for managing problem solving.* (Rogoff, 1990, p.191)

Guided participation involves collaboration and shared understanding in routine problem solving activities. While children advance their ideas in the process of participation, the expert needs to be present during scaffolding, guided participation and co-construction.

Other theorists (e.g., Rogoff, 1990; Valsiner, 1993) use the notion of *co-construction* to capture the learning process in early years. In co-construction the child is the active constructor of knowledge. Learning takes place as the child solves problems from his or her perspective (McNaughton, 1995) as such co-construction holds a potentially powerful approach in encouraging an active role for both the adults and the children in the learning and teaching process. Here *development and learning are seen as occurring through complex and dynamic exchanges between children and their actions to make sense of the world, and the social and cultural processes in everyday activities* (Hedges, 2000, p. 18). Whereas scaffolding and guided participation have limited focus on the child's contribution to the learning process, co-construction involves an equality between the learner and the teacher to develop shared meaning with shared outcomes or goals (Hedges, 2000).

Post-Piagetians (e.g., Inagaki, 1992; Nicolopolou, 1993; Rogoff, 1990) have rejected the idea that one's competence in problem solving is applicable across domains and have emphasized that competence may vary from domain to domain. The term *domain* refers to *clusters of interrelated pieces of knowledge, for which one may gain expertise through experience* (Inagaki, 1992, p.119). Children typically have specific areas of expertise or rich domain knowledge, for example, knowledge of dinosaurs. This domain-specific knowledge serves as a constraint (although positive in nature) in domains that children know well. *Constraint* refers to the *conditions that facilitate the process of problem solving or the acquisition of knowledge as well as restrict its possible range* (Inagaki, p. 119). Some constraints are 'cognitive' or internal and others are external, that is, the socio-cultural factors that tend to enhance or inhibit people's learning. Learning becomes easier as children accumulate relevant pieces of knowledge which work as constraints. Thus the child with rich knowledge of dinosaurs will continue to build on this knowledge more efficiently than the child with limited domain knowledge. Post-Piagetians have turned their attention to a variety of domain specific constraints working in problem solving and the acquisition of knowledge - whereas Piaget paid attention to domain general constraints of structures of thinking.

A shift towards the Vygotskian principles in early childhood education has promoted a focus on not only what children are capable of achieving on their own but also on what they are capable of achieving with the assistance of others. Learning assistance may be through scaffolding, or through parents and teachers developing and implementing tasks that target the zone of proximal development (Berk & Winsler, 1995; Bodrova & Leong, 1996; Fleer, 1992). This sociocultural perspective focussing on individual appropriateness emerged initially from the work of Vygotsky and suggests five key principles for early childhood education:

- *All development begins with social interaction.*
- *Learning drives development rather than development driving learning.*
- *Close interpersonal relationships and mutual understanding between social partners facilitate learning and development.*
- *The goals of development are culturally determined.*
- *Children have an active role in constructing their own unique understanding within a cultural context.* (Smith, 1996, p. 54)

An individually appropriate programme will provide for these five principles of learning and teaching.

The crucial importance of including both the dimensions of age appropriateness and individual appropriateness is advocated in *Te Whaariki* (Ministry of Education, 1996) the New Zealand early childhood curriculum statement. This is reflected in the two main principles of learning in the development of the NZ curriculum: concern for the whole child in a developmental context, and learning in a social and cultural context (Carr & May, 1996).

2.5. CURRICULUM DEVELOPMENT AND IMPLEMENTATION IN NEW ZEALAND

In New Zealand the early childhood curriculum *Te Whaariki: Early Childhood Curriculum* (Ministry of Education, 1996) is based on a central metaphor of a 'whaariki', a mat for all to stand on. The purposes of *Te Whaariki* are to set principles, strands and goals that are distinctively appropriate for the early childhood years and to provide a framework that allows for different programme perspectives to be woven into the fabric. Goals that apply to mathematics learning can be found in Appendix C.

Te Whaariki (Ministry of Education, 1996) views the curriculum for each child *as weaving their learning and emphasises a model of knowledge and understanding as a tapestry of increasing complexity and richness* (Carr & May, 1996, p. 102). Unlike the primary and secondary curriculum documents, *Te Whaariki* purposefully avoids the separation of knowledge into curriculum areas. It is suggested that learning within an early childhood centre will be holistic by nature and embedded within the social and physical experiences provided within the centre (Ministry of Education, 1996).

The curriculum centres on cultural and individual purposes emphasizing the critical role of socially and culturally mediated learning: Relationships are one of the four foundation principles of *Te Whaariki* and importance is placed on the necessity for *adults to provide "scaffolding" for the children's endeavours and learning opportunities that are active and interactive* (Cullen, 1996 p. 43). *Children learn through collaboration with adults and peers through guided participation and observation of others, as well as through individual exploration and reflection* (Ministry of Education, 1996, p. 9). Interactions are of high importance promoted through *reciprocal and responsive interaction with others both adults and peers, who can respond to children's development and changing needs* (Ministry of Education, 1996, p. 20). Furthermore, *Te Whaariki* recommends *that programmes meet the needs of the full range of children they cater for* (p. 20). There is a focus on children as individuals and their individual experiences in the family, community and society (Cullen, 1996).

In accordance with the dynamic theories of learning, which emphasize the role of culture and social context in children's development and learning, the teachers need to take an active role to support children *on their learning journey as they interact directly with their environment, participate in play experiences and engage in* *meaningful relationships* (Haynes, 2000, p. 142). This suggests that an expanded view of learning should be promoted beyond the traditional focus on autonomous play.

A report by the Education Review Office (ERO) (1998) entitled *The Use of Te Whaariki* praises the inclusiveness of the document and its approach, especially when considering the diversity of philosophical and cultural perspectives in the early childhood sector. However, concerns are raised by the ERO that *Te Whaariki* provides little direction as to how the processes and content embedded in the curriculum statement are to be identified and achieved: *Te Whaariki 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* (Education Review Office, 1998, p. 4).

Furthermore, the report (ERO, 1998) cautions that, given the wide range of experience and training of staff in early childhood centres, statements made in *Te Whaariki* are likely to be interpreted differently across the sector resulting in variable performance of early childhood services. New Zealand researchers Cullen (1996) and Smith (1996) have warned that the early childhood practitioners are likely to experience difficulties with integration of the two bodies of knowledge; individual appropriateness related to the cultural and community experiences, and age appropriate experiences. Furthermore, Cullen suggests that the inclusion of an age developmental philosophy will affirm much of what is currently happening in early childhood centres and educators will neglect the challenges for cultural and community experiences of the individual as suggested in the new guidelines. Spodek and Saracho (1990) believe that although teachers understand the intent of particular programme models, they have difficulty of implementing programmes because they hold an opposing set of learning theories (e.g., normative or age appropriate). A mismatch exists between how the teachers perceive learning situations should develop and the recommendations of the curriculum document and educational researchers.

The Exploration strand of *Te Whaariki* promotes children's development of *working theories for making sense of the natural, social, physical and material worlds* (Ministry of Education, 1996, p. 82). This increased focus on child 'working theories' for domain knowledge construction places a higher level of expectation on the role of the teacher in providing individually appropriate learning experiences (Cullen, 1996; Cullen & Allsop, 1999). The *notion that teaching is no longer taboo in early childhood philosophy,* as promoted by developmentally appropriate programmes, is supported by Cullen (1994, p. 60).

Until recently it was generally accepted that assessment of children's learning in early childhood centres was *inappropriate because of the young age of children involved and the variability of the developmental progress at this age* (Education Review Office, 2000, p. 1). The aim of this ERO report on the use of assessment to improve programmes for four- to six-year-olds was to provide information and stimulate discussion about assessment practices, and about the use of information obtained from assessment. The report raises concern that *most records provide little information about the acquisition of numeracy or language skills and it is unusual to find comprehensive evaluations of a child's development in these areas* (p. 7). The move towards more structured and recorded assessment of children in early childhood education has become more widespread over the last five years and the requirement for formally recorded assessment was enforced from April 1998. At this stage *many staff in early childhood have received little training in assessment* (ERO, p. 33). The ERO report notes the variability in assessment practices among early childhood educators:

> *Where this is done well it provides good insight into the child as a learner and is useful for programme development. In other cases the links between the records of observations and intended programme are not developed.* (Education Review Office, p. 7)

As the purpose

> *of the assessment of individual children is to provide information ... so that staff can provide appropriate learning experiences. The assessment information is expected to result in better learning opportunities rather that to provide definitive statements about what each child knows or can do.* (Education Review Office, p. 2)

There is a need for sound content knowledge of teachers to ensure they can assess children's learning and provide appropriate learning experiences.

2.6. IMPORTANCE OF TEACHER KNOWLEDGE, BELIEFS AND ATTITUDES

Closer consideration needs to be given to the role of the adult in supporting the child's learning process. Teachers need to develop an interactive style of teaching which closely matches the children's experiences and knowledge (Cullen, 1994). With this focus teachers will need knowledge about the structure and content of a subject to understand fully its distinctive characteristics and be confident in teaching. Hedges (2000) further suggests that *early childhood teachers must be aware of their role in facilitating and extending children's learning and be knowledgeable about pedagogical practices* (p. 20).

Teacher subject knowledge influences what is taught and how it is taught. A teacher who understands the relationships of individual topics or skills will organise the knowledge to better suit the learner's needs and so may be a more effective teacher (Grossman, Wilson, & Shulman, 1989). Adult subject knowledge plays a crucial role in helping children to make connections with existing knowledge and to other curriculum areas (Cullen, 1994). Confidence in subject knowledge can also help those who work with young children to be more relaxed about helping children develop understanding. Pound (1999) believes that the problem with mathematics teaching is that many of the adults who work with young children lack confidence in their own abilities in mathematics. In light of these factors many research educators claim that teacher subject knowledge must be enhanced to enable appropriate support of children's domain learning (Cullen, 1999; Sternberg, 1998). There are strong implications here for pre- and in-service teacher education programmes to ensure teachers have the necessary depth of content knowledge and confidence in mathematics (Young-Loveridge et al., 1995).

Subject knowledge must also be linked closely to pedagogical content knowledge so that new knowledge can be represented to young children in relevant and appropriate ways (Wood, 1995). Pedagogical content knowledge is

> *the ways of representing and formulating the subject that make it comprehensible to others ... alternative forms of representation, some of which derive from research where others originate from in the wisdom of practice ... an understanding of what makes the learning of specific topics easier or difficult: The conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons.* (Shulman, 1986, p. 9)

Lack of subject knowledge and pedagogical content knowledge have been associated with difficulty in making connections during teaching and leads to a focus on procedures rather than concepts. Haynes (2000) promotes *the need for informed adults who have the knowledge and confidence to plan for, and participate with, the infants and toddlers as they make mathematical sense of their world* (p. 142).

Teachers' attitudes to mathematics and their own knowledge affect the mathematics experiences provided in early childhood centres (Aubrey, 1994b). In recent research Stipek and Byler (1997) reveal significant associations between teacher beliefs, goals, and practices and - to some degree - positions on policy in early education. Teachers' beliefs about subject matter will powerfully affect their teaching (Grossman et al., 1989) and how they implement the curriculum (Thompson, 1992), influencing both what they choose to teach and how they choose to teach it. Beliefs about, and views of, mathematics teaching and learning result from the teacher's years of personal experience as a learner. Teachers' beliefs are dynamic in nature and undergo restructuring and change as individuals evaluate their beliefs against experiences (Thompson, 1992). At times the professed beliefs of teachers are inconsistent with their instructional practice, thus it is not sufficient to examine teachers' verbal data; observational data needs to be considered when evaluating teachers' beliefs. Thompson further suggests that *modifying long held deeply rooted concepts of mathematics and its teaching* remains a problem (p. 135).

In summary, Aubrey (1994b) recommends that teachers need three attributes in order to develop a positive and productive learning environment: firstly, knowledge of subject matter in a way that is useful for children's learning, secondly, the teacher demonstrates care about - and commitment to - sharing that knowledge, thirdly, there is a sense of motivating children to learn. Aubrey concluded that the *application* *of this subject knowledge in the classroom is a key element in raising of standards in teaching* (p. 4).

2.7. EARLY MATHEMATICS EXPERIENCES

In the years prior to school young children are beginning to develop a feel for numbers. Initially children's mathematical experiences are at an informal and natural level of mathematical thinking, where an intuitive understanding of number is observed and children participate in activities where number will later become important (Carr, Peters, & Young-Loveridge, 1994). An important attribute of these early childhood experiences is the embedded thinking of mathematics concepts where the relationship of context and language are directly linked. Exploration leads children to discover quantitative features from the environment; they observe and acquire skills such as counting and begin to compare and contrast groups of objects (Pound, 1999). Throughout these experiences children construct their own purposes for mathematical thinking within a social domain. Early mathematics development can be thought of as part of a more general cognitive process where:

> *strategies are first mastered in highly contextualised and socially facilitated situations and then expanded with regard to the range of situations in which they can be applied, and the degree of contextual or social support that they require.* (Saxe, Guberman, & Gearhart, 1987, p. 113)

Carr, Peters and Young-Loveridge (1994) identify the second level of mathematical thinking as an informal and cultural level where play continues to be an important medium and the adult is seen as the expert. In the course of daily living children gain much experience of numbers, large as well as small, and gradually they learn that the numbers they have learned orally in practical situations have associated number symbols (Aubrey, 1994a; Young-Loveridge, 1999). Social experiences provide the opportunity to develop an understanding of the cultural significance of number; such as to indicate comparative status, to rehearse culturally significant sequences, to recognise culturally significant symbols and to solve interesting problems (Carr et al., 1994).

As theories of learning have developed and post-constructivist views of learning have been evolved, researchers such as Donaldson, (1978), Gifford (1995), Hughes (1986) and Young-Loveridge (1999) have questioned the emphasis on early number activities drawn from 'Piagetian' concepts. Piagetian activities such as conservation[1], classifying[2], ordering, and one-to-one correspondence[3] may not be as appropriate in developing early number skills as first thought (Gifford, 1995).

Dickson, Brown and Gibson (1984) concluded from their review of research that the skills such as conservation have little predictive value and that children who are 'non-conservers' may have a concept of number which is adequate for many basic number situations. Current teaching schemes for young children put too much emphasis on making one-to-one correspondence between objects and underplay the use of counting (Dickson, Brown & Gibson, 1984; Young-Loveridge, 1989a). Rather, Aubrey (1993) suggested that teachers should start with what young children can actually do.

Natural language has a fundamental role in supporting social communication and early number representation. The role of language provides a crucial link between concrete referents with symbolic notation (Burnett, 1992). This language development is a direct influence of reciprocal interactions with adults. However despite the importance of language interactions Young-Loveridge (1996) found that opportunities to support children's learning were often missed because parents, in the home situation, were not really listening to what their children were saying. She concluded that parents and teachers need to become more aware of the processes involved in the development of number knowledge so they can scaffold their children's learning more effectively.

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[1] To conserve number the children need to recognise that the number in a set of items spread out is the same number as in the set when it is closed up.

[2] Classification involves the ability to sort a set of items using a common attribute such as selecting all the items that have curves from those that do not have curves.

[3] One to one correspondence is the ability to match one item to one other, for example when counting the child needs to give one number name to one item in the set to be counted.

One of the implications of the study by Young-Loveridge, Carr and Peters (1995) *Enhancing the Mathematics of Four Year Olds* (EMI-4) was that educational professionals at all levels have a very important role in fostering the development of children's mathematical thinking. They stressed specifically the importance of appropriate instructional resources to enrich children's experiences. These researchers found that the development of mathematical ideas in most early childhood centres tended to happen spontaneously in social contexts rather than being planned. Mansfield (1990) cautions that most of the situations found in the pre-school are not intentionally mathematical. Sand, water and block play, for example, become mathematical only when children act upon these materials, reflect on their actions, and focus on mathematical attributes or relationships. Likewise, incidental teaching of mathematics concepts occurred as part of the normal daily routines, such as cutting up fruit, counting steps, during the reading of stories. Young-Loveridge et al. (1995) suggest that many activities not generally regarded as mathematical, if the teacher recognises and promotes this, have the potential to involve mathematical thinking, for example, using counting to ensure there are enough paintbrushes for a group of children.

In these cases the influence of an adult by providing scaffolding of learning is vitally important to maximise the potentially mathematical learning situations. Teachers need the ability to set up situations that present conflicts between the child's existing ideas and new ideas, and they need to be aware of the child's possible resolutions of conflict (Mansfield, 1990). The need for more explicit planning of mathematical activities was a suggestion of Young-Loveridge, Carr and Peters (1995) as they found that there was very little mathematics learning occurring in kindergartens.

Te Whaariki, the early childhood curriculum (Ministry of Education, 1996) emphasises the crucial role of the adult, especially when dealing with number development in toddlers. As examples of experiences for toddlers it suggests that *adult conversations with toddlers are rich in number ideas, so that adults extend toddlers' talk about numbers* and that *adults model the process of counting to solve every day problems, for example "How many children want to go for a walk?"* (p. 79). However, suggested experiences for young children do not include adult input:

> *children have the opportunity to develop early mathematical concepts, such as volume, quantity, measurement, classifying, matching, and perceiving patterns and have opportunities to learn through purposeful activities, for example, sand, water, blocks, pegs, and the materials and objects used for everyday play, such as dough, fabrics and paints.* (Ministry of Education, 1996, p. 70)

Young Children's Number Knowledge

The mathematics ability of children upon entry to school can be used to determine earlier number understanding developed in children prior to starting school. Entry levels have received much attention from researchers such as Aubrey (1993, 1994, 1997) Wright (1994), Young-Loveridge (1993), and Young-Loveridge, Carr and Peters (1995). The variety of entry skill capabilities of pre-schoolers include rote counting, knowledge of number sequence both forward and backwards, subitising[4], estimation and comparison of numbers, enumeration[5], cardinality[6], identification of numerals, forming sets, addition and subtraction with concrete objects, addition and subtraction with imaginary objects, and solving division/multiplication problems practically.

Together with the wide variety of number skills, individuals' abilities within the number skills vary greatly between young children (Young-Loveridge, 1991). This range of ability level has been confirmed in overseas studies. For example, Hughes (1986) found that working-class children aged four had addition and subtraction skills comparable to those of middle-class children of three years old. As a result of the EMI-4s study, Young Loveridge, Carr and Peters (1995) recommended that early childhood teachers need to be more aware of what children's individual needs in mathematics are in order to offer appropriate support and encouragement.

There is a general consensus that number concepts form the basis upon which higher mathematical abilities can be developed. Longitudinal studies show that differences in

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[4] instant pattern recognition for small numbers

[5] matching number names with objects

[6] the last number name used refers to the number of items in the set.

mathematical ability and performance remain fairly consistent through the primary and secondary school years (Newman, 1984; Young-Loveridge, 1991). If this is the case, then it is essential that young children develop sound early number understanding on which to base further learning (Burnett, 1992).

The crucial importance of early number development has been reflected in recent research and government funding of the development of number frameworks internationally, namely, the National Numeracy Project in the England (Department for Education and Employment, 1998), the Count Me In Too Project (CMIT) (Department of Education and Training, 1997) New South Wales, Australia, which was founded on work by Steffe and Cobb (1988) and, more recently, the National Numeracy Project (Ministry of Education, 2001) in New Zealand. The CMIT project was *developed to address the challenge of teaching and learning mathematics in 'the swamp of the real classrooms'. The focus of the programme is the advancement of children's mathematical solution strategies, particularly in number* (Gould, 2000, p. 23). These frameworks describe both the progression of children's number knowledge and the strategies children apply in solving number problems. The number knowledge aspect of the framework focuses on recognition of numerals, forward and backward number sequences, knowing numbers before, after and between given numbers, and base ten knowledge. The importance of counting skills in the early years at school suggests that early childhood educators should not overlook counting experiences.

Young children need to develop a sound understanding of small numbers in order to build a strong conceptual base for later work with place value, larger numbers and operations (Payne & Huinker, 1993).

Early Counting

Observations of children learning to count, both repeating numbers verbally and in counting objects, has led to the recognition of the variety of skills involved. Young children who can count verbally (rote counting) to thirty may have this achievement dismissed as mere 'rote learning' because they cannot count thirty objects. However Munn (1994) suggests that children's verbal counting helps their ability to count objects and to use the numerals. Verbal counting is now regarded as the important first stage in learning about the number system and the opportunity to spot patterns (Ginsburg, 1983). However, Edwards and Edwards (1992) caution that problems arise for children if the 'learning to count' process has been taught on a rote learning basis alone. Children need other skills in order to count meaningfully. The work of Gelman and Gallistel (1978) suggests that young children develop five principles which, once mastered, lead to meaningful counting: Children learn the order of the number words verbally (rote counting) and that one number name relates to one object for each of the objects (one to one principle) and to separate those counted from those uncounted (abstraction principle). They learn that the number of objects in the group is the last number name spoken (the cardinal rule) and that the order in which you count the objects does not matter (abstraction rule).

Children learn to apply these principles to smaller numbers before larger numbers. Children begin counting by touching the objects and saying the numerals out loud when they count. Later, they are able to look at a series of items and produce the numerals silently. Consistent with the process of internalisation is the fact that the concept of number becomes increasingly abstract during this period of development (Pellegrini & Dresden, 1991). Children begin by viewing number as a property of a set (Gelman & Gallistel, 1978) and later are able to perceive number as an independent entity that can be acted on (Fuson & Hall, 1983).

In her longitudinal studies of New Zealand school children Young-Loveridge (1991) was able to identify five key areas of early number competency as indicators of later success in mathematics. In these key competencies the children's initial score correlated highly with their overall scores assessed annually over a five-year period. The key competencies were the ability to:

- rote count;
- form a group of objects of a specified number;
- recognise numerals;
- add and subtract imaginary objects and
- subitize.

Young-Loveridge also tracked children's knowledge of shape names, their spatial ability and their recognition of money - but none of these skills appears to predict later success.

Te Whaariki (Ministry of Education, 1996) is not prescriptive in the development of number skills in young children. In the Exploration strand the learning outcomes associated with number include:

- *familiarity with numbers and their uses by exploring and observing the use of numbers in activities that have meaning and purpose for children;*
- *Skill in using the counting system and mathematical symbols and concepts, such as numbers, ... for meaningful and increasingly complex purposes;*
- *The expectation that numbers can amuse, delight, illuminate, inform and excite.* (p. 78)

A more comprehensive outline of learning outcomes for number can be found in Appendix C. Two concerns must be raised with the curriculum statement. Firstly, that not all the key competencies as identified by Young-Loveridge (1991) are included in the learning outcomes of *Te Whaariki.* (e.g., simple number operations of addition and subtraction and the ability to subitize are not mentioned directly), and secondly, the depth of number understanding, (especially in counting skills) is not apparent in the curriculum statement.

2.8. GAMES AND MATHEMATICS

Of key importance in this study is the fact that games can prompt the exploration and use of mathematical ideas and development of mathematical knowledge and understanding. It is suggested that playing and inventing games are excellent ways to promote mathematical exploration, to introduce content, and practise mathematical skills in a purposeful way (Baroody, 1998; Gough, 2001; Jones, 1982). Most mathematical games focus on one or more of the following instructional purposes: to develop concepts, to provide drill and reinforce experiences, to develop perceptual abilities, and to provide opportunities for logical thinking and problem solving (Smith & Backman, 1975). Well-designed games can encourage children to think about numbers, properties and quantities and to compare numbers and develop networks of number relationships (Jones, 1982). Booker (1996) suggests that during game playing the manipulation of materials and verbalisation of actions, thoughts and interpretation assist in the construction of mathematical concepts. Games which include worthwhile mathematical tasks capture the children's curiosity and invite them to speculate and pursue their hunches (Baroody, 1998).

Games provide a mechanism to foster a social constructivist approach to the learning of mathematics (Booker, 1996). Social interaction is an essential part of playing games, and there is potential for children's language as well as mathematics to be enhanced (Young-Loveridge & Peters, 1994). Baroody (1998) confirms that a co-operative learning group stimulates children in the process of mathematical inquiry and fosters positive beliefs about mathematics. Two of the general benefits of using mathematical games are to stimulate interest and develop a positive disposition towards mathematics.

More recently in New Zealand Peters and Jenks' (2000) publication *Young Children's Mathematics* promotes the use of number games to develop young children's number skills. Peters (2001) suggests that *early childhood teachers can enhance children's learning goals in mathematics by bringing in ideas and activities that stimulate and challenge children. ... games with a real mathematical purpose can be powerful learning tools* (p 7).

2.9. SUMMARY

A review of the literature has highlighted various key issues consideration of which was crucial in the research study. Firstly, *Te Whaariki*, the curriculum statement for early childhood education, promotes a socio-cultural constructivist approach to teaching and learning. The basic tenet of constructivism derived from the work of Piaget is that knowledge is constructed as individuals interpret and seek to make sense of their experiences. Inherent in this view is the fact that learners are actively involved in their own learning (Dockett & Perry, 1996). The constructivist view of learning implies that the knowledge and beliefs that children bring to the learning situation influence the meanings they construct in that situation. Different children will enter the learning situation with different knowledge and beliefs and may construct different knowledge from the newly presented situation. This means that each child's existing knowledge and beliefs about the topic must be known by the teacher and taken into account (Mansfield, 1990). Educators need to have more than a superficial awareness of children's knowledge in order to build upon it in educational contexts (Cullen, 1999). The teacher will play a crucial role in further developing each child's domain knowledge, and to this end the teacher's knowledge of content and pedagogy is of crucial importance.

Secondly, in the early development of children's number understanding there are some key areas of competence which should be incorporated as essential learning in early childhood centres if children are to have a productive start to number learning. When considering the vast range of mathematical abilities within a centre, teachers will need to tailor existing activities to cater for individual learning needs (Young Loveridge, Carr, & Peters, 1995).

Thirdly, games have an important place in early years' mathematics education for both social and cognitive reasons. They contribute to both teaching and learning by providing a background in which mathematical concepts can be developed and constructed in a meaningful way. At the same time, positive attitudes and feelings towards mathematics can be maintained and nurtured. Games have the potential to build confidence and knowledge, to motivate and to develop an appreciation of learning. However, games alone will not teach number understanding and the presence of a more knowledgeable participant is vital for mediation of the learning process.

CHAPTER THREE: RESEARCH DESIGN

3.1. INTRODUCTION

This study can be broadly described as qualitative in nature in that it allows the researcher to *seek to discover and understand a phenomenon, a process, or the perspectives and worldviews of the people involved* (Merriam, 1998, p.11). In qualitative inquiry the researcher is the instrument. The task for the qualitative inquirer is *to provide a framework within which people can respond in a way that represents accurately their points of view about the world* (Patton, 1990, p. 24). Regardless of the way the data are collected, the researcher must try to understand the phenomenon being researched and interpret the reality of the situation from two perspectives: firstly, that of the participants and what the event or interaction means to them and secondly, that of the researcher - must also be cognisant of her own theoretical and conceptual framework (Anderson & Arsenault, 1998).

Qualitative research can take many forms such as case study, action research and ethnography. In this research a case study approach was used to determine whether or not the use of number games enhanced the development of number knowledge and skills in children. In conjunction with this study, professional development was undertaken by the researcher together with the teachers to support their understanding of number knowledge development in young children. The impact of this professional development played a secondary role in the study.

A researcher using qualitative research methods will often find that quantitative summaries and classifications are useful parts of the research (Linn, 1990). Both qualitative and quantitative data can be collected and analysed in the same study. Quantitative research methods are based *on testing a theory composed of variables, measured with numbers and analysed with statistical procedures in order to determine whether the predictive generalisations of the theory hold true* (Creswell, 1994, p. 2). Some quantitative methods have been utilised in this project to organise data and examine them for trends and patterns.

3.2. DATA COLLECTION METHODS

Case Study

This research study was principally organised around a case study where the researcher undertook to investigate the use of games within the everyday routines of a kindergarten. *The case study is an holistic research method that uses multiple sources of evidence to analyse a specific phenomenon or instance* (Anderson & Arsenault, 1998, p. 152). Concern with how things happen and why is shown in the case study. *The case study offers a means of investigating complex social units consisting of multiple variables of potential importance in understanding the phenomenon* (Merriam, 1998, p. 41). The purpose of the case study is to test the various factors. To be able to predict from a single example the researcher must complete an in-depth investigation of the interdependencies of parts and of patterns that emerge (Sturman, 1997).

One strength of the case study is its use of a multiple data source in providing reliability and credibility to the findings (Anderson & Arsenault, 1998). Data sources from interviews of children and teachers, scheduled observations and participant observations were used in this study. *The range of data sources may, however, present disparate, incompatible, even contradictory information. The case study researcher can be seriously challenged in trying to make sense out of the data* (Merriam, 1998, p. 193). The researcher was cognisant that from multiple data collected in this study some discrepancies could appear. It is vital that any inconsistencies are acknowledged. Direct observation can be useful for understanding the context, to determine why things are like they are. As with many case studies the interview is the prime source data in this specific study. Interviews in this case study were with teachers and children.

Interviews

The purpose of interviewing is to *access the perspective of the people being interviewed. We interview people to find out from them those things we cannot directly observe* (Patton, 1990, p. 278). The interview provides some flexibility to ask and restate questions and so is better as an exploratory tool than a questionnaire. A strength of the interview is that there is less chance of misunderstanding between the researcher and the respondent thus providing a more complete in-depth picture. Additionally, the interview format is more flexible and responses can be probed and explored. Structured and semi-structured interviews were utilised in this study.

Semi-structured interviews used with the teachers (see Appendix D) were less focussed allowing informants freedom to digress while ensuring certain pre-set questions were answered within the researcher's framework. Because of time constraints the pre-set questions *ensure the same information from each person interviewed is attained* (Patton, 1990, p. 285). In asking the same questions of each teacher in this study the researcher was able to minimise interviewer effects. Elliot (1991) suggests that the semi-structured interview allows the researcher to remain as open as possible to what information is relevant. The semi-structured interviews used were systematic and ensured that interviewer judgement throughout the interview was reduced (Patton, 1990).

A structured interview was used with children with questions formulated in advance to focus specifically on number knowledge and skills. Children's interview questions (see Appendix E) were adapted from questions that had been used by other researchers in the area of early number skills (e.g., Aubrey, 1993; Hughes, 1986; Munn, 1994; Wright, 1994; Young-Loveridge, 1989a).

Building rapport with the people in the research setting is extremely important in order to understand the situation through the eyes of the participants. In the early childhood situation it was imperative for the success of the interviews that all the children were comfortable with the researcher. With this in mind, the researcher spent a week in the centre prior to interviewing in order to ensure that children were at ease with her. Care was taken on the part of the interviewer that subtle cues were not transmitted to influence responses (Guba & Lincoln, 1981). Interviews with teachers and children were all audio-taped (with permission from the respondents) and notes were taken by the interviewer during the interview. The researcher transcribed the tapes.

The results of the initial and final interview tell you where you started, and where you ended up, but not what happened along the way. *Quantitative measures can parsimoniously capture snapshots of "pre" and "post" states, but qualitative methods are more appropriate for capturing developmental dynamics* (Patton, 1990, p. 114). To this end observations were also used in this study to capture 'developmental dynamics'.

Observation

Observational research involves the researcher in observing participants and collecting data on what they are doing. The participant as observer enters the *social life of those being studied sometimes assuming an insider role, but often playing the part of a snoop* (LeCompte & Preissle, 1993, p. 93). In joining the regular activities of the community, enhanced insights into the behaviours and motivators in the community can be made. As such, *observational data, especially participant observation, permit the researcher to understand the programme to an extent not entirely possible using only the insights of others obtained through interviews* (Patton, 1990, p. 25). In this study the researcher was a participant observer who engaged in the regular activities of the centre and periodically withdrew from the setting (Burns, 1997). Observational data on the children at play were gathered for all consenting children on three separate random occasions.

Within this study the challenge in collecting observational data was to ensure that the researcher's presence did not alter the behaviour of the people in the centre. There was concern that behaviours of both teachers and children would be altered by the researcher's presence. The teachers commented that in the initial stages of the research, the researcher's presence did make them more conscience of number development. However, while the presence of a researcher did initially in some way disturb the natural situation, more stability returned over time. It was particularly difficult in the study not to create this 'Hawthorne effect' with the children as they soon realised the researcher was interested in the number games and whenever the researcher was present she could be tempted as a willing game participant.

Researcher influence was minimised by having the teachers as the principal game observers.

A timed schedule for observations by researcher and participant teachers was used to provide a systematic description of game activity and interaction. A set of coding rules was devised to record and classify children's game playing with the results in the form of quantitative data (Croll, 1986). Setting predetermined categories and explicit criteria for assigning game playing occurrences eliminated subjectivity on the part of the observers. Observations were made every 15 minutes beginning after morning mat time (approx. 9.30 a.m.) and ending at around 11.30 a.m. when children started tidying ready for whanau group time.

Action Research

A small-scale action research was utilised during the professional development with the teachers with regard to the integration of games within the centre's programme. Action research is a total process *in which a 'problem situation' is diagnosed, remedial action planned and implemented, and its effects monitored, ... It is both an approach to problem solving and a problem-solving process* (Burns, 1994, p. 294). As such, educational research begins with the practical questions that arise from everyday classroom activity and is carried out by the people concerned with the situation that is being researched. In this small-scale study, action research provided a framework for the teachers and researcher to develop and trial alternative ways of introducing the games to the children. In each of the three professional development sessions discussion took place as to how the games would be best introduced to the children and subsequent evaluation was undertaken as each fortnight was completed.

3.3. PROJECT SCHEDULE

This section outlines the setting for the study, details of those who participated in the study are discussed and finally the phases of the study and the data analysis methods are considered.

The Setting and the Sample

The research was undertaken in a kindergarten located in a mid to high socio-economic residential area of a city. Three permanent teachers taught at the centre, assisted by a full-time teacher-aide. The study was undertaken during the morning sessions which ran from 8.50 a.m. to 12.00 noon. Forty-five children whose ages ranged from four years two months to five years attended five mornings a week. Although the roll changed slightly with children moving on to school there were fairly equal numbers of boys and girls. All children were expected to stay inside prior to daily morning mat time that began at approximately 9.10 a.m. and finished at around 9.30 a.m. Teachers rotated week about to take mat time with activities that would typically involve news, singing and a listening time. Mat time would end with a brief outline from all three teachers as to what extra activities were available for children on that day. Children had 'free choice' over activities within the kindergarten at the completion of mat time. Morning tea was continuously available and children were encouraged to prepare their own. Teachers would focus on their area of responsibility - either an outside area including water and sand play, carpentry and the confidence area, or the veranda area involving puzzles, duplo, literacy corner, or inside at the making table, play dough, morning tea, construction, home corner and computer. The teacher stationed on the veranda undertook the scheduled observations for that week. At 11.30 a.m. children and teachers began to tidy up, this was followed by whanau group time. Children were placed in family or whanau groups when they first began morning kindergarten. Every day whanau group time would involve children in such activities as stories, games and puzzles. Each teacher would plan learning activities for their own whanau group.

Phase One

The first phase of the research involved the literature review, gaining ethics approval, seeking permission from the local Kindergarten Association for the research to be undertaken, approaching the kindergarten for acceptance, setting up a mutually agreeable entry and research period, the development of a child interview and selection and development of appropriate games. All three teachers consented and participated fully in all aspects of the research including the professional development, assisting with data collection from scheduled observations of children's game playing, and the initial and final interviews with the researcher (see Appendix A for Teacher Information Sheets). Consent forms for all children were sent home to parents or guardians seeking permission to interview children twice; initially prior to introduction of games and finally after game usage was completed (see Appendix B for Caregiver Information Sheets). A number of the children who had parental consent were later eliminated from the sample as they turned five during the study and so left the centre to move on to school. Ten children individually participated in the initial and final interviews. A selection process was unnecessary as these were the total of consenting children who would be attending the kindergarten throughout the research period.

Phase Two

Early in the second phase initial interviews were undertaken individually with the children. This was to determine the level of number understanding prior to the commencement of the research. Interviews occurred during session-time in a quiet area of the kindergarten. Initial interviews were also completed with the teachers. Initial teacher and child interview questions can be found in Appendices D and E respectively.

Professional development sessions with the teachers, completed during each of three consecutive fortnights, focussed on early essential number knowledge and skills and how to recognise and develop these in young children (see Appendix H for overview). Teachers were familiarised with the three new games and related number skills, and discussed suitable ways to introduce the games early in the fortnight. This action research cycle was vital to ensure that games were introduced successfully. Three different approaches for game introduction were used and these are discussed in Chapter Six.

This second phase was broken into three fortnights during each of which a professional development session preceded the introduction of the three new games. As a result of feedback from the teachers and researcher the method of game introduction varied. During Phase Two teachers and researcher observed game usage by the children every fifteen minutes throughout the morning. Teachers took week-about responsibility for these observations, noting the following: which games were being played, who was playing them, and if there was an adult present. The researcher relieved teachers of this duty when she was present in the kindergarten.

Throughout Phase Two the researcher undertook three separate observations of the ten consenting children at play. Each observation period was between one and a half to two hours and usually involved three children simultaneously.

Phase Three

Phase Three involved final interviews of teachers and the ten children. All interviews were completed over a five-day period at the end of the third fortnight. Children were individually interviewed reusing the initial structured interview (see Appendix E) to determine any improvement of number knowledge and skills. Teachers were individually interviewed (see Appendix F) to gain opinions on the games, to determine any change in beliefs and practice, to discuss their confidence in the teaching of number skills, and lastly to receive feedback on the value, or otherwise, of the professional development sessions. Teacher interviews were semi-structured in nature.

Phase Four

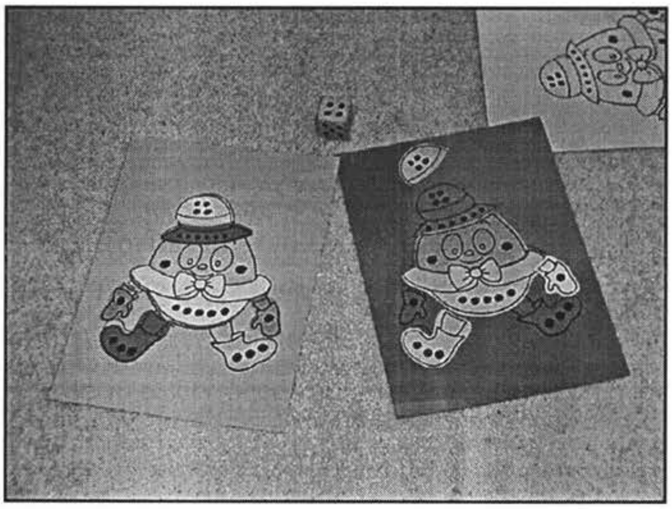
Phase Four involved the analysis of data from various sources: teacher and child initial and final interviews, scheduled observations of game usage, and casual observations of children at play.

3.4. THE GAMES

Games selected for use in the research focussed on areas of knowledge and skill identified as crucial for young children's early number development as described in Chapter Four. Black line masters for most of the games can be found in Appendix G.

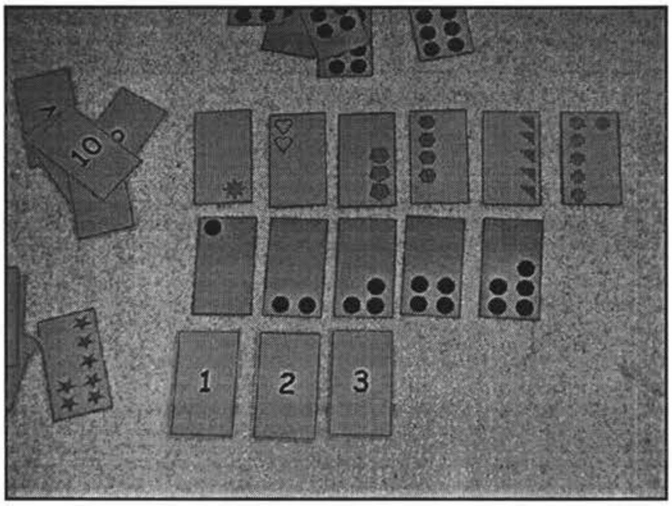
First Fortnight:

In the first fortnight the games focussed on counting skills, one-to-one matching and ordering sets according to size. The need for numeral recognition was kept to a minimum.



Humpty Dumpty was sourced from the Count Me In Too Project (Department of Education and Training, 1999, p. 24). In playing the game each child had a game board and matching pieces of the Humpty Dumpty figure. Each piece had a number of dots on it from one to six and the piece directly matched, in jigsaw-like fashion, onto the same piece on the game board. In turns the child rolled a dot pattern dice, counted or recognised the number, and placed the piece with the same number of dots on the game board. The game continued until the child's Humpty Dumpty was covered. Number skills developed in this game were one-to-one matching, counting, and subitizing.

Stepping Stones used twenty-five pieces of lino cut in various 2D shapes, large enough for one child to stand on. Pieces were placed in a large circle on the floor. One child rolled the large dice (dot patterns from one to six) and all children involved in the game moved forward that number of spaces. Children could leave or join the game as they desired. There was no winner. Number skills developed were one-to-one matching, counting, and subitizing.



Ordering Sets had four sets of cards showing a different representation of sets of sizes one to ten to be ordered. Illustrations on the sets of cards were:

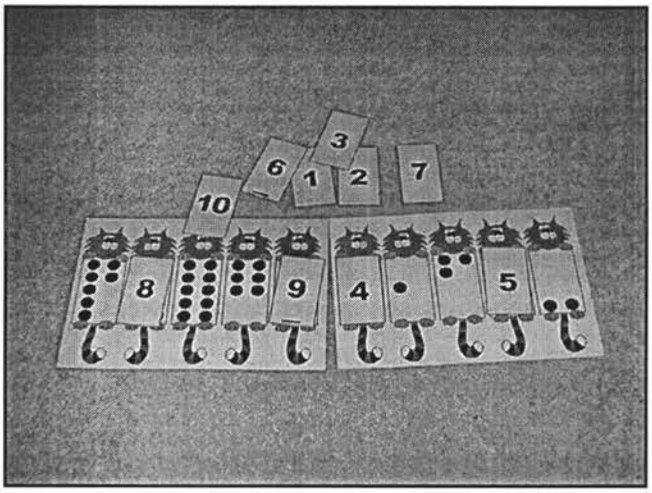
- using a tens frame layout showing dot patterns using pairs of dots or pairs plus one arrangement,
- a variety of shapes using a tens frame layout always completing the first five,
- from the Beginning School Mathematics resource (6.1.44) showing unordered sets of animals and
- numeral cards showing numerals from one to ten.

Children could select which sets of cards they preferred to use depending on their level of confidence. Number skills developed were one-to-one matching, counting, subitizing and numeral recognition.

Second Fortnight:

During this fortnight all the new games used numerals and so required numeral recognition or identification by the children.

Beehive was sourced from the Count Me In Too Project (Department of Education and Training, 1999, p.34). Each child had a game board with a large beehive on it. Each child selected a numeral card (one to ten) and had to make a set showing that number of bees and place them around the beehive. Number skills developed were numeral recognition, counting out a particular sized set and matching the set to the numeral.

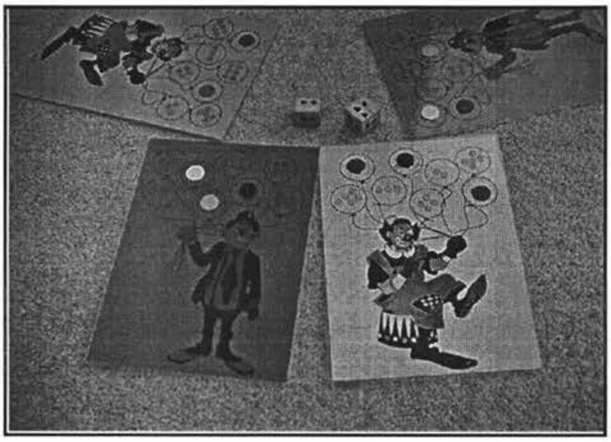


Cats was sourced from the EMI-5s study (Young-Loveridge & Peters, 1994, Game 13). Each child had a game board with five cats on it. On each cat were a number of dots from one to ten, shown in tens frame layout. Half of the boards showed unordered sets sized from one to five and the other boards sets sized from six to ten. A child could select which board to play with depending on their confidence. Children also had a pile of numeral cards which they had to match to the cat showing the same number of dots. Number skills developed were numeral recognition and identification, dot pattern recognition (subitizing), and counting.

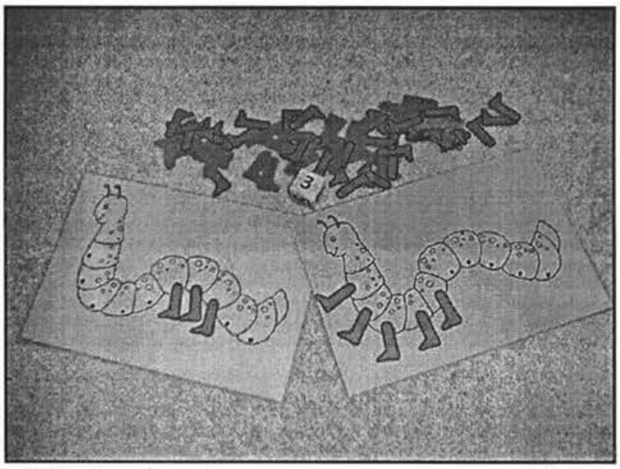
Memory utilised the same cards as were used for Ordering Sets as above. Popular games of Memory, Snap and Happy Families extended the use of the same cards further. Number skills developed were one-to-one matching, counting, subitizing and numeral recognition.

Third Fortnight:

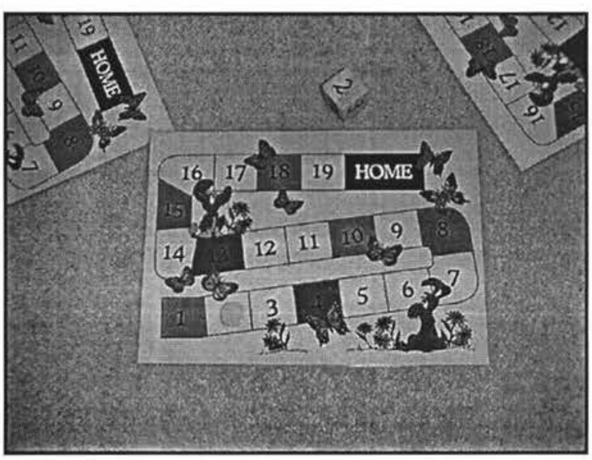
During this fortnight simple number operations (addition and subtraction) were introduced into the games. Numeral and set recognition together with counting continued to be a focus.



Clowns was sourced from the EMI-5s study (Young-Loveridge & Peters, 1994, Game 16). Each child had a game board showing one of the two clowns. Each clown was holding eight balloons and on each balloon was a dot pattern from two to six (some numbers were repeated). Two dice were rolled, the first had dot patterns 1,1,1,2,2,2 and the second 1,2,2,3,3,4. Children rolled the dice, counted up the number of dots and covered the matching set on one of the clown's balloons. Number skills developed were one-to-one matching, counting, subitizing, counting on and early addition.



Caterpillar was sourced from Exploring 6-10 by Bev Dunbar (1999). Each child had a game board showing a large legless ten-segmented caterpillar. Before starting the child placed one leg per segment on the caterpillar. A numeral dice (one to six) was rolled and the appropriate number of legs was removed. Number skills developed were one-to-one matching, counting, numeral recognition and early subtraction.



Tracks was sourced from EMI-5s Project (Young-Loveridge & Peters, 1994, Game 3). There was a game board showing a path numbered one to nineteen and 'HOME'. The child rolled the numeral dice (one to six) and moved the counter the appropriate number of places. The objective of the game is to be the first player to reach home. Number skills developed were one-to-one matching, counting, and numeral recognition.

3.5. PROFESSIONAL DEVELOPMENT

The researcher undertook three two-hour professional development sessions with the teachers. Each session focussed on the number knowledge and skills being introduced and practised in the new games. Teachers' awareness of the importance of early number knowledge development was enhanced in these sessions, which included collegial discussion regarding the support teachers could provide for the learning needs of their children and how best to cater for these needs. The action research cycle which focussed on how the games were to be introduced to the children and evaluating the success of previous strategies continued in each professional development session. Summary details of each session can be viewed in Appendix H.

3.6. DATA ANALYSIS

Both quantitative and qualitative data were collected in the study. Quantitative analysis of game usage based on data collected in scheduled observations, and improvement of individual children's number skills as determined from children's interviews, were initially determined and are reported in Chapters Four and Five. Observations and teacher interviews were analysed for categories and trends to provide further insight into the use of number games in developing children's number skills. This analysis was qualitative in nature and is reported in Chapters Four and Six.

Reliability, Validity and Associated Limitations

The inability of qualitative research to be generalised to other communities has been a criticism of this type of research. Anderson and Arsenault (1998) suggest that generalization is not a fundamental component of this type of research. *The replicability of the research of any given experience is less important in* *understanding human behaviour than in the recognizability of the description by those who lived the experience* (Guba & Lincoln, 1981, p. 213).

In general, qualitative data analysis relies heavily on the process of triangulation. Triangulation, using multiple investigators, multiple sources of data, or multiple methods of data collection to confirm emerging findings, is one strategy to enhance internal validity. Patton (1990) suggests that triangulation of methods will most often revolve around comparing data collected through qualitative methods with data collected through some kind of quantitative method. In this study the use of multiple data sources in the form of teacher and researcher observations, and multiple collection methods, namely interviews and observations, helped to eliminate bias and detect errors or anomalies. *Triangulation prevents the investigator from accepting too readily the validity of initial impressions, it enhances the scope, density, and clarity of constructs developed during the course of the investigation* (LeCompte & Preissle, 1993, p.48). Validity of participant observations was confirmed using the teacher interviews for interpretation of meaning.

Reliability refers to the extent to which research findings can be replicated. Reliability is problematic in social sciences because human behaviour is never static (Merriam, 1998). *Qualitative research occurs in natural settings and is often undertaken to record processes of change, so replication is only approximated, never achieved* (LeCompte & Preissle, 1993, p. 332). Thus the researcher's task is to describe and explain the world as those in the world experience it. By describing in detail how data are collected, how categories were derived, and how decisions were derived the researcher can provide an audit trail so the methods can be authenticated contributing to the reliability of the study. In this study an observation schedule was initiated to produce a factual account of game usage. Careful design of the schedule was needed to ensure that important details such as who was playing and how the games were being played, and whether or not a teacher was present were considered. To ensure reliable procedures for the observation schedule it was important that the observers were well trained and consistent in their observation. These issues were discussed in the professional development programme. Reliability of interviews may vary greatly according to the skill of the interviewer. In this study the use of the same set of questions and only one interviewer assisted the reliability of results.

Internal validity deals with the question of how research findings match reality. *As human beings are the primary instrument of data collection and analysis in qualitative research, interpretations of reality are accessed directly through their observations and interviews* (Merriam, 1998, p. 203). Researchers need to present insights and conclusions that ring true to readers (Merriam, 1998). The readers need to be presented with enough detail to confirm that the author's conclusions make sense. If the readers can relate to the case and see similarities in other situations then the researcher has been successful in producing a valid case. In this study internal validity was assured through meticulous record keeping and open decisions being made concerning all aspects of the research process. The extent to which generalizability or external validity is possible will relate to the extent to which the case is typical. When dealing with qualitative data it is assumed that reality is *holistic, multidimensional, and ever changing* (Merriam, p. 202).

External validity is concerned with the extent to which the findings of one study can be applied to other situations. In qualitative research a single case study is selected precisely because the researcher wishes to *understand the particular situation in depth, not to find out what is generally true of many* (Merriam, p. 208). Patton (1990) believes that qualitative research should provide *a perspective rather than truth by using empirical assessment of universal theories* (p. 156).

The Researcher as an Instrument

In qualitative research the researcher is the instrument who selects the design, collects, analyses and interprets the data (Merriam, 1998; Patton, 1990).

> *Because qualitative data depend, at every stage, on the skills, training, insights, and capabilities of the researcher, qualitative analysis ultimately depends on the analytical intellect and style of the analyst. The human factor is a great strength and the fundamental weakness of qualitative inquiry and analysis.* (Patton, 1990 p. 372)

Participant observation allows the researcher to see the world as viewed by the subjects in the study. It permits the researcher to use herself as a data source and allows the researcher to build up tacit knowledge of the situation (Guba & Lincoln, 1981). However, it is difficult for the observer to guard against her own personal biases, attitudes, prejudices or assumptions, especially in relation to the observations. Individual characteristics of the researcher - such as personal experiences, talents and skills, personality and preferences - affect the research activities. As such *the role the researcher assumes within the culture and the researcher's identity and experience are critical to the scientific merit of the study* (LeCompte & Priessle, 1993, p. 92).

Ethical Considerations

Ethical dilemmas in qualitative studies are likely to emerge with regard to the data collection, data analysis and the dissemination of findings. Interviewing carries with it both risks and benefits to the informants. *Respondents may feel their privacy has been invaded and tell things they never intended to reveal* (Merriam, 1998, p. 214). The act of observation may bring about changes in the activity, rendering it somewhat atypical.

Analysing data may present ethical problems. Since the researcher is the primary instrument for data collection *opportunities exist for excluding data contradictory to the researcher's views* (Merriam, p. 216). In all phases of the research the investigator must be as nonbiased, accurate, and as honest as humanly possible. Disseminating findings can raise further ethical problems. There is a continuum of ethical issues based on how 'public' the behaviour is made. At a local level it is nearly impossible to protect the identity of either the case or the people involved.

In order to minimise these effects the following steps were taken to ensure that these ethical principles were applied:

1. Approval was gained from Massey University Human Ethics Committee, Protocol 00/102.
2. Approval was obtained from the Ruahine Kindergarten Association to undertake the research in a kindergarten under their jurisdiction.
3. Approval was obtained from the head teacher of the kindergarten to enter the kindergarten for research purposes.

4. Informed consent was obtained from the teachers after they had been given an information sheet about the project and had time to consider the implications of granting consent.
5. Informed consent was obtained from parents after they had been given an information sheet about the project. Only those children whose parents or guardians consented were interviewed.
6. Anonymity and confidentiality of those involved were assured. False names have been used throughout the study to ensure anonymity of all participants.
7. No potential harm to the participants was envisaged.
8. Assumptions made by the researcher have been made apparent.

To improve the reliability of the research it is best for the researcher to detail her background, experiences and possible expectations and the influences she has brought to the research which may have influenced the results. The researcher in this study is an experienced primary school teacher who has taught predominantly in junior classes. The researcher is currently teaching in pre-service primary and early years teacher education programmes specialising in mathematics education. The project reflects the researcher's current interest in number development in young children. The researcher brought to the study the following assumptions that must be declared:

1. number development is crucial in early years for children's future confidence in mathematics;
2. children's knowledge level and confidence in number varies greatly between children from an early age;
3. parents, caregivers and teachers have a vital role in development of early number skills;
4. in play, young children favour areas of familiarity or confidence and avoid activities where they are less confident;
5. rich mathematical experiences are not always adequately provided in Early Childhood Centres.

3.7. LIMITATIONS OF THE PROJECT

There are obvious limitations of this project design and implementation that must be considered in conjunction with the research findings:

1. Parents who consented to their children's participating possibly felt their children were confident in number and would manage an interview. Non-consenting parents may have been concerned about their children's confidence with number.
2. The small sample size of children interviewed makes it difficult to generalise results.
3. The sample may have been slightly biased due to the nature of the research study.
4. Crucial times when games may have been used (i.e., pre-mat time) were not observed.
5. Scheduled observations were made on only half the possible occasions due to the fact that teacher - who were prime data gathers - were otherwise engaged. Game usage might have been higher if all observations had been completed.
6. The mental activities involved in the game playing cannot be determined through observations. We cannot infer that children were thinking mathematically during the game playing. It also follows that we could infer that children might have been thinking mathematically at times other than during game playing.
7. Interviews were taken during session time and within an area open to all children. This was to ensure that children felt comfortable and not isolated. Interviews often attracted an audience who also participated. Occasionally it was difficult to ensure that answers represented the thoughts of the child being interviewed and not the peer spectators.

3.8. SUMMARY

A qualitative research design was adopted to explore the influence of number games in young children's development of number skills. Ongoing professional development of teachers throughout the research period was undertaken to enhance teacher awareness and provide reflective feedback on game usage for each cycle. Three major data collection methods were used: initial and final interviews of teachers and children, scheduled observations of game usage, and participant observation of children at play. Information was analysed initially using quantitative methods and then confirmed from interviews and observations. The results and discussion of this data collection are presented in subsequent chapters.

Chapter Four focuses on responses to games, drawing together a summary of teacher and researcher incident counts of game usage throughout the six-week period, and the teachers' comments on the games drawn from the post research interview. Chapter Five focuses on the children's number development resulting from an analysis of children's interviews arising from pre and post games usage, and the researcher's observations of the selected children during normal centre sessions. Raising teacher awareness through the professional development of the teachers forms the sixth chapter, where trends from the teacher's initial and final interviews are discussed and the suitability of the professional development sessions is analysed.

CHAPTER FOUR: RESPONSES TO GAMES

4.1. INTRODUCTION

Games selected for use in the research focussed on areas of knowledge and skills identified as crucial for young children's early number development as described in Chapter Two. Descriptions of these games can be found in Chapter Three. Three games were introduced each fortnight to the children. Once introduced, all games remained available to the children throughout the research period.

Over the six weeks, game usage by all children was documented daily as incident counts by the teacher 'working the veranda' or by the researcher. Incident counts of game usage were to be made every 15 minutes. At each fifteen-minute interval the teacher would record which game or games were being played, who was playing the game/s, and whether or not an adult was present. Observations began after morning mat time (usually around 9.30 a.m.) and continued through to 'tidy up time' (around 11.30 a.m.). No observations were made prior to mat time as teachers decided that during this period too many demands were made on their time as children arrived at the kindergarten, messages from parents were handled and teachers prepared for the morning's teaching. Children had to stay inside during the pre-mat time. During this time, games may have been used - especially with parents who chose to wait for mat time to begin before leaving their child. There was a maximum of seven observations of game usage per day, and over the six-week period there were 210 possible observation periods. Unfortunately, on some days observations were not completed for every fifteen-minute time slot due to teacher commitment to other activities: observations were made on only 103 of the possible 210 fifteen-minute time slots. Within the observation period time each game play was recorded for all children. Hence on some days the number of games played exceeded the number of times observations were made. For example, on Day 5 three observations were made and six games were being used (see Appendix I for full game usage chart). Games were recorded being played 91 times during the six-week research period.

4.2. GAME USAGE

It was difficult to determine the most used game because not all games were available at all stages of the research, and novelty factors also impacted on usage in each time period. In the first fortnight Humpty, Stones and Order were introduced in whanau groups, and when all children had been introduced to all three games they were then made available during general session times. During the second fortnight new games introduced were Beehive, Cats and Memory. Clowns, Caterpillar and Track were introduced in the third fortnight. The percentage each game was observed being used per fortnight is summarised in Table 4.1 - for more details see Appendix I. Other mathematics puzzles and games normally available in the centre were also still available during the research period, and their usage is recorded as 'Other'.

Table 4.1: Percentage each game was used per fortnight.

Fortnight	Humpty	Order	Stones	Other	Beehive	Cats	Memory	Clowns	Caterpillar	Track
One	42%	5%	33%	20%	N/A	N/A	N/A	N/A	N/A	N/A
Two	20%	8%	20%	8%	8%	25%	11%	N/A	N/A	N/A
Three	0%	0%	6%	2%	6%	6%	0%	38%	23%	18%

In the first fortnight, Humpty and Stones were the two more popular games. However, as expected, their usage fell off as new games were introduced in the second fortnight. While Cats appeared the more popular of the games introduced in the second fortnight, Humpty and Stones maintained comparable success. In the third fortnight, Clowns was the more popular of the new games. Over the six-week period the most popular games, that is, those with high usage from the observations, were Humpty, Stones, Cats, and Clowns.

Individual children developed strong preferences for particular games, with high game users repeatedly using the same games. Table 4.2 summarises the games used by the ten children interviewed. Discussion of individual children's preferences follows in Chapter 5 and is related to individual children's development of number awareness.

Table 4.2: Games each child played

	Humpty	Order	Stones	Other	Beehive	Cats	Memory	Clowns	Caterpillar	Track
Jim	R R R		I I I I I	I	R R	R R I	I			T I
Kim	R I	T	I	I I I I		T		R	I I	
Susan			I I I I I I	R				P		
Jacob		I	I R			T		R I I		T
Harry			I	I		T		R R	R	T
David			I			T T				
Joe	I I									
Alice	I	T								
Helen						T				
Sally										

1=one independent game playing observed, T=teacher assisted, R=researcher assisted, P=parent assisted

During the six-week study games were played on 91 observed occasions with 222 individuals participating in the playing sessions. Data gathered on game usage of all children indicated that girls were more likely to use the games than were boys. There were equal numbers of boys and girls in the centre. Sixty-six percent of the game players were girls. The amount of actual time spent game playing by girls compared with boys was not measured. Adults were present 37% of the times when girls played, whereas adults were present 47% of the times when boys played. It was difficult to determine why this occurred. It was possible that teachers actively encouraged the boys to play the games by being physically present, whereas girls tended to game play more voluntarily. It could be that boys were drawn more to the games when there was an adult present. The influence of these factors was not able to be determined from the study.

4.3. OBSERVATIONS AND IMPRESSIONS OF GAMES

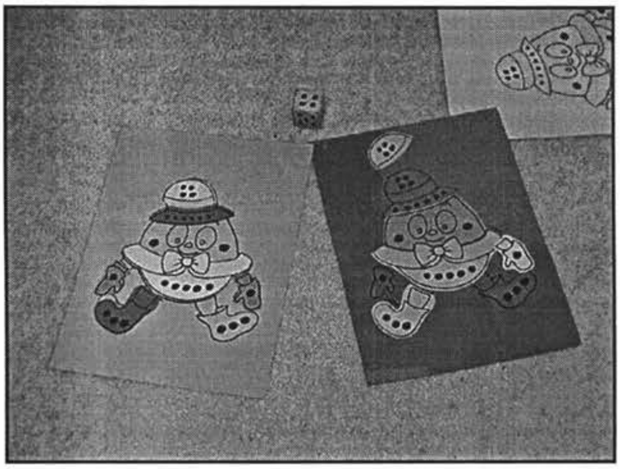
Teachers were asked in the final interviews (see Appendix F) to rate the games using a score from 1-5 on different variables including; children's enjoyment, suitability of mathematics for children involved, and whether or not they would use the game again. This is summarised in Table 4.3. The higher the score the more positive the teacher is about the game.

Table 4.3: Summarised teacher ratings of preferred games.

Teacher	Stepping Stones	Humpty Dumpty	Order	Beehive	Cats	Memory	Cater-pillar	Clowns	Track
Nancy	13	14	13	15	14	13	13	15	13
Liz	15	15	13	14	15	13	15	13	9
Anne	15	15	11	12	14	10	11	13	12
Total	43	44	37	41	43	36	39	41	34

Teachers' ratings indicated that Stepping Stones, Humpty, Beehive, Cats and Clowns were the most preferred games. This matched very closely with the children's preferences as indicated by game usage.

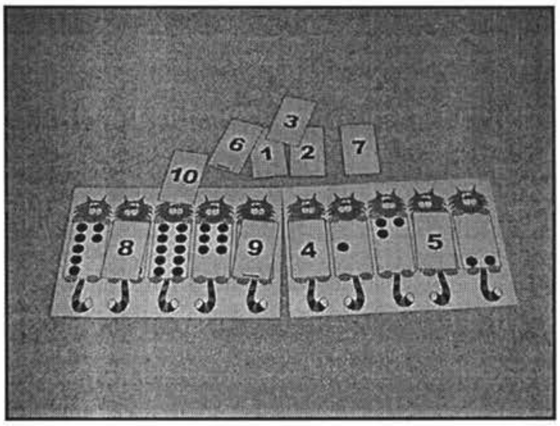
Final interviews with the teachers provided an insight into the reasons why they preferred various games.



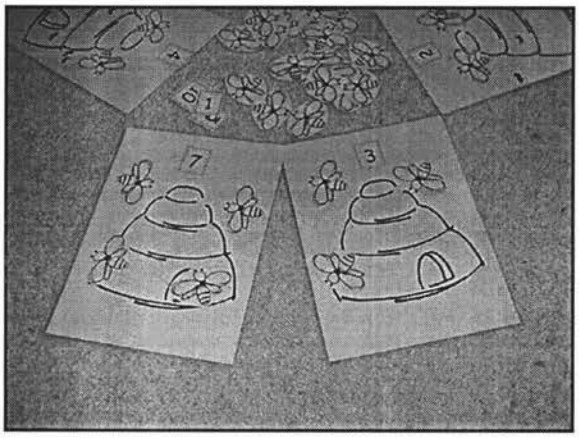
Liz favoured Humpty Dumpty as "*the character is familiar*" and it was "*pitched about right*". Anne believed the game "*appealed to kids, sitting in the bag on the shelf*". This need to appeal was reinforced by Nancy, who found attractiveness an important attribute for a suitable game: "*Humpty was attractive and the first time I introduced it the children were interested and really seemed to understand what they were supposed to do.*"

Children found Humpty attractive and would frequently ask the researcher to play. The rules were changed slightly to avoid long waits in rolling the desired dot pattern. Children persevered with the game ensuring that all pieces were correctly in place. During the playing of the game the more able children tended to dominate. They called out the number rolled, selecting the correct piece to help the less experienced in order to speed things up for their own turn. Some of the pieces were frustratingly fiddly to place on the card and some children became upset - especially when their game board was bumped and the pieces moved even slightly.

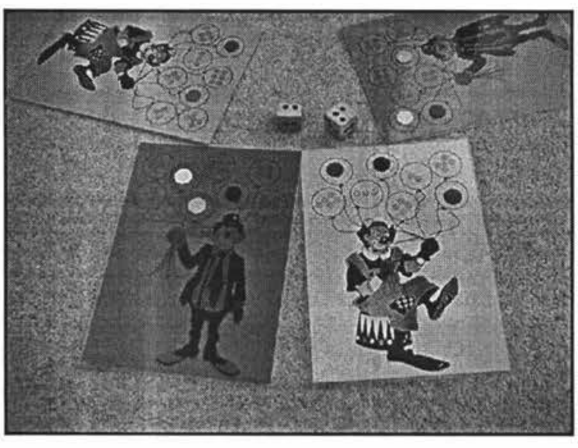
Stepping Stones appealed to Anne because it involved *"bigger motor skills ... for those children who could not sit down and concentrate they could certainly do that."* The obvious presence of the game gave it appeal to children, *"it was big and that made it obvious which drew children to it."* Stepping Stones, although popular with the children did have its problems. Children tended to stand directly behind one another and so only the first in the line had to count and take one step per count, all the others just followed. The researcher and teachers spent some time with this game reinforcing the one step per count and encouraging children not to follow too closely. Instant recognition of number of dots on the dice was a valuable skill developed using this game. When an adult was present the game was more frequently used, but unfortunately more children using the game resulted in less accurate counting and dice pattern recognition by participants.



The opportunity for multi-ability usage was a key positive feature of the Cats game: *"It was flexible because for the children who just had emergent skills you could limit it to 1-5 cards and the ones right up to ten gave more of a challenge for those who thought they were a bit clever"* (Nancy). Once again the appearance of the game was a positive feature: *"Cats were cute"* (Nancy). The game was seen as more useful for general class time rather than whanua group time, despite the fact that it was viewed as useable across a range of levels.



Initially the Beehive game caused a dilemma with some children as the original game board had sketches of little bees buzzing around the hive. Some children tried to one-to-one match the bees to be placed on the board with the bees already drawn. The numbers of bees did not always match the numeral card selected. The game boards were replaced with hives with no bee sketches. Such problems emphasise the need for a teacher/adult to observe actual game usage and make any necessary adaptations to ensure the desired learning outcomes. Nancy viewed Beehive as attractive and "*children understood how many bees had to be in the beehive.*"



The challenge of Clowns was viewed as a positive attribute. It made demands on the children's skills – a feature which was commented on by both Nancy and Liz. Liz observed, "*they could count them all and got the hang of counting all the numbers facing up* (presumably this means the dots on the dice) *and finding the number on the clown.*" Two of the teachers described Clowns as appealing for children.

In the questionnaire teachers were asked to rate the suitability of the level of mathematics required by the game. Table 4.4 summarises the teacher ratings where 5 meant the teacher strongly agreed that the level of mathematics used in this game was right for the children and 1 meant the teacher strongly disagreed.

Table 4.4: Teacher rating of mathematics suitability.

	Stepping Stones	Humpty Dumpty	Ordering Sets	Beehive	Cats	Memory	Cater-pillar	Clowns	Track
	Introduced in first fortnight			Introduced in second fortnight			Introduced in third fortnight		
Nancy	4	5	5	5	4	4	5	5	5
Liz	5	5	5	5	5	5	5	4	3
Anne	5	5	4	3	4	3	3	4	3
Total	14	15	14	13	13	12	13	13	11

5 = most mathematically suitable, 1 = least mathematically suitable

Overall, the teachers appeared to rate all games as suitable in terms of mathematical content. Stones, Humpty, and Order - which were purposefully less mathematically demanding, and which were assessed by teachers as involving more suitable mathematics - were the three games introduced early in the research. Skills and knowledge required by the games introduced in the third fortnight were more demanding mathematically. The games the teachers rated with the most suitable levels of mathematics also matched those games that they found more appealing overall.

Results from the children's interviews indicated that the children had number knowledge well above that demanded of these teacher-favoured games. For example, teachers rated Humpty as one of the games with the most suitable level of mathematics, however the skills developed in this game included one-to-one matching and counting which were skills in which most of the children interviewed demonstrated competence (see Table 5.1 for more detail). Games introduced later in the research study developed these early skills and also challenged more advanced number skill development. For example, Track involved counting and one-to-one matching and also included numeral recognition and counting-on skills as further challenges. Concern could be raised regarding teacher expectations and the provision of opportunities to challenge all children mathematically, and cater for diverse children's learning needs. However, it is unknown whether or not the children interviewed were a true cross section of the kindergarten population: If the children sampled were more able, then the suitability of the games selected by the teachers for the rest of the children would be more appropriate.

In the questionnaire teachers were asked to rate how they felt the children enjoyed the games. Table 4.5 summarises the teacher ratings where 5 = teacher strongly agreed that the children enjoyed the game and 1 = strongly disagreed.

Table 4.5: Teacher ratings of children's enjoyment of games.

	Stepping Stones	Humpty Dumpty	Ordering Sets	Beehive	Cats	Memory	Cater-pillar	Clowns	Track
	Introduced in first fortnight			Introduced in second fortnight			Introduced in third fortnight		
Nancy	4	5	4	5	5	4	4	5	4
Liz	5	5	3	4	5	3	5	4	3
Anne	5	5	3	4	5	3	4	4	4
Total	14	15	10	13	15	10	13	13	11

5 = most enjoyed by children, 1 = least enjoyed by children

Games teachers rated as most enjoyable for children were Stepping Stones, Humpty Dumpty, Beehive, Cats, Caterpillar and Clowns. The teachers' ratings matched the children's game usage where Humpty, Stones, Cats, and Clowns were the most frequently used.

Games of Limited Appeal

The children (see Table 4.1) used Order, Beehive, Memory and Track less frequently overall. The teachers confirmed this lack of appeal. Liz found Memory less attractive as it did not have "*interactive appeal ... I think the games children enjoyed playing were the games they played with others.*" The games that did not rate highly for Nancy were those "*on small cards. The children wanted to gather the cards up into a clump. It was as if they were playing cards and they had to collect them all up. They were collecting them without really looking what was on the face of them.*" Memory, rated as less enjoyable by the teachers, was introduced in the second fortnight and was not as mathematically challenging as some of the later games. However the large number of cards in the game probably made it more complex to complete, demanding higher levels of concentration from the children.

Beehive was used infrequently by the children. However it was a game that the teachers rated as being enjoyed by the children and one which had the right level of mathematics. It did not have the teacher expected appeal for the children. The mathematics skill required was not high although it did demand the recognition of numerals - which the child interviews showed as one area of less confidence (see Table 5.2). It could be hypothesised that 'games of appeal' were within the area of domain knowledge of most of the children and so demanded less mathematically.

Ordering - which rated as a low-usage game - used small cards and involved little interaction between players. Teachers rated the mathematics at a suitable level for children of this age. Ordering was also rated as less enjoyable by the teachers. Once again, the game was more complex to play and did not encourage social interaction.

Track was introduced in the last fortnight and did not have an observed high usage. Liz commented that *"it is less visually appealing and I don't think it's immediately obvious to the children what they need to do"*. She questioned whether or not *"children would pick up something they don't know how to do and risk that"*? The fact that it *"had less pieces to get involved"* also led Liz to believe that the game would be less appealing to children. The type of dice was also questioned, *"it's got a dice with numbers on and you don't often see dice with numbers on."* Certainly the games introduced in the first and second fortnights all had dice with dot patterns. This game demanded numeral recognition skills which children appeared to avoid in their selection of games. Teachers rated Track as the least suitable mathematically and was one of the games children used the least.

4.4. SUMMARY

Humpty, Stones, Cats and Clowns had high appeal for the children as determined by the high user rate in the scheduled observations. These games were visually appealing and were easy to pick up and play. The level of mathematics demanded by these games could be varied and children appeared to utilise their current domain knowledge.

Teachers rated the games using variables of: children's enjoyment, suitability of mathematics and ease of use. Ratings indicated that Stones, Humpty, Beehive, Cats and Clowns were most preferred. Qualities such as familiarity, attractiveness, adaptability of rules, use of large motor skills, catering for range of number ability, mathematically challenging, and ease of use were all mentioned by the teachers in their discussions of more appealing games.

Games provided for a range of abilities and teachers appeared to rate all games as suitable in terms of mathematics content. Games children preferred provided for a range of number knowledge and skills. Children preferred games that were interactive by nature and yet could still be played independently, but alongside other children. Those games which appealed to children and teachers were straightforward to play, and it was almost implicit when viewing the game how it should be played. Games with a wealth of fiddly pieces, such as Memory or Order, did not attract children and this was probably due to a more complicated playing approach. Games with more involved rules, such as Track, did not appeal. This factor may be overcome if more assistance by a teacher were available during the early phase of the game play. The teachers also saw attractiveness, colour, and familiarity of 'theme' as positive features for number games.

CHAPTER FIVE: CHILDREN'S NUMBER DEVELOPMENT

5.1. INTRODUCTION

Initial and final interviews were used to determine whether or not children's number knowledge and skills had improved during the period games were used in the kindergarten. Data gathered provided information on which specific number skills had improved during the research period. While it was expected that number skills were likely to improve with maturation and everyday experiences it was hypothesised that children who were low game users would show less improvement than their high game using peers.

The ten children interviewed demonstrated, as expected, a wide range of number knowledge. Results from the initial interview were consistent with those obtained by other researchers (see Aubrey, 1993, 1997; Suggate, Aubrey & Pettitt, 1997; Young-Loveridge, 1987, 1988) who found that young children had an extensive range of number skills such as competencies in rote counting, enumeration, subitizing, writing numerals and in addition and subtraction skills. Results also reflect trends consistent with these research studies in the variability of number skills among the children, for example, some children excelled in rote counting and had little numeral recognition ability, whereas other children were limited in their ability to rote count yet could complete simple addition and subtraction problems.

After the study period children were re-interviewed on their number skills in order to determine overall gains in number knowledge during the study. Table 5.1 overviews each child's performance during the research period with improvements in each child's knowledge indicated by an arrow.

Table 5.1: Areas of improvement for ten sample children.

	Rote Count						Meaningful Count		Order Variance		Cardinality		Identify Numerals			Recognise Numerals		
	1-5	6-10	11-15	16-20	21+	31+	N	Y	N	Y	N	Y	1-3	4-6	7-10	1-3	4-6	7-10
Susan			→	→	29	40		.		.		.			Y			Y
Helen			→	→	30	49		.		.		.			Y			Y
Kim			←	←	28	39		.		.		.			Y			Y
Sally			→	→	30	39		.	→	→ .	→	→ .		.	.		.	.
Joe			→	→ 16	24			.	N ←	←	→	→ .	.			.		
David		→	→ 11 14					.	→	→		.	.	.		Y		
Jim		10 →	→ 13					.	→	→ .	→	→		.	.		.	.
Alice	→	→ 9	11					.	→	→ .	N →	→	N	.		N	.	
Jacob	→	8 →	→	18			→	→	→	→	→	→ .	.	.		.	.	
Harry	5 →	→	12					.		.	→	→ .		Y		.	.	

Table 5.1 contd: Areas of improvement for ten sample children

	Written Numeral						Number After			Before	Subitizing			Addition		Subtraction	
	Scribbles	Picto-grahic	Idio-syncratic	Num 1-3	Num 1-5	Num 1-10	1-3	1-5	1-10		1-3	1-5	1-10	Concrete	Imaginary	Concrete	Imaginary
Susan						Y			Y	N→Y			Y	Y	N→Y	N→Y	→Y
Helen					.	→ .	.		. →	N	.	. →		Y	N→Y	Y	N
Kim						Y	.		. →	N→Y		Y		N Y→	N	N→Y	N
Sally						Y	.		. →	N	.	. →		Y	N	N→Y	N
Joe		Y →		.			N			N	Y			N Y→	N	Y	N
David		Y					N			N	N			Y	N	Y	N
Jim	Y						.		. →	N	.	. →		N Y→	N	Y	N
Alice	Y	→					N			N	N			N Y→	N	N→Y	N
Jacob		Y					N			N	N →	.		Y	Y	N→Y	N
Harry		Y						Y		N	Y			Y	N	Y	N

A numerical score was calculated for each child dependent on the level of performance in the initial and final interview. The scoring system mirrored closely those used by Aubrey (1993), Wright (1994) and Young-Loveridge (1989a). These scores provided a grading on which the children were categorised into high, moderate and low improvers. (Details of the scoring can be found in Appendix J.) Analysis of scores for each focus question also provided information about the particular number skills in which children had made the greatest improvements. Table 5.2 shows each child's numerical scores for performance and the number skill areas in which the greatest improvements were made.

Areas in which children appear to have made the greatest improvement were rote counting, recognition of numerals, recalling the number after a given number, and addition and subtraction using direct modelling with numbers less than seven. It should be noted that some number skills showed a low improvement score because children had already mastered this skill (e.g., meaningful counting) whereas other skill areas (e.g., subtraction without materials) had a low score as few children had shown any improvement. Children scoring highly in the initial interview had less room for improvement. Helen and Susan, in particular, scored highly and displayed very sound early number skills at the time of the initial interview - thus in order to improve their number knowledge, games with more mathematically challenging experiences would most likely have been required. The games introduced in the third fortnight would have provided for the stage of number knowledge of these confident children. The games from the first two fortnights provided a low scoring child with a wealth of activities tailored to early stages of number development - thus it was possible that these children had a greater scope for improvement.

Table 5.2 Numerical scores for individual children

	Rote Counting			Meaningful Counting			Cardinality Principle			Order Variance			Recognition of Numerals			Identification of Numerals			Writing Numerals		
	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement
Alice	2	3	1	2	2	0	0	0	0	0	0	0	0	2	2	0	2	2	1	4	3
Jacob	2	4	2	2	2	0	0	2	2	2	2	0	1	2	1	1	2	1	2	2	0
Sally	5	6	1	2	2	0	2	2	0	2	2	0	2	3	1	2	3	1	4	4	0
Kim	6	5	#	2	2	0	2	2	0	2	2	0	3	3	0	3	3	0	4	4	0
Jim	2	3	1	2	2	0	2	2	0	2	2	0	2	3	1	2	3	1	2	2	0
Joe	3	4	1	2	2	0	2	2	0	0	0	0	1	2	1	2	1	#	2	4	2
Helen	5	6	1	2	2	0	2	2	0	2	2	0	3	3	0	3	3	0	4	4	0
Susan	5	6	1	2	2	0	2	2	0	2	2	0	3	3	0	3	3	0	4	4	0
David	3	3	0	2	2	0	2	2	0	0	2	2	1	1	0	1	2	1	2	2	0
Harry	1	3	2	2	2	0	2	2	0	2	2	0	1	2	1	2	2	0	2	2	0
Improvement by Skills			9			0			2			2			7			5			5

	Ordering after			Ordering before			Subitizing			Add -Concrete			Subtract – Concrete			Add – Imaginary			Subtract Imaginary					Improvement by Individuals
	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement	Pre	Post	Improvement	Pre Sc	Post Sc	
Alice	0	0	0	0	0	0	0	0	0	0	3	3	0	3	3	0	0	0	0	0	0	5	19	14
Jacob	0	0	0	0	0	0	0	2	2	3	3	0	0	3	3	2	2	0	0	0	0	15	26	11
Sally	0	2	2	0	0	0	1	2	1	2	3	1	0	3	3	0	0	0	0	0	0	22	32	10
Kim	0	2	2	0	2	2	2	2	0	0	3	3	0	3	3	0	0	0	0	0	0	24	33	9
Jim	0	2	2	0	0	0	1	2	1	0	3	3	3	3	0	0	0	0	0	0	0	18	27	9
Joe	0	0	0	0	0	0	1	1	0	0	3	3	3	3	0	0	1	1	0	1	1	16	24	8
Helen	0	2	2	0	0	0	1	2	1	3	3	0	3	3	0	0	3	3	0	0	0	28	35	7
Susan	2	2	0	0	1	1	3	3	0	3	3	0	0	3	3	0	1	1	0	1	1	29	36	7
David	0	0	0	0	0	0	1	1	0	3	3	0	3	3	0	0	0	0	0	0	0	18	21	3
Harry	1	1	0	0	0	0	1	1	0	3	3	0	3	0	-3	0	0	0	0	0	0	20	20	0
Improvement by Skills			8			3			5			13			12			5			2	195	273	78

5.2. NUMBER SKILL DEVELOPMENT

The initial interviews provided some base line data on the children's number knowledge. The final interview provided information on individual children's number knowledge development. The discussion that follows focuses on specific number skill development and the progress made by the ten children sampled.

Rote Counting

Children were asked to rote count until they could go no further. Four of the ten children could initially count to 29 or beyond. These children were Susan (29), Helen (30), Sally (30), and Kim (39). These four children appeared throughout the initial interview as more capable. For convenience of reporting they are named the *confident group.*

David (11) and Joe (16) were initially counting confidently to ten but had not mastered the difficult teens and crossing the decade to the twenties. These two children were named in the *developing group.*

Four of the children could initially count up to ten or less. These were Harry (5), Jacob (8), Alice (9) and Jim (10). These children were in the *emergent group.*

All but one child (Kim) improved in their ability to rote count. Children making significant improvement were Joe (low game user) who progressed from 16 to 24 and Jacob (moderate game user) who progressed from 8 to18. Jacob's improvement being most significant as his counting moved through the difficult early teens. The confident group, apart from Kim, all improved their counting through one decade and met difficulties moving into the next decade: Sally stopped at 39 and Helen at 49, both children appear not quite sure how to continue in the next decade of numbers.

Harry (from 5 to 12), Alice (from 9 to 11) and Jim (from 10 to 13) were all attempting to move within the difficult teens and through to the next decade. The number names within the teens (e.g., eleven, twelve, thirteen) do not assist children in recalling number names, unlike the twenties where repetition is experienced (e.g., twenty-one, twenty-two, twenty-three).

Meaningful Counting

All the children interviewed were able to count a set of three and a set of six. They could all extract a set of two, five and seven accurately. It appeared initially that all children could count small sets meaningfully.

Cardinality Principle

All children in the confident and developing groups could initially provide the cardinal number for a group of objects when asked, "How many counters do you have in your group?" From the emergent group, Jacob and Alice both initially responded by recounting the group, "1, 2, 3, 4, 5, 6." They did not understand that the last number in the count was the number of items in the group. Jacob developed this understanding of cardinality during the research period, however Alice did not.

Numeral Recognition

The four children from the confident group of rote counters, Susan, Helen, Sally and Kim were all confident in recognising[7] numerals i.e. "tell me what this number is?" and identifying[8] numerals i.e., "point to numeral four". Initially Jim and the confident group were accurate with numerals up to six, with Helen and Kim recognising and identifying numerals up to ten. The developing and emergent groups were confident with small numbers only in the initial interview. An improvement was observed in the final interview where these children were recognising and identifying numerals up to four and possibly six. Jim, although from the emergent group could identify and recognise numerals to ten in the final interview. Focus on the fine difference between

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[7] *Recognise* indicates that child could name the numeral when shown it on a label card e.g., What number is this?

[8] *Identify* indicates the child was able to point to a numeral presented in an unordered row of numeral label cards e.g., "Point to number three".

'identifying' and 'recognising' numerals did not provide any significant results. Small variations appeared between numerals children could identify and those they could recognise. Overall, there was an improvement in children's ability to both recognise and identify numerals.

Writing Numerals

In the initial interview the four confident children accurately recorded using number symbols to represent group sizes to seven. Sally, Kim and Susan were confident using symbols up to number nine. At the time of the final interview these children could all accurately record numerals to ten.

David, Joe, Jacob, and Harry initially used a pictographic representation of the number, using a picture to represent each item in the group. David used humps, Joe used squiggles, Jacob used circles and Harry used a variety of different shapes including logs, corners and circles to represent the correct number of items in the group. In the final interview David, Jacob and Harry continued with pictographic representations, however Joe used formal symbols for small numbers.

Alice and Jim limited their recording to using scribbles and circles respectively in the initial interview. They were accurate with the correct number for groups of size one and three only. At the end of the study Alice had made significant improvement in her ability to record, moving from the pictographic stage to writing numerals for groups of up to three items. Joe remained at the same stage. Improvements in numeral writing could not be interpreted as significant across the group of ten children.

Ordering of Numbers

Most of the children had difficulty with this task. Initially, only Susan could identify the 'number after the one given' and none of the children could identify the 'number before the one given' in the rote counting sequence. Children may have had difficulty initially in understanding this question and used 'counting from one' rather than an instant response to answer the question. In the final interview children responded more positively and had more success in completing the task. All the competent group and Jim (emergent group) could name the 'number after' any number up to ten, and Susan and Kim (confident group) were able to name the 'number before'. The rest of the children were unable to complete this question. Overall, children in the study made significant improvement in naming the number after one given.

Subitizing

Some of the children had difficulty with this skill; perhaps because to identify quickly the number of items in the set was a seldom-required task. When asked the question "how many.....?" children were expecting to count the dots on the flash card. The children's initial ability to subitize varied in the confident group. Helen and Sally, although initially less able, were confident in subitizing groups of up to five at the final interview. Jim and Jacob (from the emergent group) both made a noticeable improvement in their ability to subitize. The rest of the children reverted to counting after the set size increased beyond two. It was expected that this would be an area of great improvement as the majority of the games using dice utilised this subitizing skill.

Addition and Subtraction

Harry, Helen, David, Joe and Jacob were proficient in addition and subtraction with materials, using numbers less than six. Of this group, only Helen was from the group of confident rote counters. Harry, Jacob, David and Joe initially appeared less confident with number knowledge, however these four children had stronger computational ability. Jacob accurately completed addition problems, without the use of materials, using numbers less than six in the initial and final interviews. All children in the study could add and subtract using direct modelling with materials and small numbers at the time of the final interview. Jacob, Helen and Susan were confident with adding smaller numbers without reliance on direct modelling at the final interview, and Susan also successfully completed some subtraction questions without equipment. Overall, the children's ability to complete simple number operations showed marked improvement (Table 5.2).

5.3. IMPROVEMENT COMPARED WITH GAME USAGE

Table 5.3 ranks the children using overall improvement scores. Improvement scores ranged from 14 to 0. Table 5.3 shows that the children (Alice, Jacob and Sally) who made greatest improvement varied in their range initial interview scores. High improvers displayed a range of number knowledge competence. Similarly, low improvers were spread amongst the group from emergent to confident children.

Table 5.3: Children ranked by level of improvement

Child	Ability Group	Initial Interview	Final Interview	Improvement Score	Imp. Group.
Alice	emergent	5	19	14	High
Jacob	emergent	15	26	11	
Sally	confident	22	32	10	
Kim	confident	24	33	9	Moderate
Jim	emergent	18	27	9	
Joe	developing	16	24	8	
Susan	confident	29	36	7	
Helen	confident	28	35	7	
David	developing	18	21	3	Low
Harry	emergent	20	20	0	

Due to the relatively short research period it was impossible to determine whether or not this trend will continue. Aubrey (1997) and Young-Loveridge (1987) found that as the children move into formal education, lower achieving children's improvement rate lessens when compared with the improvement rate of higher achieving peers. A longer-term study would be needed to assess this issue.

Figure 5.1 shows a positive correlation when comparing initial and final interview scores. This was an expected trend - that the higher the initial score, the higher the final score.

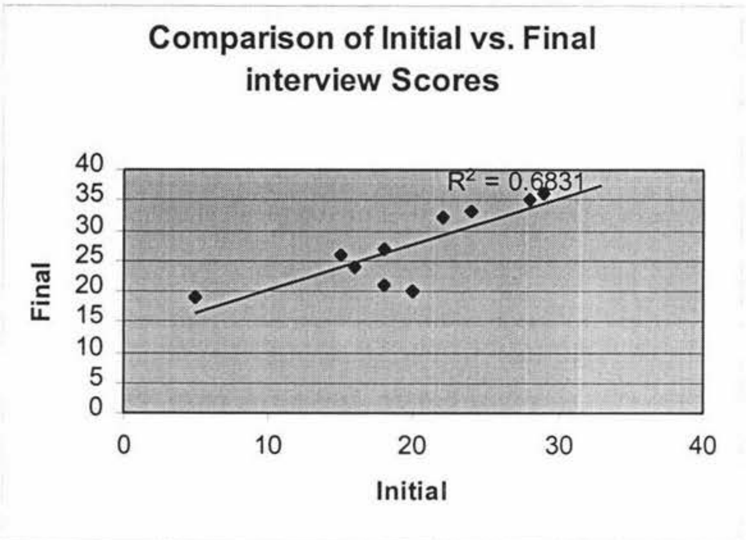

Figure 5.1: Initial score compared to final score

When comparing the initial score with the amount of improvement, Figure 5.2 shows that improvement scores were higher for lower-achieving children. Generally, children can be expected to improve regardless of their initial score. Caution must be exercised in generalising these trends due to the small sample size.

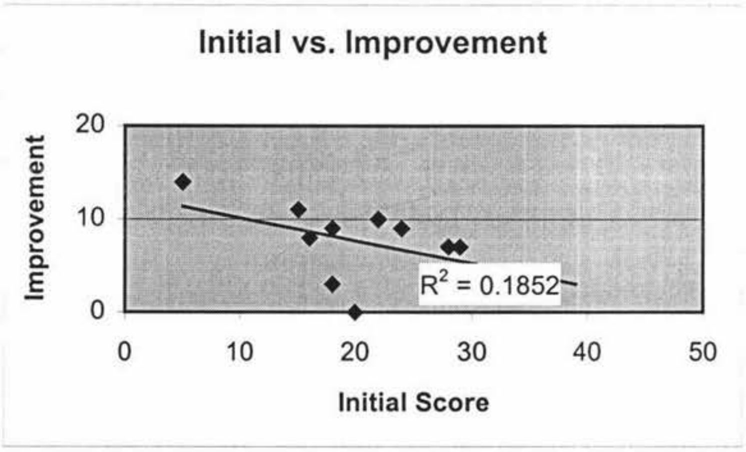

Figure 5.2: Initial score compared with improvement

Table 5.4 ranks the children by rate of game usage and from initial data it appears that the games usage did not influence improvement scores. For example, high game users, Jim and Kim, were not the highest improving children. Alice, who showed the most improvement, was a low game user (Table 5.4).

Table 5.4: Children ranked by amount of game usage

Child	% Game User[9]	Initial Int	Final Int	Improvement
Jim	18.70%	18	27	9
Kim	13%	24	33	9
Susan	9%	29	36	7
Jacob	9%	15	26	11
Harry	8%	20	20	0
David	3%	18	21	3
Joe	2%	16	24	8
Alice	2%	5	19	14
Helen	1%	28	35	7
Sally	0%	22	32	10

Figure 5.3 shows that there is no correlation between the amount of game usage and the rate of improvement. It appears that using the number games overall had little effect on the improvement scores of the sample group.

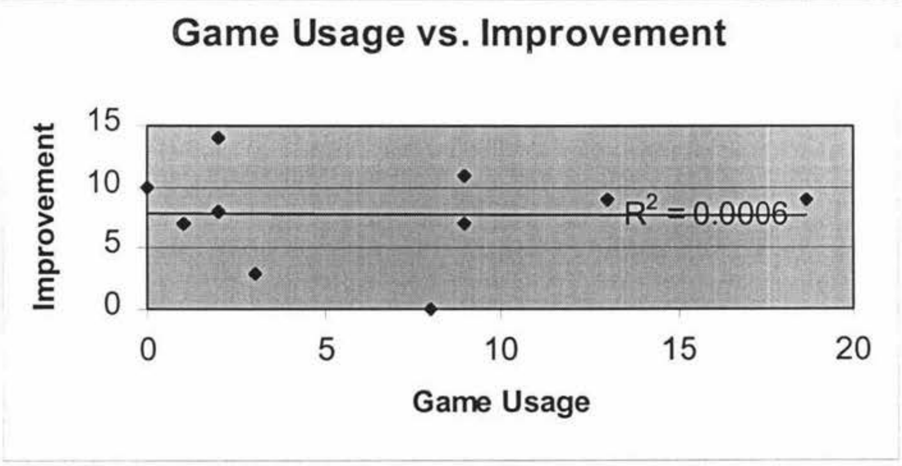

Figure 5.3: Game usage compared with improvement.

[9] Game User % is calculated using the number of times the child was observed playing the games compared with the total times the games were observed being played by all children (91 times).

There was also very limited correlation between the initial score and the amount of game usage, as seen in Figure 5.4. It was initially hypothesised that more capable children would be higher game users - however, it appeared that for the small sample used the child's ability in number had little influence on how much they used the games. This fact was a positive finding in that all children were prepared to use the games, and weak domain knowledge did not deter the children from game involvement.

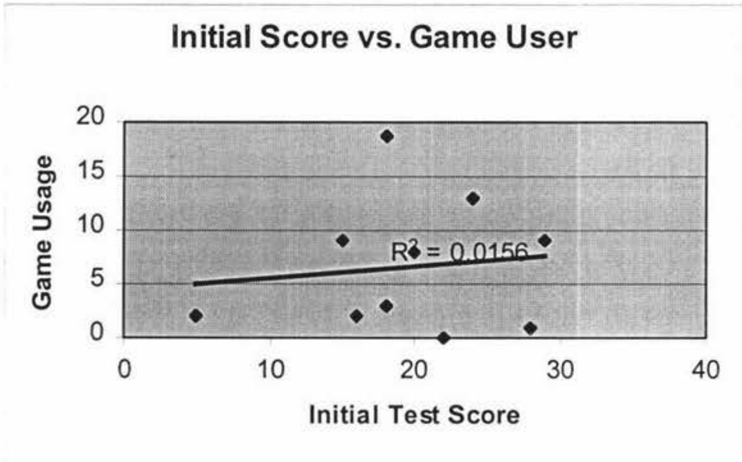

Figure 5.4: Initial test score compared with rate of game usage.

Correlation graphs provided information on general trends in game usage and improvement of the ten children interviewed overall. However, by looking more closely at individual profiles of children's number skills improvement and reviewing the popular games, more information about specific skill improvements became evident.

Number skills in which children appeared to have made the greatest improvement were in rote counting, recognition of numerals, recalling the number after a given number and addition and subtraction using concrete materials with numbers less than seven. Highly used games such as Humpty, Stones, Cats and Clowns provided practice in rote counting, one-to-one matching, subitizing, numeral recognition and identification, and simple addition. There are consistencies between the children's improved number skills and the skills provided by the more popular games.

5.4. INDIVIDUAL PROFILES

Profiles of individual children, their skill development and game usage provide a clearer picture of the relationship between number skill improvement and specific games. Seven of these profiles are detailed below as each provides a unique description of the improvement and game usage of individual children. Table 5.5 provides an overview of the seven children profiled.

Table 5.5: Summary profile of seven children

Child	Initial Score	Game Usage	Initial Interview	Improvement
Jim	18	High	emergent	Moderate
Kim	24	High	confident	Moderate
Jacob	15	Moderate	emergent	High
Harry	20	Moderate	emergent	Low
Alice	5	Low	emergent	High
Helen	28	Low	confident	Moderate
David	18	Low	developing	Low

Jim (High Game User, Moderate Improvement)

Jim was four years nine months at the time of the initial interview. He could rote count very slowly and steadily to ten, enumerate a set of four and six and provide the cardinal number for both sets. He could recognise and identify the numerals from one to five, seven and eight. Jim made little scribbles to represent the number of objects in a group but was accurate only with one and three. He could subitize sets of one and two, but he was unable to add or subtract. Jim was in the emergent group.

In the final interview, Jim could rote count to 13, moving tentatively through the decade and into the teens. He could now recognise numerals from one to nine and identify numerals from one to ten. Jim could subitize sets of one to six and was beginning to use symbols when recording the items in a set. He could now recall the number just after the one given for numbers less than ten. When adding, using materials, Jim was accurate with numbers less than seven. He had improved his score by nine to 27.

Jim was the highest game user (18.7%). He played Humpty (with researcher x3), Stepping-Stones (x5), Other, Beehive (with researcher x2), Cats (with researcher x2, on own x1), Memory, and Track (with teacher x1 and on own x1). The games he played tended to be the games introduced earlier in the study and focused on counting, subitizing, numeral recognition, and one-to-one matching. Jim's improvement in the area of numeral recognition, numbers before and after, subitizing and addition matched very closely to the skills in the games he played and thus it is feasible that playing games might have contributed to his number knowledge development. While Jim seemed hesitant to join the other children in play, he appeared to enjoy playing Stepping-Stones with other children. Jim tended to play the games with which he was confident or when there was an adult present to support him. Eight of the seventeen times he played with the number games there was an adult present. The frequent presence of an adult scaffolding Jim's game playing may also have had a positive effect on his improvement.

Kim (High Game User, Moderate Improvement)

Kim was four years five months at the time of the initial interview. She could rote count to 39 and was confident in accurately counting and giving the cardinal number of various size sets less than ten. She could recognise and identify numerals from one to ten and write all numerals to represent sets between one to ten items. Kim could subitize sets of size one to five. Her score in the initial interview was 24.

By the time of the final interview Kim could name the numbers just before and just after any number between one to ten. Her ability to subitize now included sets from one to ten. A greater improvement in subitizing was expected because, as a frequent game user, Kim was exposed to a large number of games using dice pattern and set recognition. Kim was also able to accurately complete addition and subtraction involving numbers less than seven using materials. Her score improved by nine points to 33.

As noted above, Kim was a high game user (13%). She played with Humpty (with researcher, and also with other children), Order (with teacher), Stepping Stones, Other (x4), Cats (with teacher), Clowns (with researcher) and Caterpillar (x2). These games provided number experiences in one-to-one matching, counting, numeral recognition, subitizing, ordering numbers, addition and subtraction. Her greatest number skill improvements were in recalling the number just before and just after the one given and in addition and subtraction using concrete materials. There is some commonality between Kim's number skill development and the games she used. As a high user, Kim was more frequently exposed to exploring numbers within the games and this may have positively affected her knowledge levels. Kim was observed playing games 12 times over the six-week research period, playing with an adult on four of these occasions. Kim reported that her favourite game was Cats because "*she had played it lots in whanau group time*".

Jacob (moderate game user, high improvement)

Jacob was aged four years and five months at the time of the initial interview. He could rote count to eight, could count a set of both four and six but did not understand the cardinality principle. He could recognise the symbol for one and could identify the numerals one, three and four. Jacob would draw circles to accurately record the number of items in a set he had no ability to subitize. His ability to complete operations with numbers was unexpected. He was able to add numbers less than seven together using direct modelling - although he did not answer using the cardinal number for the set. For example, when questioned in the interview;

Interview Question 8a

Researcher: *This Teddy has three counters and this Teddy has two counters. How many have they got altogether?*

Jacob: *This one has three and this one has two*

Researcher: *Put them together, how many are there together?*

Jacob: *one, two, three, four, five*

Researcher: *How many are there altogether?*

Jacob: *one, two, three, four, five*

Interview Question 8b

Researcher: *This Teddy has five counters and this Teddy has two counters, how many have they got altogether?*

Jacob: *One's got two and one's got one, two, three, four, five*

Researcher: *how many altogether?*

Jacob: *one, two, three, four, five, six, seven*

Researcher: *how many altogether?*

Jacob: *one, two, three, four, five, six, seven*

In the initial interview Jacob could also add imaginary objects without providing the cardinal number of the resulting set.

Interview Question 9a

Researcher: *now I want you to pretend this Teddy's got one counter and this Teddy's got two counters, how many altogether?*

Jacob: *one, two, three*

Researcher: *How many does he have?*

Jacob: *one, two, three*

Researcher: *now this Teddy's got three counters and this Teddy's got two counters, how many altogether?*

Jacob: *one, two, three, four, five*

Researcher: *How many does he have?*

Jacob: *one, two, three, four, five*

In the final interview Jacob scored 26 points which was an improvement of 11 points, one of the largest improvements. He was now capable of rote counting to 18, providing the cardinal number of the set, recognising numerals one to six and identifying numerals one to four, six and ten. He continued to draw circles to represent a number of items in a set and had no idea of before and after numbers. Jacob could subitize sets from one to five in standard patterns, add and subtract with materials and provide the cardinal number of the resulting set. He made some outstanding improvements when compared with his peers. His ability to rote count from eight initially, to 18 in the final interview, moving through the tricky teens, is noteworthy. Jacob made improvements in his ability to subitize, providing the cardinal number for a set, and early number operations.

Jacob was the only child in the group who moved groups from initially being emergent to the developing group. He was a moderate game user (9%), and played Ordering cards, Stepping Stones (x2), Cats, Clowns (2x with mother, 1x with other children) and Number Track. Often Jacob played games when an adult was present (four of eight times) and on two occasions this person was his mother. Although only a moderate game user, the frequent presence of an adult scaffolding Jacob's game playing may also have had a positive effect on his improvement. The games he played focused on a range of skills - mainly one-to-one matching, subitizing, numeral recognition, addition and subtraction. These skills reflected closely the improvements Jacob made in his number development. He said he liked to play all the games and in the final interview was quite confident in explaining how to play a selection of the games.

Harry (Moderate Game User, Nil Improvement)

Harry was aged four years and five months at the time of the initial interview. He could rote count to five, could count a set of three and five and provide the cardinal number for the set. Harry could recognise the numerals one, two, four, and five and could identify numerals one to five. He could recall the number just after one, two, three and four (when given in random order), however he could not tell the number just before. Harry used a variety of different pictures to represent a set of objects including logs, lines, circles and corners. He could instantly recognise a set of one and two, and could add and subtract using materials and numbers less than six. He had an initial interview score of 20.

In the final interview also Harry had a score of 20. He had improved his rote counting, now achieving 12, and improved with numeral recognition to numbers one to five. He became quite restless and had difficulty concentrating in the interview, hence some of the final questions were not completed. It could have been assumed from the initial interview that he would be successful at this task, however this cannot be accurately predicted - as evidenced by the fact that his score remained the same over both interviews.

Harry was a moderate game user (8%)[10]. Games he played were Stepping-Stones (as he passed by), Other, Cats (with teacher), Clowns (with researcher x2), Caterpillar (with researcher) and Track (with teacher). On five of the seven times Harry played with the number games an adult was present. The frequent presence of an adult scaffolding Harry's game playing may also have had a positive effect on his improvement. Therefore there is some doubt that Harry accurately fits the moderate user and the low improvement categories. The games Harry played focussed on one to one matching, subitizing, numeral recognition, counting, and simple number operations. Rote counting and numeral recognition were two areas in which Harry improved and were skills developed in the games he played. If the interview had been completed he may have shown improvement in other areas also.

Alice (Low game user, High improvement)

Alice was aged four years and three months at the time of the initial interview. At the initial interview Alice was particularly shy and rather reserved in her responses. However, she was keen to participate so the interview proceeded. Alice could rote count to nine and was able to enumerate sets of four and five. She could not give the cardinal number for the set. Alice could not recognise any numerals but she could identify numeral one. She used circles to record numbers. Her ability to subitize was limited to one item and when she was provided with a simple number story she had no concept of addition or subtraction. Alice scored five in the initial interview, which was the lowest score of all participant children. Consideration must be given to the fact that Alice was very reserved during the initial interview.

Alice's interview scores showed the most improvement during the research period and this could be attributed to the fact that the in second interview she was more relaxed. At the final interview she could rote count to eleven. Her most outstanding improvements were in her ability to identify and recognise numbers from one to five and to write numerals for one, three and five. She was also able to complete simple addition and subtraction using number stories with numbers less than seven. While her score had improved to 19, representing the greatest improvement of all children

[10] Due to Harry's high level of absence during the research period his actual game user rate was higher than the assigned score as percentages for game usage were calculated assuming that children were present for all sessions.

interviewed, she was still in the emergent group. The games Alice played with were Humpty and Order - both games providing practice in one-to-one matching and counting. Based on Alice's low observed user status (2%), it is unlikely that these games had much influence on her number development. However, as with all children, she may have used the games during an unobserved time when teachers were busy or during pre-mat time with her parent.

Helen (Low Game User, Moderate Improvement)

Helen was four years and five months at the time of the initial interview. At this time she could rote count to 30, could count sets of four and six and tell the cardinal number of the sets. She was accurate in both recognising and identifying numerals between one and ten. Helen could accurately record numerals for sets from one to nine items. She could subitize sets of one to four and six. She was able to add and subtract numbers less than seven using direct modelling. Helen scored 28 for her initial interview, which placed her in the confident group.

In the initial interview Helen scored particularly highly and there was limited scope in the interview for her to improve apart from numbers before and after, and simple number operations without the use of materials. In her final interview Helen could rote count to 49 and she could tell the number just after the numbers from one to nine. She was also able to add without the use of materials. Her score was 35 for the final interview, an improvement of seven.

Helen was a low game user at 1%. It is unlikely that her improvement could be attributed to the game playing. She played the Cats game once with her friend Kim and a teacher. At the end of her second interview Helen said she liked the Clown game because "*it was easy to play.*" Helen may have experienced this game during whanau group time or at some stage when observations were not being made. She is very confident in number knowledge and perhaps her low game usage indicated this self-confidence and that she did not find the games challenging or catering for her needs. Helen may also have plenty of support in this area at home and so used her time at the kindergarten for other purposes. Her friend Kim was a high game user, but this factor did not appear to encourage Helen to use the games more frequently. Throughout the observations of individual children it was apparent that they tended to move amongst each other quite freely and tended not to have firm play friends.

David (Low Game User, Low improvement)

David was four years and three months old at the time of the initial interview. He could rote count accurately to 11 and continued through to 19, getting muddled with 12, 15 and 17. He could count a set of four and six, and provide the cardinal number of the set. David could recognise the numeral two and identify one, two, four, and five. He used 'humps' to accurately record the number of items in a set. He could instantly recognise a set of one item, and he was able to add and subtract using materials with numbers less than seven. His score for the initial interview was 18.

In the final interview David scored 21 - which was considered a low improvement. He could rote count to 14 and improved in his ability to identify and recognise numerals. When asked to identify a numeral he appeared to be visualising all the numerals in order before he could point to the required numeral. He could now identify numerals one to five, although somewhat slowly.

David was a low game user (3%). He used Humpty and Cats (with teacher). These games focussed on one-to-one matching, counting, subitizing and numeral recognition. His improvement in his ability to rote count and his identification of numerals was limited compared to his peers. His observed low user status may be a reason for his low level of improvement. David preferred to be playing outside and was observed at play outside on all three observed occasions.

5.5. GENERAL COMMENTS

Throughout the observations there seemed to be no obvious or observable reasons why children played at particular activities. Games were placed in a very visible and easily accessed central position. Although teachers placed particular games out 'ready to be used' children tended not to play with them unless another child or an adult was present and drew them to the game. This socialising aspect of the games cannot be overlooked. Children tended to be attracted by adults using the games. This created a dilemma for the researcher as she wanted to see the games being used - but was concerned about influencing the results. The researcher did not set out deliberately to attract children to the games. If however, a child initiated the play, then the researcher would participate. Games were designed to be suitable for individuals to play so there was no actual need for two or more players to be present. Although children appeared to prefer company when playing a game, often they did not directly interact. Frequently teachers would draw children's attention to the games, especially if there was a child or two looking for something to do. It was apparent from children's comments and game familiarity that they had played the games more often than the times they were observed playing. Observations were made on 103 of the 210 available slots, allowing for half as much time again unaccounted for.

Pre-mat time observations would also have provided extra informative data. Pre-mat time may have provided the ideal time for parents, as effective scaffolders, to use the number games. The games also provided for a finite length of playing time that may have suited parents and guardians. While the contribution of parents to the children's number skill development was not researched in this study, their contribution to children's mathematics skills is widely recognised in other studies (e.g., Anning & Edwards, 1999: Aubrey, 1997; Sharpe, 1998; Young-Loveridge, 1988).

Evidence from the research sample suggests that the use of games did not directly affect the overall development of children's number knowledge. However, some children made significant improvement in their number knowledge during the six weeks of the study. This may be related in some cases to high use of the games, but in other cases it may not.

The presence of an adult in over half the game playing sessions for three of the four emergent children is noteworthy. Less confident children were seeking the assistance of an adult to scaffold their learning. This high rate of adult presence was not evident in any other ability group.

A number of other factors could also have contributed to the children's knowledge development and these could not be documented in a study of this size. These factors include: increased teacher awareness, parental awareness through newsletter and visibility of games, researcher present in the centre, and games being played during non observed times (e.g., before mat time and on days not documented). The provision of number games as pre-mat time activities to utilise and develop parental involvement could be a valuable area for further investigation.

CHAPTER 6: RAISING TEACHER AWARENESS

Initial teacher interviews undertaken prior to the professional development programme provided background information on teachers' views about mathematics.

6.1. TEACHER BELIEFS

Teachers' feelings towards mathematics varied greatly - from Nancy who was *"never very successful"* to Anne who "*never had any problem with mathematics.*" Teachers differentiated between school mathematics that *"I can't handle"* and everyday mathematics *"I need and use everyday, no problem."* Although teachers had varying success in mathematics they all believed that mathematics has an important role both in school and after leaving school. Anne explained "*it's incredibly important through school....you're only going to use as part of your job then you get to know it.*" Mathematics was viewed as crucial by Liz, who believed "*it is essential to our well being to be able to handle mathematics.*"

All teachers reported they had received very little recent professional development in the area of mathematics. Past experiences of professional development varied between teachers, Anne recalled that "*probably specifically on maths it has been quite a while.*" Nancy had not received any professional development in mathematics for seven or eight years and certainly nothing since *Te Whaariki* had been introduced. Liz had attended an associate teachers' meeting in 2000 that she found extremely valuable "*especially the written form feed-back resulting from the teachers' brainstorming.*" Liz further explained that professional development outside the focus of the kindergarten was more up to the individual: "*I've chosen to do and it's an area of personal choice. It's an area I'm interested in and so I choose to go.*"

6.2. IMPACT OF TE WHAARIKI

The impact of the introduction of *Te Whaariki* varied across the teachers. Liz indicated the *"huge impact on early childhood education, in particular it's changed the way we do things. ... It (Te Whaariki) requires that we establish our philosophy and our core curriculum collectively."* Liz cautioned that implementation involved *"planning for individual children and you've got to work gradually, work-wise I think we have a phenomenal work load."* The influence of *Te Whaariki* was less for Nancy, who explained that there was *"some difference in just not playing 'guess what the teacher is thinking games' ... more open-ended questions and more open-ended results rather than saying 'that's wrong - it needs to be on the other side'."* Anne had returned to teaching since *Te Whaariki* had been introduced and hence the changes were not as obvious for her; she credited changes as more due to a new environment rather than as a result of a new curriculum.

6.3. TEACHERS' NUMBER CONTENT KNOWLEDGE

In the initial interview teachers believed the language of mathematics to be an important aspect to develop in young children. They focussed their attention on "*the shapes, basic shapes, certainly know all the colours, size such as 'bigger' and 'smaller' and those sorts of concepts ... looking at pattern, talking about colours and design, and shapes ... learn the maths language like positional words, and number words, and colours and shapes and things like that.*" Number, and particularly meaningful counting was mentioned by two teachers: " *We all learn to rote count but to be then able to count meaningfully is essential*" and "*Ideally to count meaningfully to at least 20 confidently... and the number recognition - I've never really done much with the kids but the one-to-one counting.*"

During the first professional development session each teacher was asked to select the five concepts she thought would be most critical in determining later success in mathematics. The list is shown as Figure 6.1.

- Awareness of comparative size (e.g., comparing lengths or heights.)
- Awareness of comparative volume. (Which will hold more water?)
- Classifying events as possible or impossible
- Counting a group of objects
- Fractions (e.g., finding ½ and ¼ of shapes)
- Knowing days of the week, using a calendar
- Money, comparing values of coins
- Position/movement language e.g., over, inside, middle, underneath, backwards, near, next to, rolling, spinning
- Recognising repeating patterns (e.g., **#**#**#*)
- Recognising symmetrical patterns (e.g., ooOO#OOoo)
- Recognising the symbols for the numbers (e.g., read "3" as "three")
- Rote counting
- Shape language e.g., triangle, square, oblong
- Simple addition and subtraction (e.g., I had five lollies but ate two of them how many left?)
- Sorting objects into categories
- Talking about relationships (e.g., "older than" saying "I'm older than you")
- Telling the time to the hour and ½ hour on clocks
- Writing equations (Savell & Davies, 2001)

Figure 6.1: Selection list for key mathematics competencies

The importance of number knowledge was recognised as an important early skill by only one of the teachers prior to the professional development sessions. Research studies completed by Young-Loveridge (1989b) have highlighted the importance of early number confidence in determining later success in mathematics. She found that confidence in other areas of mathematics was not as crucial as early number confidence. The kindergarten teachers' unawareness of the importance of number knowledge has been documented elsewhere and was not unexpected (Davies, 1999; Savell & Davies, 2001). Teachers' selections of areas of key competencies are listed in Table 6.1 and indicate a lack of focus on number skills in early mathematics development.

Table 6.1: Key competencies selected by teachers

Concept	Times selected
Sort objects into categories	3
Position/Movement language	3
Awareness of comparative size	2
Fractions (e.g., finding ½ and ¼ of shape)	2
Recognising repeating patterns	2
Shape language (e.g., triangle, square, oblong)	2
Counting a group of objects	1

Final interviews provided a valuable insight into the change in thinking about the importance of number by the teachers. Two of the teachers commented how affronted they were initially to discover the inaccuracy of their ideas of important mathematics concepts. Liz comments, "*I was quite affronted that I hadn't worked it* (important mathematics skills) *out very well. ... that was quite a startling discovery for me.*" Anne reflected that the earlier activity - selecting important mathematics skills - "*just threw me as it was completely different than what I thought were important.*" In the final interviews teachers displayed a changed opinion on important skills to develop in early childhood. Teachers elaborated about the ways they were keeping number concepts to the forefront of their teaching, with Liz commenting that "*being aware that this can be useful to children later on has meant that I've been able to include them in the programme.*" Nancy comments that "*I concentrate much more on counting things and beyond the usual finger play things that go to about five.*" Liz has "*modified some of the activities I do with children as a result of that* (the selection activity)" and she continued that "*counting on and counting back, and simple calculations are some things which are very easy to include in our programme.*" It was very positive to note that teachers' views of what mathematics skills are important to develop in young children changed considerably over the six-week period. However, comments from the initial and final interview about how these skills could be developed changed very little over the research period.

In the initial interview Liz used *"the teachable moment and opportunities as they presented themselves, it's having the materials and equipment in the core curriculum...the always available curriculum. The other is assessing and knowing what the child is capable of."* Liz's initial focus on embedding the mathematics was quite different from that of Anne, who preferred to use puzzles or songs as a vehicle for number development. Development of number skills for Anne *"comes out in songs, the different games at mat time, the puzzles, the ideal time is when you've got kids sitting there. We can introduce a bit more and talk about a bit more."* Nancy preferred *"using them in everyday context, like morning tea - for instance, talking about the shapes of the fruit. ... Sitting down in the puzzle area and helping them when they get things wrong, helping them talking it through"* was another approach initially suggested by Nancy.

In the final interview the teachers confirmed initial beliefs about methods for developing number concepts. Liz reaffirmed that making the number skills fit into part of the existing programme appeared to be the most acceptable method of exposing the children to more number concepts. Liz reiterated her focus more on the individual needs of the child when it came to number development, commenting that "*still ascertaining what skills children have and growing them, and extending them. So I think initial awareness and assessment by teachers is essential. You have to know where children are at before you can move them on.*" This embedded approach was seen as appropriate by Anne who commented "*being much more aware of talking about things, general talking everyday things you've got like the playdough and bring in ideas of bigger and smaller numbers.*" Nancy commented that she would "*probably use more games. I'll surely do more of that now 'cause I can see more purpose.*"

6.4. INDIVIDUAL NEEDS

Catering for individual needs is a focus of the early childhood curriculum. Assessing individual needs and catering for these assessed needs generated differing views from the three teachers in the initial interviews. Liz strongly supported a focus on individual needs explaining that:

> *"We have an assessment sheet ... things like getting children to cut out shapes and getting them to talk about the shape. That goes in the portfolio. Once we know, we can say, 'okay what child doesn't know any shapes' and we will steer them towards looking at shapes. If we find we have two or three or four children who are at the same level then we will set up an activity within a given week, if they* (the children) *didn't choose to join that activity they would be invited to participate. If they were very resistant to that involvement then we may make a group activity in whanau group time."*

When Anne was asked whether or not there was a particular focus on mathematics with any individual child she commented that "*I don't think we specially have. If we saw a need for them we would; it generally ends up being a bit more general.*" Nancy saw her teaching as "*50/50*" between focussing on individuals as opposed to general teaching. She explained that "*if you see a child having difficulty with something I will work with them individually.*" Nancy used the checklist to "*pull out at different times and have a bit of a blitz and go through everything for one or two children and then put it away again and come back later.*" In this case it appeared that the assessment sheets were used to record completed achievement rather than to plan further learning experiences. This use of assessment was raised as a concern in the ERO (2000) report on the use of assessment to improve the programmes of four- to six-year-olds. Assessment and documentation of children's specific ability in number knowledge did not appear to have a priority. By providing number activities and embedding number activities teachers appeared comfortable they were providing for all learners' needs.

Teachers were asked during the final interview to indicate which games they felt best provided for the mathematical needs of their children. The games teachers selected as suitable would not be appropriate for the level of number knowledge of some of the more capable children interviewed. For example, all the teachers rated Stepping Stones as one of the games with the most suitable level of mathematics despite the fact that the skills developed in this game included one-to-one matching and counting which were skills in which most of the children interviewed already demonstrated competence (see Table 5.2). Stepping Stones also develops skills in subitizing - which was an area of weakness in the children interviewed. Games introduced later in the research study also developed these skills and provided more challenges as they developed further number skills. For example, Clowns, involving counting and one-to-one matching, also included simple addition as a further challenge. It appeared that the teachers underestimated children's existing number knowledge and the related relevance of learning activities. However, it must be noted that the games selected as suitable by the teachers were appropriate for some of the children in the study, and indeed probably for many other children in the centre.

The final teacher interview focused on changes that resulted from their involvement in the professional development programme. Liz commented that the individual assessment could be an area of change: "*When we review it* (the check list) *we want to look at what numbers our children can count up to and what numbers children can recognise.*" However, Anne continued to view the checklist as a record for parents rather than using to inform further teaching: "*It would be interesting to see how far they can count and write that on a record for the parents to see.*"

Other changes which Nancy would make as a result of the professional development included "*the need to put some input into it* (playing of games*) as an adult ... when someone else was there they* (the games) *were used much more.*"

Nancy believed that her own knowledge had developed: "*I think I am more aware now of the skills that are necessary*" and that she was using this knowledge "*more in incidental play like counting while we wait for a turn.*"

Likewise, Anne hoped to bring *"number into everyday teaching. In a way it's a more conscious effort of getting out a game that deals with number whenever you are on resources. You* (the teacher) *should be able to think of things, to develop number concepts, at this end* (indicating the playdough and making table) *or outside."*

Liz saw the changes resulting from the professional development as more gradual as having the researcher *"influence and encourage and you've spiked the teachers' thinking. So that would be the greatest strength to have participated in this research."* She elaborated that she is more *"aware of what things are important, that you can include it* (number development) *in everyday activities."*

The professional development sessions were integral to the success of the project. Spontaneous discussions between researcher and teachers, and teachers and teachers generated thought-provoking ideas and stimulated all parties to consider closely the best practices to ensure the development of number skills in children.

6.5. ACTION RESEARCH CYCLES

Professional development sessions with the teachers, completed during each of three consecutive fortnights, focussed on early essential number knowledge and skills and how to recognise and develop these in young children. Time was also spent familiarising teachers with the three new games and related number skills, and discussing suitable ways to introduce the games early in the fortnight. This action research cycle was vital to ensure that games were introduced successfully. Three different approaches for game introduction were used. Each approach was developed in consultation with the teachers during the professional development session. Feedback on the success of the preceding game introduction was used to refine the process in subsequent cycles.

Cycle One: Originally the researcher suggested that the teachers would introduce the games to the children during whanau group time. Over three days each whanau group was introduced to each new game. Difficulties became obvious to both the researcher and teachers concerning the most appropriate way to action the game introduction. The teachers experienced difficulties in using a structured teaching approach, they were not sure of language to use and it conflicted with their own teaching styles as they tried to tell children how the game should be played. The number of children in the group and the range of abilities also caused difficulties for the teachers. It was suggested that an alternative method of game introduction be used for the second fortnight.

Cycle Two: In the second fortnight, after teachers had been introduced to - and discussed - the specific number knowledge and skills being developed in the new games, it was decided the games should be introduced as a veranda activity by the teacher on veranda duty that week. In this way the teacher would have more time to focus on the children and fewer children would be attempting to play with the game at the same time. The teacher introducing the games stamped each child's hand after they had played the game as a way of knowing who had played. While game playing was very attractive to the children, getting a stamp appeared to become a priority rather than learning to play the game appropriately. The teachers and researcher questioned whether or not this was the most suitable way of introducing the new games for the development of number knowledge.

Cycle Three: In the professional development session in the third fortnight the method of game introduction was re-evaluated. It was decided to return to the initial approach of introducing one game at a time during whanau group time. More time was spent with the teachers discussing the game and how to best cater for the number of children and the range of abilities. It was suggested that not all children need to participate in the game at once, and alternative puzzles were provided so the teacher could concentrate on introducing the game to half the whanau group at a time. Photocopies of some of the games were made so more game boards were available. This method of game introduction was the most successful. Children were more focused on the new game, had less wait time between turns and were playing at their own level rather than at the level of the whanau group.

The difficulty of game introduction was not viewed as a long-term problem. When the study was completed the teachers could include the number games as part of the 'normal available activities' to use with children as and when the need arose.

6.6. SUMMARY

Teachers in the kindergarten were very positive towards, and keen to participate in, the research study. The focus on mathematics, and more particularly number, had been identified as an area of professional development need prior to the suggestion for a research study. The researcher was cognisant throughout the study of the time pressure on the teachers and endeavoured to develop mutual benefits for all parties concerned.

The professional development raised some interesting issues for both the researcher and the teachers. The vital importance of early number skills for young children was superficially recognised by the teachers in the initial stages. Throughout the study it was acknowledged that the teachers already have an extensive working knowledge of best teaching practice. Therefore, developing teacher awareness and knowledge of specific early number skills which could be developed with young children became a focus of the professional development sessions. Teachers were receptive of ideas and incorporated new knowledge into their teaching immediately. Teachers already recognised the variability in children's ability in number and now had a better understanding of how to further develop children's number skills. The importance of assessment, planning and teaching for children's needs, based on the philosophy of *Te Whaariki*, through co-construction and guided participation was briefly discussed.

Responses from the teachers to their involvement in the research study and the professional development sessions were very positive. The three two-hour sessions were effective in providing the teachers with an overview of number knowledge and skills and possible approaches for developing these in young children through the use of number games.

CHAPTER SEVEN: DISCUSSION AND CONCLUSION

7.1. INTRODUCTION

The major goal of this study was to examine the use of number games to increase young children's number knowledge and skills. Particular focus was on game usage by children and links to their number knowledge development. The use of games by particular groups of children, those formed on the basis of gender or ability, was also considered.

In parallel to the implementation of the number games within the centre the teachers undertook a series of three professional development sessions to further enhance their understanding of young children's number knowledge development.

In this chapter the use of number games for the development of young children's number knowledge and skills is discussed. The success of on-site teacher professional development is also considered. Implications of findings from this study and suggestions for further research are outlined. Finally, conclusions from this study are presented.

7.2. GAME USAGE FOR DEVELOPING NUMBER KNOWLEDGE

Development of Number Knowledge

In the initial interviews children displayed a wide range of number knowledge competencies including rote counting, enumeration, subitizing, writing numerals, numeral recognition, and addition and subtraction skills. These results were consistent with those obtained by other researchers (see Aubrey, 1993, 1997; Suggate, Aubrey & Pettitt, 1997; Young-Loveridge, 1987, 1988) who found that young children had an extensive range of number skills. Study interviews showed that children's ability levels across this range of competencies varied greatly. For example, within the sample of ten children some could rote count initially to 30, whereas others could not count past nine or ten. This finding was consistent with those of other researchers (see Wright, 1994; Young-Loveridge, 1987). The ten children were categorised, by their ability to rote count, into three groups labelled *emergent*, *developing*, and *confident*.

Each of the ten children's improvement level in number knowledge and skills was calculated using a numerical score resulting from the initial and final interviews and all children made improvements in their number knowledge. Improvements were made across the range of competencies, in particular, in the areas of rote counting, recognition of numerals, recalling the number after a given number, and addition and subtraction using direct modelling with numbers less than seven. Research has shown that that higher-achieving children would make greater improvements (see Aubrey, 1994; Hughes, 1986; Newman, 1984; Young-Loveridge, 1989). However, in this study it was found that the amount of improvement was relatively consistent across all ability groups. Emergent children appeared to make slightly more improvement, but with a sample of ten this correlation between initial score and level of improvement was not statistically significant.

Individual profiles detailing the specific skill development of each child illustrated the range in which improvements were made. Some children's profiles illustrated areas of improvement which related to the skills employed in the particular games the children played, for other children this was not the case.

Use of Games

Games are strongly associated with play and provide a meaningful context for the development of number skills in a holistic and embedded manner (Mannigel, 1998; Ministry of Education, 1996). It is suggested in *Te Whaariki* that teaching and learning within early childhood centres should be both individually and age appropriate (Carr & May, 1996). The developmental appropriateness of number game playing is assured as teachers can scaffold children's learning through guided participation and co-construction (Hedges, 2000).

It was apparent from the research study that the use of number games in early childhood settings to assist the development of number knowledge in young children was appropriate. Number knowledge and skills improved in all children in the study, however a direct link to the use of number games could not be made in the case of all the children. It was hypothesised that more able children would be higher game users, however children of all ability levels participated in game playing with no discernable pattern evident regarding frequency. This fact was promising, indicating that games had universal appeal rather than for a particular ability group only.

It was also hypothesised that children who were the high game users would be likely to show the greatest improvements - however, the range of improvement scores showed no correlation to the rate of game usage. It is probable that factors outside the study focus contributed to the learning of the high-improving children who were low game users. More constant and accurate monitoring of children was needed to account for the low-improvers who were high game users and to determine what learning was taking place during game play.

Data gathered on game usage indicated that girls were more likely to use the games than were boys. Although there were equal numbers of boys and girls in the centre, sixty-six percent of the game players were girls. It should be noted that frequency rather than the actual time spent game playing by girls compared with boys was not measured. Adults were present 37% of the times when girls played, whereas adults were present 47% of the times when boys played. It was difficult to determine why this occurred. It was possible that teachers actively encouraged the boys to play the games by being physically present, whereas girls tended to game play more voluntarily. It could be that boys were drawn more to the games when there was an adult present. These factors were not measured in the study. Individual profiles showed an adult was present over half of the times that three of the four emergent children played the games. In the study it was hypothesised that the presence of an adult would assist children by scaffolding their learning (Nicolopoulou, 1993). The apparent preference by boys and emergent children for an adult to guide and co-construct their learning has strong implications for teaching.

Children preferred games that were interactive by nature and yet could still be played independently but alongside other children (e.g., Beehives and Cats). This preference for interaction among players confirms earlier findings of Booker (1996) and Ellington, Gordon and Fowlie (1998). Preferred games provided for a variety of ability levels within the game itself, for example, Cats could be used with smaller or larger numbers depending on the child's confidence. Those games that appealed to children and teachers the most were perceived as straightforward; it was almost implicit when viewing the game how it should be played. Games with a wealth of fiddly pieces, such as Memory or Order, did not attract children and this was probably due to a more complicated playing approach. Games with more involved rules, such as Track, did not appeal. This factor may be overcome if more assistance by a teacher were to be made available during the early phase of the game play. The teachers also saw attractiveness, colour and familiarity of 'theme' as positive features for number games.

Teacher Involvement

Responses from the teachers to their involvement in the research study and the professional development sessions were very positive. Due to the time limits on the research study and the researcher-imposed instructional resources it was difficult to ensure teachers' comprehensive understanding of the games. However, the three sessions *"spiked the teachers' thinking"* (Nancy) about number development in the kindergarten. Teacher awareness of the importance of embedding number development in meaningful contexts for children was frequently mentioned and actioned. Assessment of children's number knowledge was undertaken and recorded, however it was not apparent that this information was used to inform planning of future learning experiences.

7.3. IMPLICATIONS

It is important to consider the issues raised by the preceding discussion and the implications it has for the development of number knowledge and skills in young children.

Teachers in early childhood centres, although enthusiastic and keen to promote number skills, need to be aware of the most appropriate knowledge and skills to develop. This study reinforced findings of earlier studies (e.g., those by Cullen, 1999; Sternberg, 1998; Young-Loveridge, 1995) for the need for professional development to improve teachers' knowledge in the area of number development in young children. Without a strong awareness of the most appropriate number knowledge and skills to develop in children, teachers would be unlikely either to initiate curriculum to encourage mathematical learning or to provide appropriate mathematical experiences.

Results from the interview emphasised the wide range of ability in number knowledge and skills in children. Previous research has shown that teachers need to be aware of individual children's ability levels to successfully cater for the learners' needs (Cullen, 1994; Hedges, 2000). This fact was confirmed in this study where it was found that teachers were unaware of key areas for children's number knowledge development. More purposeful assessment is needed by the teachers to inform and plan further appropriate learning experiences. The range of number games used in this study provided appropriate experiences to match the individual needs of the children from emergent to confident abilities.

Number games have the potential to provide relevant learning activities to develop a wide range of number knowledge and skills and to cater for a range of abilities in young children. Although not all children were high game users the use of games did provide valuable learning experiences for game users. Stones, Humpty, Cats and Beehive were particularly useful for the development of meaningful counting. Cats, Beehive and Memory developed skills in numeral recognition and cardinal number, also further developing counting skills. Early number operations were developed in Track, Caterpillar and Clowns. All games using dot-patterned dice encouraged subitizing skills.

The importance of adults to provide valuable scaffolding of children's learning through guided participation and co-construction was apparent in the study (Rogoff, 1993; Valsiner, 1993). Some high game users did not develop expected number skills - perhaps indicating a need for scaffolding. The preference for an adult to be present during game play was more apparent with boys and those children displaying emergent number skills.

7.4. LIMITATIONS

Ethical and practical considerations prevented the interviewing of all children at the kindergarten. It was suspected that children whose parents had consented were perhaps more mathematically able. It was difficult to determine whether or not a representative cross-section of abilities had been used in the study.

The sample size of ten meant that trends observed using quantitative data analysis were not statistically sound. This small sample size coupled with the suspected bias of the sample resulted in a questioning of the validity of any apparent trends. A larger sample size was needed to more accurately use this type of data analysis.

The length of interview (over twenty minutes in some cases) was long for young children and they became restless and lacked concentration. For the more capable the final interview did not extend them far enough. Scoring from the initial and final interview was based on systems used in other research studies, however it was subjective in the allocation of possible scores for various skills.

Timed observations were not consistently actioned. The teachers were often too busy and although committed to the planned fifteen-minute timed observations they were often caught up with other issues. An independent observer who could commit to long periods of observation would obtain more accurate and detailed results. The timed observations provided no detail of how long children were actually involved in playing the games. Length of play may also contribute to the depth of understanding developed.

It was presumed that during game play appropriate learning of number skills would take place. What children actually learned during game play was difficult to assess. Due to the fact that some moderate game users made low improvement it must be assumed that learning of number skills did not always eventuate through game play.

Pre-mat time was never observed for game usage. It was suspected that during this time parents or guardians might have used the games with their children. This would have contributed to improvement in children's number knowledge and skill, especially as parents may scaffold their child's learning and identify specific skills to further develop with their child.

The contribution that parents and teachers made, outside of game usage, to children's number knowledge development was not measured in the study. The contribution of these educators cannot be overlooked when determining children's knowledge development in any curriculum area. Teacher interviews highlighted the fact that the teachers were embedding number knowledge into other teaching experiences provided for the children within the centre.

The use of number games by the children in the kindergarten was a focus for a brief six-week period; in order to determine the lasting influence of number games a longer study period would be required together with a reassessment of children's number knowledge and skills to gauge retention. This research study tended to emphasise areas for future, more focused, long-term study.

7.5. SUGGESTIONS FOR FURTHER RESEARCH

The following issues have been identified from the preceding results and discussion as possible areas of further study.

1. Use of games during pre-mat time to encourage adults in scaffolding their child's number learning. Encouraging number game playing at this time may provide a catalyst for developing parents' awareness of their child's number knowledge and skills.
2. Although it is difficult to determine exactly what learning has occurred, a closer focus on children's game playing, of children's dialogue and action, may provide an insight into the development of number and other skills such as social skills.
3. Not all high-improvers were high game users; other experiences occurring in the children's lives were also contributing to knowledge growth. A future focus may explore other ways early number experiences in early childhood centres are developed.
4. The question must be raised as to how confident early childhood educators are in developing number knowledge and skills in children. Further investigation is needed into the professional development of teachers in early childhood settings such as kindergarten, day care, kohanga reo etc.. Professional development sessions were highly successful in raising teacher awareness of children's number knowledge and skills development.

7.6. CONCLUSIONS

The methodology used in this research included both qualitative and quantitative approaches using interviews, timed observations and casual observations to determine the effect of number games on children's number knowledge and skill development. A sample of ten children, together with their three teachers, was used in the study. Three professional development sessions were undertaken with the teachers in the area of number knowledge development.

The findings of this study contribute to our understanding of children's number knowledge development through the use of number games. The results show that the children's number knowledge improved through the research study regardless of the frequency of number game play. From the sample of ten children it appeared that high games usage had little effect on improvement of achievement. Other number learning experiences at home or in the kindergarten must have contributed to children's learning. However, individual children's profiles provided strong links between specific games used and skills developed. It was positive to find that children of all ability levels were prepared to play the number games, indicating a wide appeal for this type of learning experience.

Girls were the higher game players. An adult was present 47% of the time when boys played games compared with adults being present only 37% of the times girls were involved in game play. The presence of an adult encouraged game play and provided valuable scaffolding of learning for children using the number games.

Initially teachers were unaware of the vital importance of early number skills as a foundation for future mathematical thinking. As a result of the professional development sessions, teachers gained a deeper understanding of the number knowledge and skills which it is appropriate to develop in young children.

The appropriateness of number game playing is assured as teachers can scaffold children's learning through guided participation and co-construction. Number games have the potential to provide relevant learning activities to develop a wide range of number knowledge and skills and to cater for a range of abilities in young children.

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APPENDICES

9.1. APPENDIX A: INFORMATION SHEET FOR TEACHERS

(Massey University Letterhead)

Games and Activities to Develop Early Number Skills in Young Children

INFORMATION SHEET FOR TEACHERS

My name is Ngaire Davies and I am currently undertaking research for my Masters in Educational Studies (Mathematics). I have been working for the last eight years as a mathematics education lecturer. Part of my work within the university has involved the development of a curriculum mathematics course for our Early Childhood Education students.

Through my research and my contact with teachers I have become aware of the importance of early number skills in young children and the variety of focus within the centres. Currently we know little about how young children interact with 'play activities' to develop mathematical thinking and confidence. Through the introduction of simple games and activities I hope to discover which features appeal and assist children developing early number skills. This research will provide an overview of benefits to teachers and for children and will provide centres with a valuable resource for further development in early number understanding.

The professional package I am offering is in the development of early number skills in children. The package consists of three fortnightly sessions of one and a half-hours duration focussing on specific aspects of number development and associated mathematical activities. In the two weeks following the professional development session the number activities will be trialed within the normal centre programme. All children will be able to interact with the number activities as usually expected within the centre. In order to evaluate the impact and effectiveness of these mathematical activities I would need to informally interview a group of eight children prior to the introduction of these activities to determine their early understanding of number. After a few weeks a second informal interview will follow to determine the children's response to the activities. Teachers will make informal assessment of the activities and children's participation in a manner consistent with usual practice. Teachers will be interviewed informally each fortnight to assess the success and usage of the mathematical activities. The information gathered will be used in the preparation of a research report.

Because of the young age of the children the interviews will last about 15 minutes and a mutually acceptable time will be arranged with the teacher. It is intended that this research will not interfere with free-time. Each child will be asked to take part in two similar interviews. Teachers will be interviewed (for approx. fifteen minutes) towards the end of each fortnight at a time mutually agreeable.

Consent will be gained prior to all interviews. Interviews with children and teachers will be recorded on audio tape and I will make transcriptions of the recordings. All information given will remain confidential to the research and any publications resulting from it. The tapes will be held securely and will be destroyed at the completion of the research. Although the teachers, children and caregivers involved in the interviews may well be aware of the others involved, the names of teacher's, all children and the centre involved will remain confidential to the researcher and supervisor. Neither the centre nor any individuals will be identified either directly or indirectly in verbal or written form. Direct quotes from the interview tapes will be used but teachers and children will be assigned pseudonyms to maintain their anonymity.

You are welcome to participate in this research. Participation is voluntary. In accordance with the requirement of the Massey University Human Ethics Committee teachers have the right:
to decline to participate;
to refuse to answer any particular questions;
to withdraw from the study at any time;
to ask any questions about the study at any time during participation;
to provide information on the understanding that their name will not be used unless they give permission to the researcher;
to be given access to a summary of the findings of the study when it is concluded.

If you are willing to be included in the professional development package and associated research please complete and return the attached consent form. I will contact teachers to discuss mutually agreeable times for the professional package to begin, to negotiate twice weekly times to visit the centre for observations and to discuss when interviews with children and teachers can take place.
A summary of the research findings will be sent to your centre in mid 2001.
If you have any further questions please contact either my supervisor or me.

Yours sincerely

Ngaire Davies

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9.2. APPENDIX B: INFORMATION FOR CAREGIVERS

Games and Activities to Develop Early Number Skills in Young Children

INFORMATION SHEET FOR CAREGIVERS

My name is Ngaire Davies and I am currently undertaking research for my Masters in Educational Studies (Mathematics). I have been working for the last eight years as a mathematics education lecturer. Part of my work within the university has involved the development of a curriculum mathematics course for our Early Childhood Education students.

Through my research and my contact with teachers I have become aware of the importance of early number skills in young children and the variety of focus within the centres. Currently we know little about how young children interact with 'play activities' to develop mathematical thinking and confidence. Through the introduction of simple games and activities I hope to discover which features appeal and assist children developing early number skills. This research will provide an overview of benefits to teachers and for children and will provide centres with a valuable resource for further development in early number understanding.

The teachers of the centre that your child attends have agreed to undertake professional development in the area of early number skills. Throughout this time activities and games will be introduced to the children. All children will be able to interact with the number activities as usually expected within the centre. In order to evaluate the impact and effectiveness of these mathematical activities I would need to informally interview a group of eight children prior to the introduction of these activities to determine their early understanding of number. After a few weeks a second informal interview will follow to determine the children's response to the activities. Teachers will make informal assessment of the activities and children's participation in a manner consistent with usual practice. The information gathered will be used in the preparation of a research report.

Because of the young age of the children the interviews will last about 15 minutes and a mutually acceptable time will be arranged with the teacher. It is intended that this research will not interfere with free-time. Each child will be asked to take part in two similar interviews.

Interviews will be recorded on audio tape with the permission of the child's caregiver and I will make transcriptions of the recordings. All information given will remain confidential to the research and any publications resulting from it. The tapes will be held securely and will be destroyed at the completion of the research. The names of all children and the centre involved in the research will remain confidential to the researcher and supervisor. Neither the centre nor any individuals will be identified either directly or indirectly in verbal or written form. Direct quotes from the interview tapes will be used but children will be assigned pseudonyms to maintain their anonymity.

Your son/daughter is welcome to participate in this research. Participation is voluntary. In accordance with the requirement of the Massey University Human Ethics Committee children and their caregiver have the right:

to decline to participate;
to refuse to answer any particular questions;
to withdraw from the study at any time;
to ask any questions about the study at any time during participation;
to provide information on the understanding that their name will not be used;
to be given access to a summary of the findings of the study when it is concluded.

If you are willing for your child to be included in the interview please complete and return the attached consent form. I will contact all carers who return a consent form to let you know if and when your child will be interviewed.
A summary of the research findings will be sent to your centre in mid 2001.
If you have any further questions please contact either my supervisor or me.

Yours sincerely

Ngaire Davies

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9.3. APPENDIX C: MATHEMATICS INCLUDED IN *TE WHAARIKI*

Mathematical understandings appear in the Communication and Exploration strands of *Te Whaariki.* Specific goals and learning outcomes are as follows:

Communication Strand
Goal 3: Children experience an environment where they experience the stories and symbols of their own and other cultures.

Learning Outcomes
familiarity with numbers and their uses by exploring an observing the use of numbers in activities that have meaning and purpose for children;
skill in using the counting system and mathematical symbols and concepts, such as numbers, length, weight, volume, shape and pattern, for meaningful and increasingly complex purposes;
the expectation that numbers can amuse, delight, illuminate, inform, and excite;
experience with some of the technology and resources for mathematics, reading, and writing;
experience with creating stories and symbols

Exploration Strand
Goal 3: Children experience an environment where they learn strategies for active exploration, thinking, and reasoning.

Learning Outcomes;

confidence in using a variety of strategies for exploring and making sense of the world, such as in setting and solving problems, looking for patterns, classifying things for a purpose, guessing, using trial and error, thinking logically and making comparisons, asking questions, explaining to others, participation in reflective discussion, planning, observing, and listening to stories;
the ability to identify and use information;
a perception of themselves as explorers;
the confidence to choose and experiment with materials.

Goal 4: Children experience an environment where they develop working theories for making sense of the natural, social, physical, and material worlds.

Learning Outcomes:

spatial understandings, including an awareness of how two- and three- dimensional objects can be fitted together and moved in space.
(Ministry of Education, 1996)

9.4. APPENDIX D: INITIAL (SEMI-STRUCTURED) INTERVIEW FOR TEACHERS

Questions for Teacher Interview
How do you *feel* about mathematics?

School experiences?

Family experiences?

Importance – Why?

What maths *skills* do you see as important to develop in the children you teach?

How do you assist in developing these skills?

Do you do any checking on individual children?

Do you focus particular on maths with any children?

Have you had any *professional development* in the area of maths?

Opportunities?

When?

Has the implementation of *Te Whariki* changed what you do with regards to maths? In what ways?

What would *assist you most* in developing number skills in children?

9.5. APPENDIX E: CHILDREN'S INTERVIEW QUESTIONS

Number Interview Chart

	Question:	Child's Response:
1	Familiarity with Numbers: Tell me about the numbers you can see in this picture? cake, bus, phone, letter box Can you tell me some other places you might see numbers?	
2	Rote Counting: How far can you count starting 1, 2, ...	
3	Meaningful Counting: Count an array of 3 and 6 In a line In a circle Extract a set of 2, 5 and 7 from a larger set	line circle 4 line circle 2 5 7
4	Cardinality Principle: That last number used is number in the set.	
5	Order Variance: Count a line first from left, right and centre Set of 4 and 6	3 left right middle 5 left right middle
6	Recognition of Numerals: See if child can point to 1-10, 12, 14 in random order Tell me the name of this numeral	1 2 3 4 5 6 7 8 9 10 12 14 1 2 3 4 5 6 7 8 9 10 12 14
7	Writing Numerals: Put something on paper to show how many 1-6 then 6-10	1 2 3 4 5 6 7 8 9 10
8	Ordering of Numbers: What number comes just before/ after 3, 5, 8, 1	After 3 5 8 1 Before 3 5 8 1
9	Subitizing: Flash typical dot patterns of 3, 5, 2, 1, 4	1 2 3 4 5 6

	Addition-Concrete objects	2+1= 3+2= 5+2= 4+3=
	Subtraction–Concrete objects	3-1= 4-2=

		5-3= 7-4=
	Addition – Imaginary objects	1+2= 2+3= 4+3=
	Subtraction Imaginary objects	2-1= 4-2= 5-3=
	Missing Addend 3+?=4 Show 3 counters screen 2 There are five altogether, how many are under the screen? 1+?=3 2+?=4 3+?=5	3+?=4 1+?=3 2+?=4 3+?=5
	Missing Subtrahend 3-?=1 Child collects set of 5, I am going to take away some, how many did I take away? 4-?=2 3-?=2 5-?=3	3-?=1 4-?=2 3-?=2 5-?=3

9.6. APPENDIX F: FINAL INTERVIEW (SEMI-STRUCTURED) FOR TEACHERS

Questions for Post Teacher Interview

What do you now see as important number skills that you would focus on with the children you teach?

How do you see yourself developing these skills in children?

What are your thoughts about using number games with children?

Can you complete this questionnaire on each of the Games used?

Thinking about the games that were introduced which ones appealed and why?

What made them suitable for whanua group time? Session time?

What changes do you think you will make at Kindergarten as a result of this close encounter with number?

Questionnaire on Number Games

Please indicate your agreement with the following scale;
1 strongly agree 2 agree 3 neutral 4 disagree 5 strongly disagree

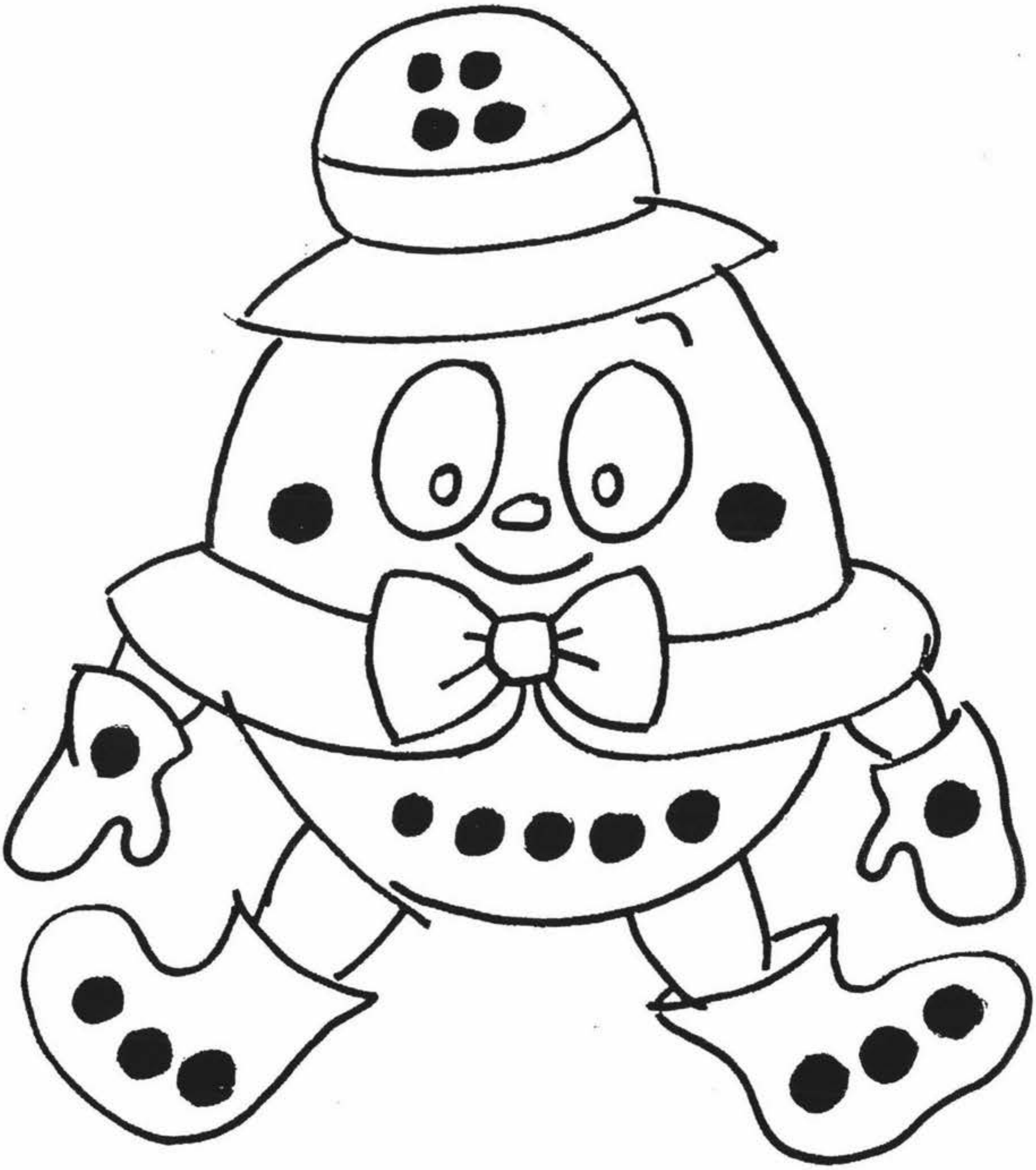
	Stepping Stones	Humpty Dumpty	Ordering sets	Beehive	Cats	Memory	Cater-pillar	Clowns	Track
Children enjoyed playing this game.									
The right maths level for the children was used in this game.									
This game is suitable to use in Whanau group time									
This game is suitable to use in general session time									
I would use this game again									
This game developed children's skills in:									

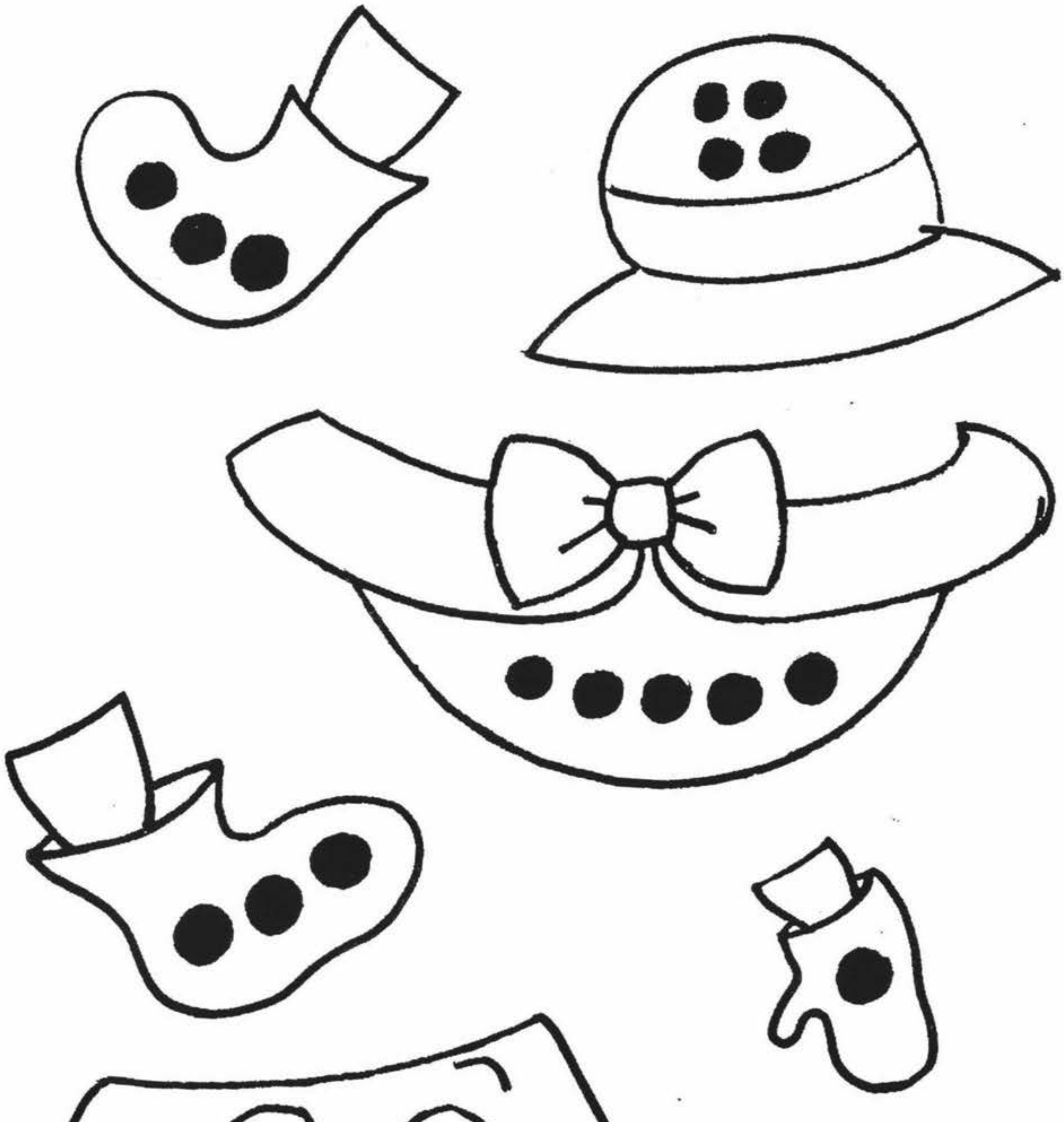
9.7. APPENDIX G: BLACK LINE MASTERS FOR GAMES

Black line masters for the games are to be found on subsequent pages.

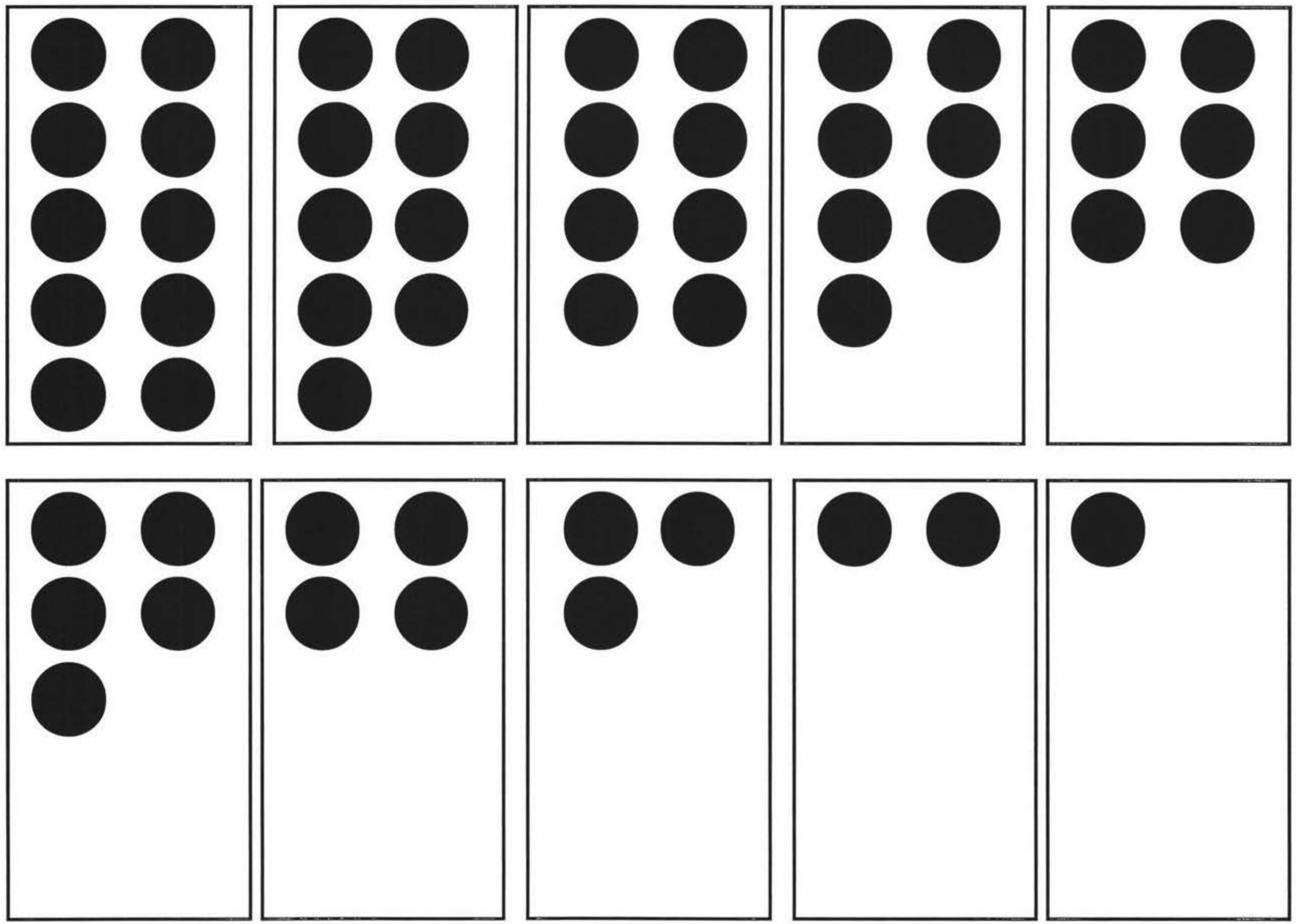
Name of Game	Source	Included
Humpty Dumpty	*Humpty Dumpty* was sourced from the Count Me In Too Project (Department of Education and Training, 1999, p. 24)	Game Board Pieces
Order	Developed by researcher	Ordered Dot Unordered Dot Variety Patterns Numerals
Cats	*Cats* was sourced from the EMI-5s study(Young-Loveridge & Peters, 1994, Game 13)	Game Board 1 Game Board 2 Numerals
Beehive	*Beehive* was sourced from the Count Me In Too Project (Department of Education and Training, 1999, p.34).	Game Board Bees Numerals
Clowns	*Clowns* was sourced from the EMI-5s study (Young-Loveridge & Peters, 1994, Game 16).	Game Board 1 Game Board 2
Caterpillar	*Caterpillar* was sourced from Exploring 6-10 by Bev Dunbar (1999).	Game Board Legs
Track	*Tracks* was sourced from EMI-5s Project (Young-Loveridge & Peters, 1994, Game 3).	Game Board

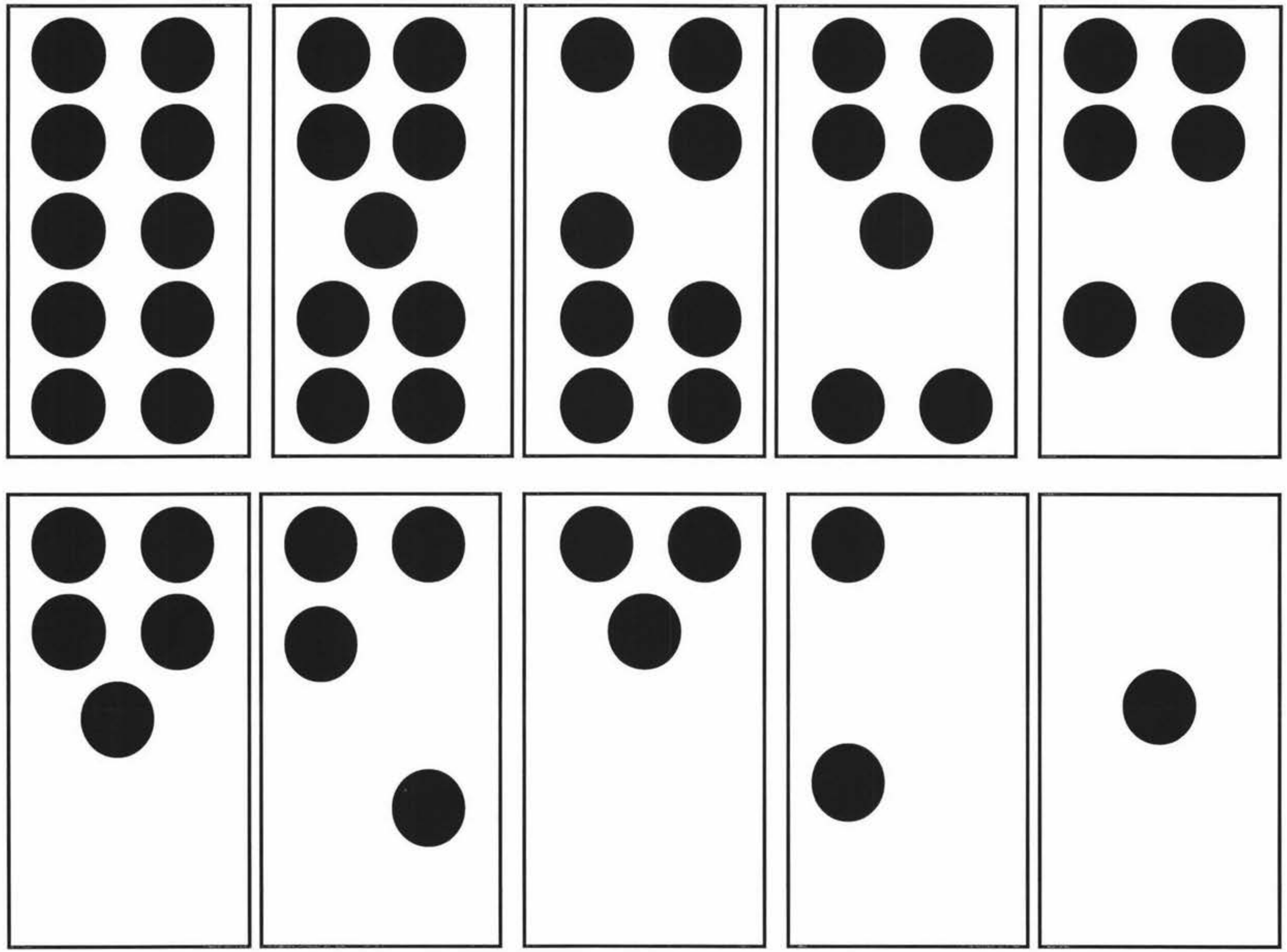
Humpty Dumpty

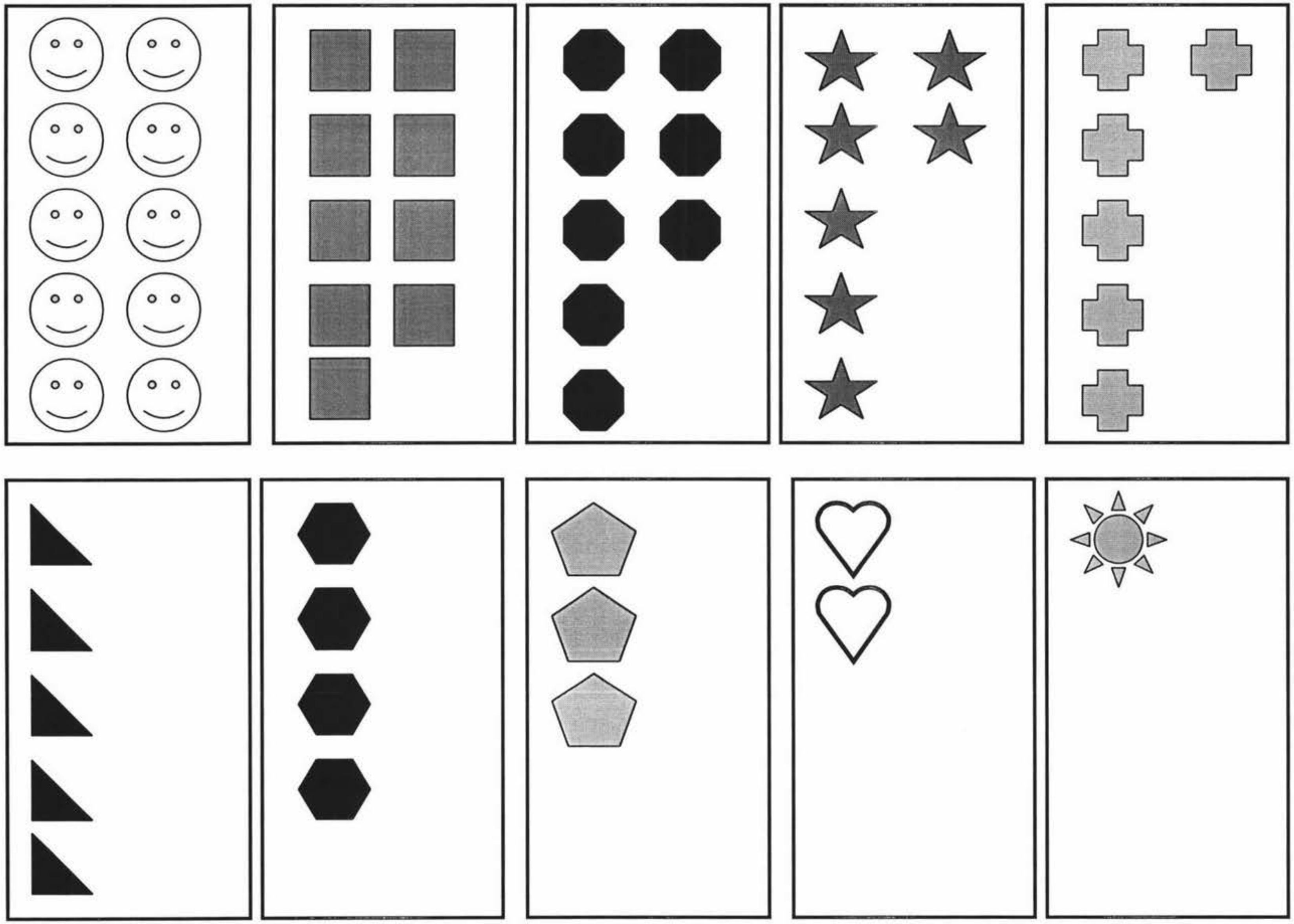




Order

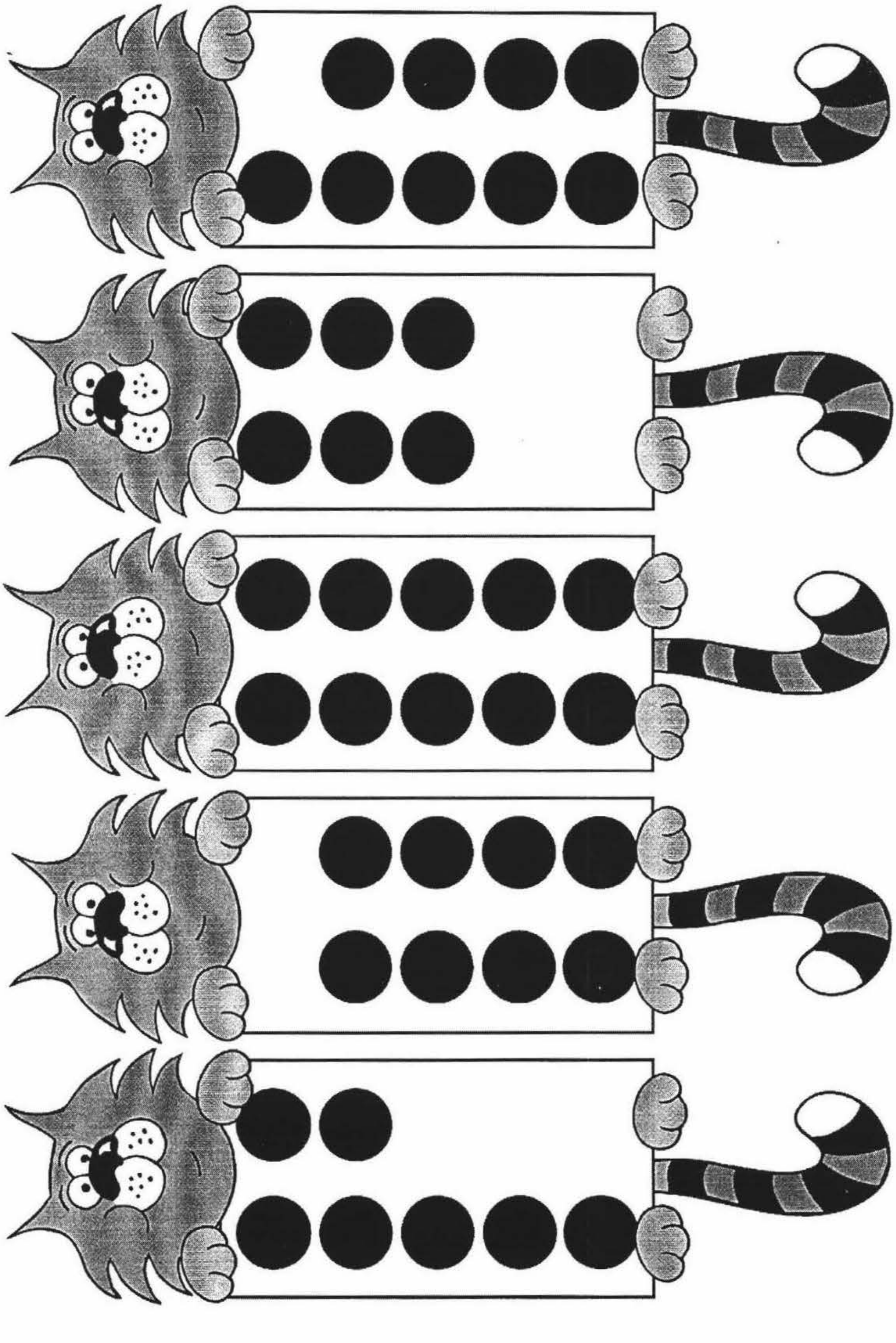


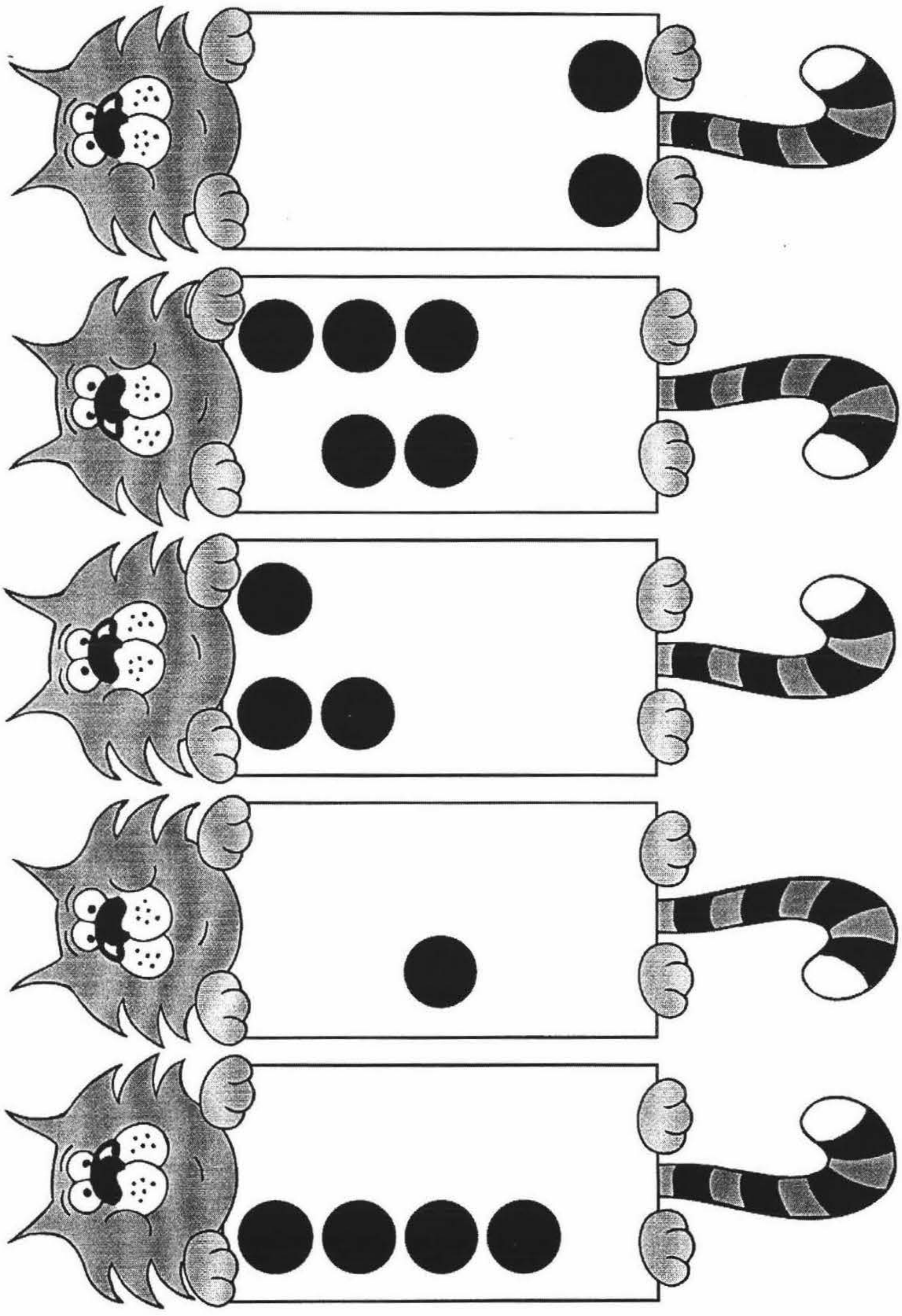




1	2	3	4	5
6	7	8	9	10

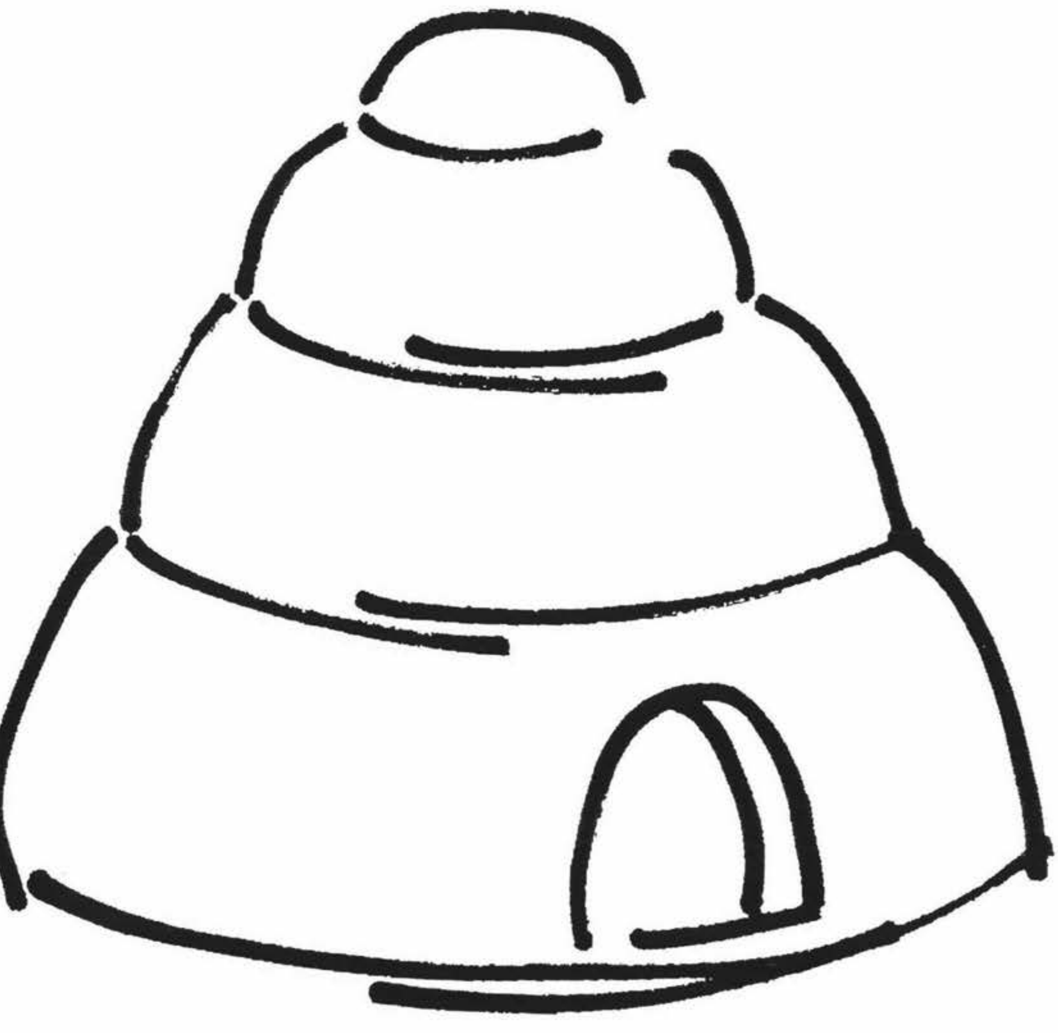
Cats

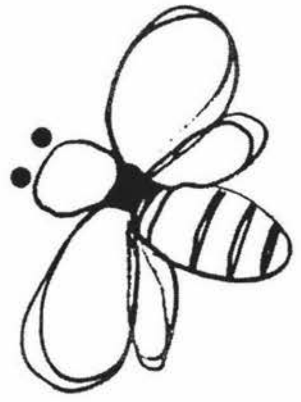
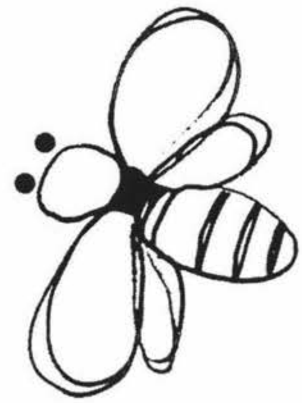
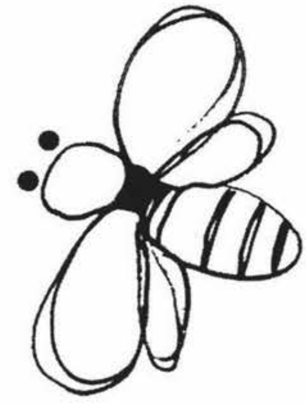
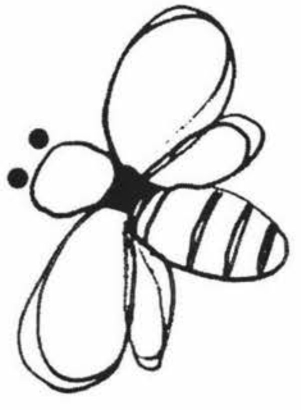
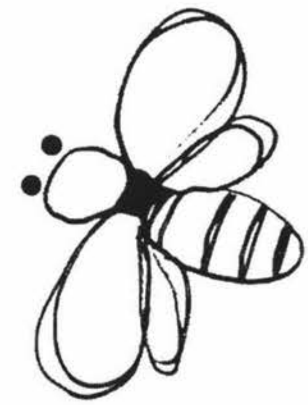
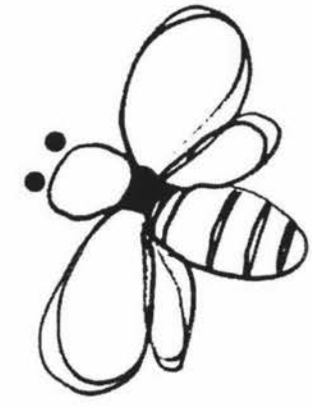
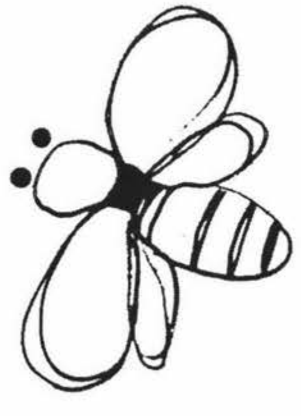
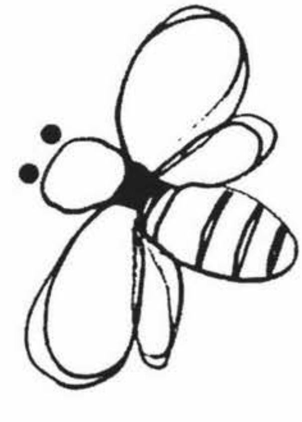
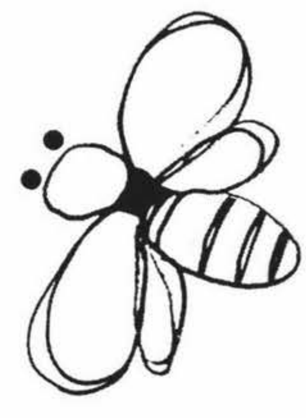
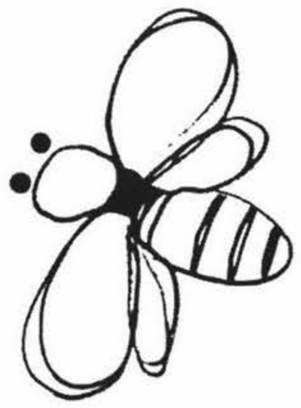
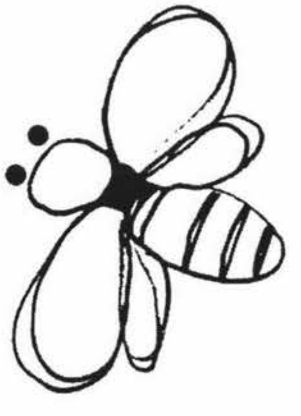
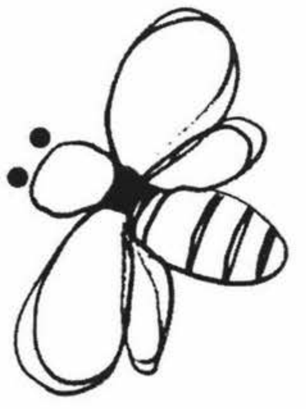




1	6
2	7
3	8
4	9
5	10

Beehive



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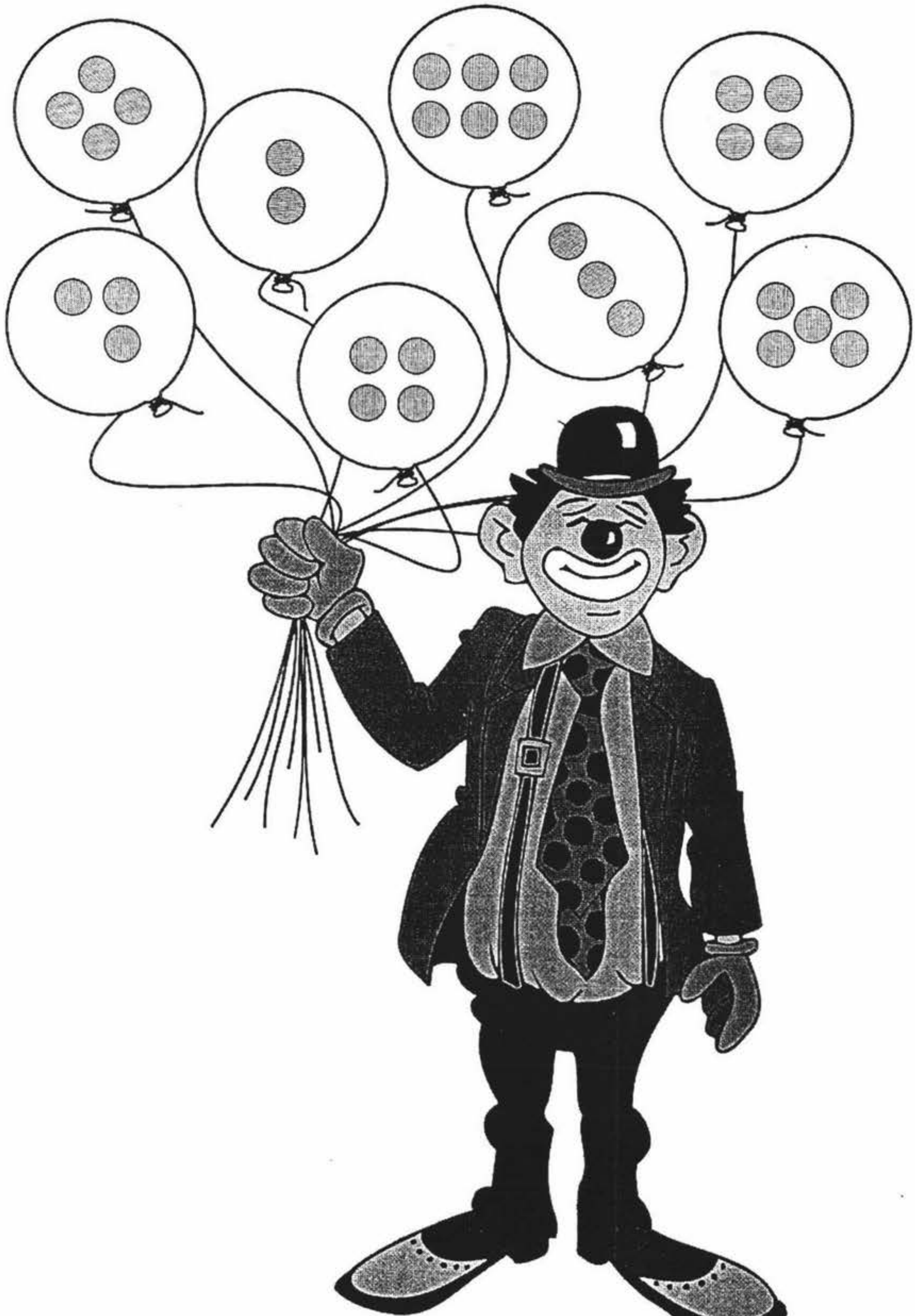
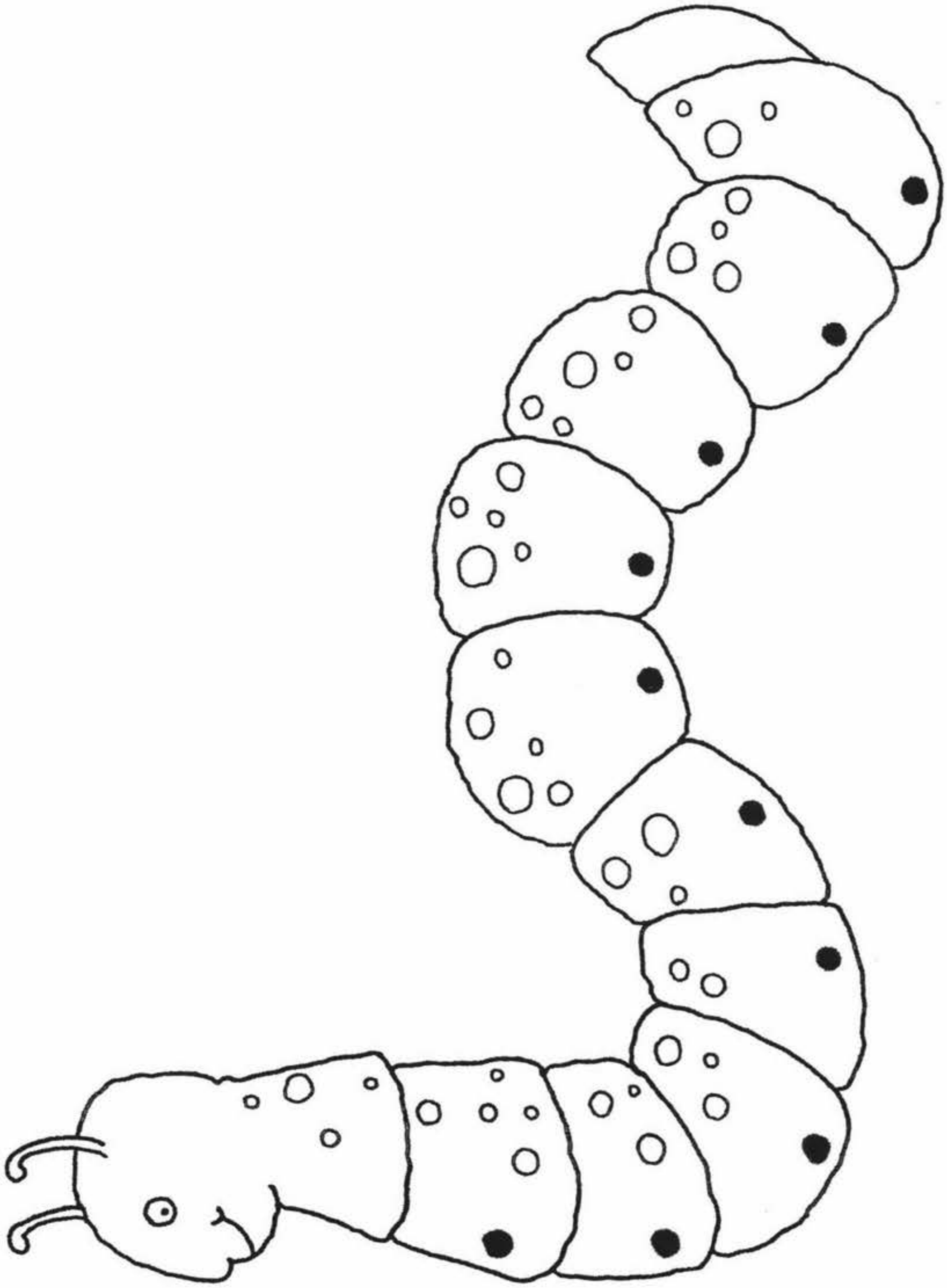
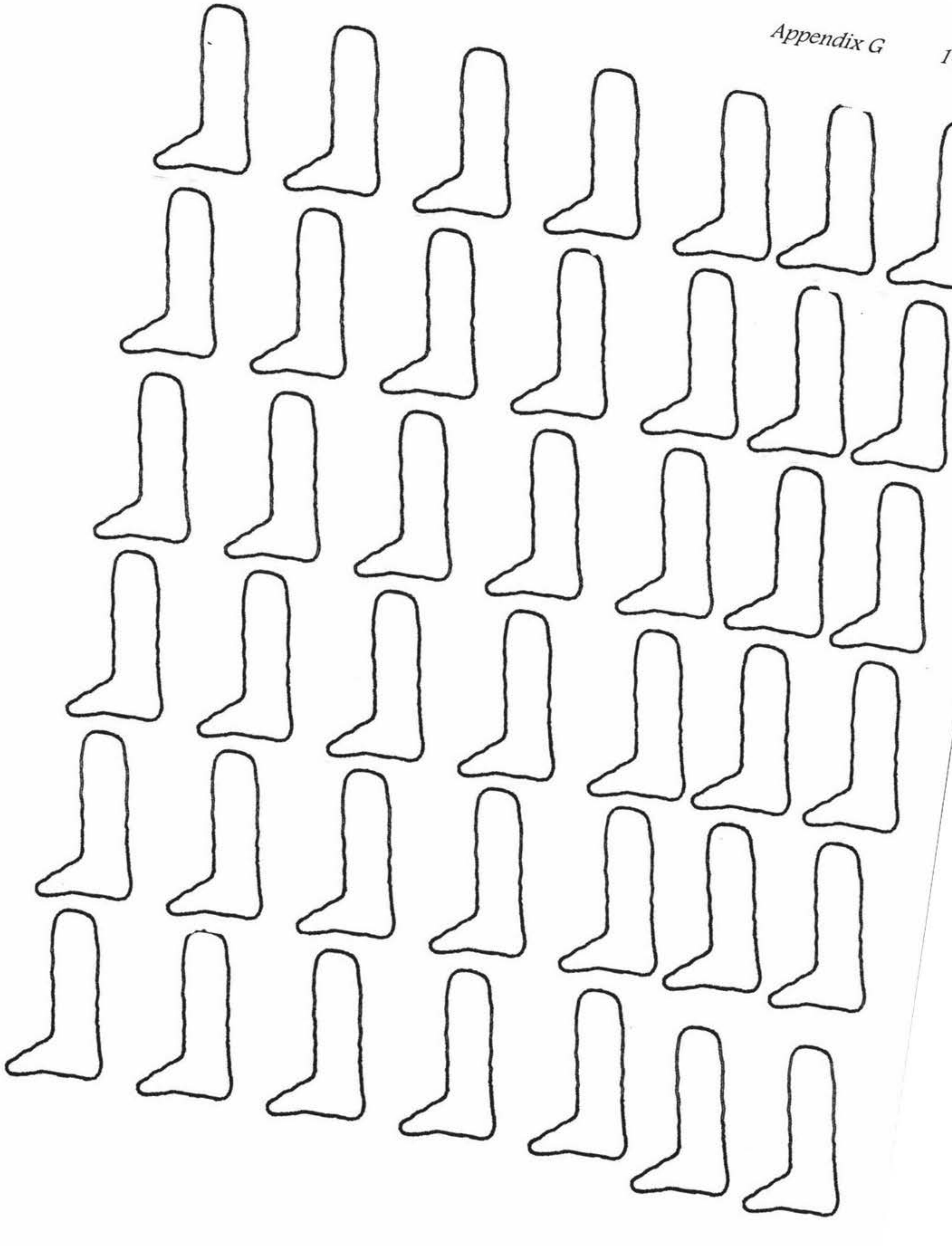
7	8	9
10	12	14

Clowns

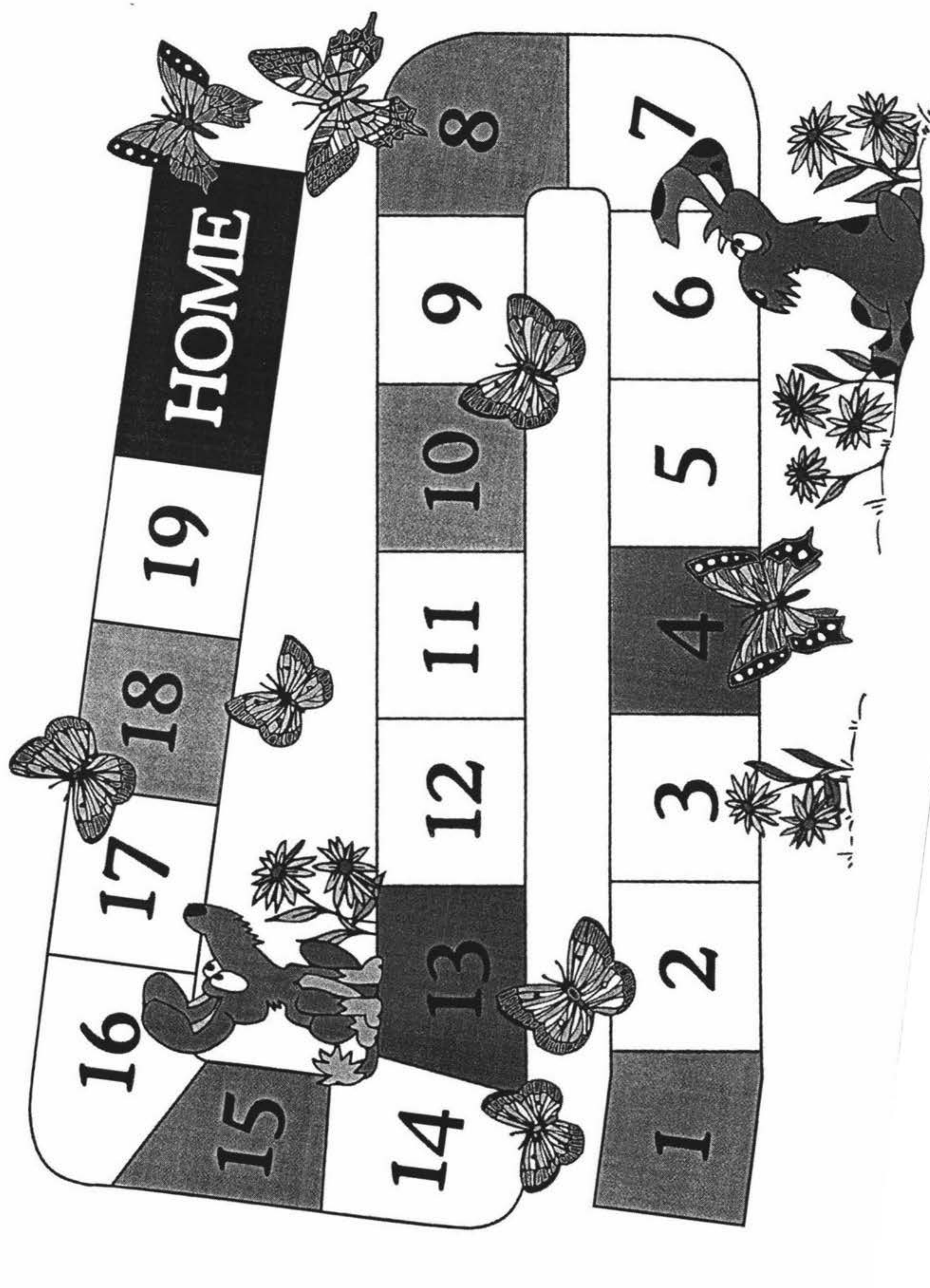


Caterpillar





Track



9.8. APPENDIX H: TEACHER PROFESSIONAL DEVELOPMENT OVERVIEW

Professional Development Session I

Ngaire Davies
Massey University College of Education

Messages From Research
Children start school with a wide range of mathematical competencies.
The gap between high and low achievers is widening as the children move through school and that the distribution is stable, those that start as low achieving are unlikely to change.
The child's performance on examinations in the teens could be predicted accurately from results taken at 7 or at 10 years of age.
There are some aspects of mathematics which seem to act as predictors of later success. These predictors are early skills that children show at a young age and have tended to indicate success in later years.

Mathematical skills that have been found to link with later success in a mathematics are:
Counting a group of objects
Recognising the symbols for numbers e.g. read "5" as "five"
Rote counting
Simple addition and subtraction in story context. E.g. "Teddy had 3 toys and he gave 2 his friend. How many did he have left?"
Instantly recognising number patterns, subitising.

Five Principles That Are Involved In Counting

Principle:
This involves both keeping track of items (those counted and those not yet counted) and producing distinct tags (number words) one at a time.

Stable Order principle:
The sequence of number words has to be produced in a stable order.

Cardinality:
The last tag represents the whole set, e.g. if five objects have been counted "1, 2, 3, 4, 5" then the last tag "5" describes the whole set.

Order:
The order in which objects are counted is irrelevant.

5. There is no restriction on the number or types of items that can be counted.

Professional Development Session Three

November 2000

Where is Number in Te Whariki?
Communication:
Goal Three: *Children experience an environment where they experience the stories and symbols of their own and other cultures.*

Learning Outcomes: knowledge, skills, and attitudes
Children develop:
Familiarity with numbers and their uses by exploring, and observing the use of numbers in activities that have meaning and purpose for children:
Skill in using the counting system and mathematical symbols and concepts such as numbers, length, weight, volume, shape, and pattern for meaningful and increasingly complex purposes:
The expectation that numbers can amuse, delight, illuminate, inform, and excite:
Experience with some of the technology and resources for mathematics, reading, and writing:
Experience with creating stories and symbols.

How does number develop at primary school?
'Mathematics in the New Zealand Curriculum' is divided into five content strands; Number, Measurement, Geometry, Algebra and Statistics. Each strand is divided into Levels from one to eight. This covers all the mathematics content to be learned from Year 1 to Year 13
In Number, Level One (approx. Years 1 & 2 depending on the child's ability)
EXPLORING NUMBER
Within a range of meaningful contexts, children should be able to:
Make up, tell, and record number stories, up to 9, about given objects and sequence pictures;
Form a set of up to 20 objects;
Read and write any 2-digit whole number;
Rote count to at least 50.

EXPLORING COMPUTATION AND ESTIMATION
Within a range of meaningful contexts, children should be able to:
Make sensible estimates and check the reasonableness of answers;
Model and explain addition calculations with a sum up to 20;
Using 20 objects, model and explain subtraction calculations;
Find by practical means, one half and one quarter of a shape, and half of a set of objects.

What progression will children move through in developing number confidence?	
Show an interest in numbers and counting	A child watches with interest as the teacher spoons the powder paint into the pot counting as she does
Use some number names and number language spontaneously	A child looked at the bricks at the door and said, "There are lots and lots … a hundred, a million."
Enjoy joining in with number rhymes and songs	A small group of children were jumping from log to log. A child jumped three logs and shouted, "Three!"
Use mathematics language in play	
Show curiosity about numbers by offering comments or asking questions	George handed round the cups to the children saying, "There's one for you, and one for you," as he went around the group.
Use some number names accurately in play	
Willingly attempt to count, with some numbers in the correct order	
Recognise groups with one, two, or three objects	When Nicole arrived each day she counted how many children had already put their name label to show they had arrived.
Show confidence with numbers by initiating or requesting number activities	
Count up to three or four objects by saying one number name for each item	Simeon pointed to the numeral 5 on the telephone. 'That says five and I'm five too,' he said.
Recognise some numerals of personal significance	
Begin to represent numbers using fingers, marks on paper or pictures	
Recognise numerals 1 to 5, then 1 to 9	Even when the game was over, Josh continued throwing the die, reading the numeral and counting out the counters from a pile.
Count out up to six objects from a larger group	A group of children were doing a jigsaw together. They shared out the pieces and counted to check that everyone had the same number.
Count actions or objects that cannot be moved	
Select the correct numeral to represent 1 to 5 then 1 to 9 objects	
Show increased confidence in numbers by spotting errors	
Count an irregular arrangement of up to 10 objects	Ref: Investing in our Future: Curriculum Guidance for the Foundation Stage. London: Qualifications and Curriculum Authority. (May 2000)
Say the numbers after any number up to 9	
Begin to count beyond 10	

How do Counting Skills Develop?
Learning Framework
Emergent – A child who is an emergent counter may have some number knowledge but it is generally made up if discrete pieces of information. For example the child may know some of the sequence of number words and be able to recognise some numerals while still being an emergent counter.

Perceptual – A child who is a perceptual counter can count perceived items, matching number word sequence to the items. A perceptual counter is limited by his or her knowledge of the forward sequence of number words.

Figurative – A child at the figurative stage can determine the total in two collections of concealed items but typically counts from 1 to do so.

Counting on – A child at the counting on stage uses advanced count by one strategies to solve addition or missing addend tasks. A number takes the place of a completed count and a child can count on or back to solve problems.

Facile – A child at the facile stage can use a range of strategies other than counting by one. This includes a part-whole knowledge of numbers that enables children to draw on doubles or known combinations to five and ten.
Count Me In Too Project, NSW

Symbol Development

Martin Hughes worked with a group of ninety-six children whose ages ranged from 3yrs 4mths to 7yrs 9mths. His 'Tin Game' involved children recording on paper 'something to show' how many bricks were in the tin. The responses the children made were grouped into four broad categories, each of which represented the child's stage of development in recording using number symbols.

Stage One: The initial stage of recording Hughes called the idiosyncratic stage where children used scribble, the meaning of which was not clear.
Stage Two: The second stage was the use of pictographs where children represented the number of bricks in the tin with a picture that showed some semblance to what they were trying to represent
Stage Three: Iconic was the third stage and children used the like of tally marks to represent in a 1-1 matching with the number of bricks.
Stage Four: The final stage was the use of formal or conventional symbols

Ref: Hughes, M. (1986). Children and number: Difficulties in learning mathematics. Oxford: Basil Blackwell.

9.9. APPENDIX I: GAME USAGE CHARTS

Date	Day	Observed No of Times	Games	Assistance	Which Children	Which games
16-Oct	1	7	6	nil	Jimx2 Susanx2	Humptyx3Stonesx3
17-Oct	2	4	2	nil	Jim	Humpty Stones
24-Oct	3	5	2	R	Kimx2 Jimx2 Harry	Other Humpty
25-Oct	4	5	4	nil	Jim Susan	Humptyx2 Stonesx2
26-Oct	5	3	6	nil	Joe Kimx3 David	Humptyx2 Stones Otherx3
27-Oct	6	1	1	T	Alice Kim	Order
30-Oct	7	7	6	Rx3	Susan Harry Susan	Stonesx4 Orderx2
31-Oct	8	7	9	Tx4 Rx2	Alice Jacob x2 Harry David x2 Jim x2	Beehive x2 Catsx4 Stones Humpty Order
1-Nov	9	6	1	T	nil	Snap/Memory
2-Nov	10	7	8	Rx5	Jim x4	BeeHive Cats x2 Snap/Memory x2 Humpty x3
7-Nov	11	5	7	Px1 Tx2	Jim	Cats x2 Snap/Memory Clowns x2 Other x2
8-Nov	12	7	2	T	Kim x2 Helen	Cats Other
11-Nov	13	3	3	nil	Susan Jacob Joe	Stonesx2 Humpty
13-Nov	14	4	4	Px2	Jacob x2	Clowns x4
14-Nov	15	2	2	T	Jacob Harry	Caterpillar Track
15-Nov	16	7	5	nil	Jim x3	Clowns Track x2 Cats Bee hive
16-Nov	17	1	1	R	Harry	Caterpillar
20-Nov	18	7	8	R x3	Kim x3 Susan x2 Jacob	Caterpillar x4 Track x2 Stones x2
21-Nov	19	7	7	Rx3	Harry x2 Jacob Kim	Clowns x5 Track Other
22-Nov	20	7	6	Rx2 T	nil	Clowns x3 Caterpillar x2 Cats
23-Nov	21	1	1		nil	Beehive
		103	91	R x20 Tx11 Px2 nil x6		

9.10. APPENDIX J: DETAILS OF SCORING FOR CHILDREN'S INTERVIEWS

Skill being Assessed	Level of Success	Allocated Score
Rote Counting	1-5 6-10 11-16 17-24 25-34 35+	1 2 3 4 5 6
Meaningful Counting	Set of 4 Set of 6	1 1
Cardinality Principle	Demonstrated Not understood	2 0
Order Variance	Understood Not understood	2 0
Recognition of Numerals	Recognises1-3 Recognizes 4-6 Recognizes 7-10	1 2 3
Identification of Numerals	Identifies 1-3 Identifies 4-6 Identifies 7-10	1 2 3
Writing of Numerals	Scribbles Pictographic Iconic Numeral	1 2 3 4
Ordering of Numbers	Use Counting Instant after Instant before	1 2 2
Subitising	Set size 1-3 Set size 4-6 Set size 7-10	1 2 3
Addition Direct Modeling	1 correct 2 correct 3 correct	1 2 3
Subtraction Direct Modeling	1 correct 2 correct 3 correct	1 2 3
Addition Imaginary	1 correct 2 correct 3 correct	1 2 3
Subtraction Imaginary	1 correct 2 correct 3 correct	1 2 3