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SCHOOL-INITIATED MATHEMATICS IN THE HOME:

FIVE-YEAR-OLDS AND THEIR PARENTS INTERACT

FIONA RUTH ELL

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Arts in Education,
The University of Auckland, 1998
Families' use of a Maths Games Library was investigated using a socio-cultural framework. The Maths Games Library was a home-school communication project, initiated by parents and teachers at North Primary. Thirteen families took part in audio-recording their game playing with their five-year-old children. Thirty-one families were interviewed by telephone about their use of the Maths Games Library. Families were found to use the games in a variety of ways. The games were played with different group compositions and frequencies, and were an established part of the home-school routine. Analysing the interaction on the audio tapes revealed two frameworks for the game playing activity, those of a game-focused framework and a mathematics-focused framework. Parents in a game-focused framework played as equal partners with their children, taking turns and talking about the progress of the game. Many turns were silent. Parents who used a mathematics-focused framework introduced more mathematical concepts through game play, and questioned their children more frequently. Longer interactions resulted from this, and parents and children responded contingently to each other more often than in the game-focused framework. One teacher recorded game playing with two children. Their dialogue suggests an evaluative framework which may be part of a school-bound interaction pattern. Within the mathematics-focused framework, three approaches to introducing the concept of addition are found. The results suggest that parents mediate children's mathematics learning through game playing in distinct ways. Evidence of scaffolding or contingent responsiveness can be found in game playing when the parent, child and game are considered as part of the activity. Parents responded to the child and the game by adapting the game, introducing more advanced concepts, and choosing an appropriate framework. Communication from the home to the school, informing parents about children's learning in mathematics and levelling of the games are considered as areas which could improve the role of the games as a bridge between home and school. The study highlights the significance of activity as the agent of development, indicating that the nature of interaction between players in a game can make a difference to children's learning in mathematics.
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This thesis is dedicated to my husband Ross and my son Angus, who suffered the most.
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CHAPTER ONE

THE MATHS GAMES LIBRARY PROJECT AND
THIS RESEARCH - AN INTRODUCTION

I think the maths games library is a really valuable resource and an excellent way of involving parents and children in maths discussion.
Parent, Family 7

The maths games library is a superb encouragement of interaction with children and number learning. When it's enjoyable for children, they learn faster.
Parent, Family 9

These comments from parents of five year olds refer to a 'maths games library', a resource of games and activities for parents and children to share at home. This library was established in 1996 by a team of parents and teachers. To understand and interpret the findings presented in this thesis it is necessary to know something about the maths games library - how it came to be, what is in it and how it works.

In 1995, the Ministry of Education offered a contract to schools entitled ‘Parent Education in Relation to Mathematics’ (PERM) (Cooper, Patrick & Whitehead, 1996). This contract offered schools payment for teachers to be released from the classroom and inservice education on working with parents. Teams were established in each school, comprising parents and teachers. These teams developed a survey for all parents to complete, and then planned appropriate activities to meet the needs expressed by the school community. The schools involved tackled a range of projects, each of which was tailored to the survey results. At this time, the author of this thesis was the teacher responsible for maths in a high decile primary school on Auckland's North Shore (referred to throughout this thesis as 'North Primary'). A large amount of community support for the PERM project was forthcoming in this school community, and a team of four teachers and eight parents was established. The school already ran a Family Maths programme (Stenmark, Thompson & Cossey, 1986), and had been doing so for over five years.
The value of this tradition was reflected in the parents' responses to the survey, where the Family Maths programme was felt to be very useful and enjoyable. Parents also requested evening sessions on the curriculum, and many indicated they would be willing to attend a series of these meetings. Four evenings were held, each taking a curriculum strand, and showing how it was taught across the levels of the school. One evening was led by a mathematics adviser. An evaluation of these sessions led to a further survey - what did parents wish to do now? The most popular option for continuing parent education was the establishment of a 'Maths Games Library', a lending system where children could bring home mathematics activities to share. A particular need was identified in Year 2, where children did not have homework as such, and parents felt they saw a lot of reading books, but knew nothing about their child's maths progress.

A team of teachers and parents worked together to make the game sets. This team comprised members of the school's PERM group, and additional parents who expressed an interest in being involved. Twenty parents were involved over a two-day period, alongside two teachers. Some commercial games were purchased, other games came from a range of mathematics source books and teachers' ideas. Materials such as polyhedra construction equipment were also purchased and included in the kits. Thus some of the activities were materials for the parent and child to explore together, but the majority were more 'game-like', with a turn-taking pattern.

Thirty-five game bags were provided at each class level. Brightly coloured bags with velcro tops were used to hold the games, and sets were colour-coded for each class. In each bag were instructions, playing equipment and any additional materials required, such as counters or calculators. The bags were designed to provide everything necessary for game playing. The PERM team coloured and decorated the games, and they were all laminated to make them as attractive as possible. A decision was made not to include consumable materials such as worksheets or paper. Each week the children would be issued with a game, and a week later they would return it. Teacher Aide time was provided to check the contents of the bags and allocate the games to children. Each classroom was provided with a crate for issuing and a crate for returns, which were stored in the classroom.
In the first year of the project, 1996, game sets were made for Year 2 and Year 3 (two sets of each). In 1997, sets for the New Entrant / Year One classes were made. Sets for Year 4 are being produced in 1998.

The New Entrant / Year One set is the basis of this study. The materials in this set are similar to those described above, but include a number of games drawn from the work of Young-Loveridge and Peters (1994). As these games had been the focus of effective intervention previously, they formed a primary source for the games library at this level.

The 'Maths Library' idea emerged from three sources. Firstly, the notion of using games at home came from the work of Young-Loveridge (1993). The team were looking for a way of communicating something about the ways mathematics could be learned and explored, as well as about the contents of the mathematics curriculum. Game-playing was felt to be an open-ended activity, which would encourage talk about mathematics and would show the value of such activities in the classroom. The second source of inspiration was the Inventing Mathematics for Parents and Children Together (IMPACT) project (Merttens & Vass, 1990). The notion of taking home mathematics to 'do' together with parents came from here. An essential aspect of IMPACT was missing from this project, however. The children did not know the games they were getting and were not able to take the initiative in the home as IMPACT children were. In addition, the results of the game playing were not included in the classroom programme. Essentially, the games library operated separately from the classroom, and separately from classroom teacher involvement. The third information source was another school which had already established a games library. The PERM support team located a teacher who had worked with parents in a West Auckland school to devise a games library. She had included worksheet and writing activities as well as games, and had developed games for Years 1-3. Although she had recently left the school (and begun another library project), she met with the parent-teacher team and showed us what she had done and talked about the practicalities of administering the library. Her library had been launched with a fish and chip night, to which a large number of parents had come. Following this, parents had been invited to join the library, and signed on to say they would be responsible for the equipment.
This had proved very successful, both for preserving the equipment and involving the parents in the project. This scheme was not adopted by the project under discussion, however, as it was felt that strong links with the parents had already been established.

The games library is now an established part of the North Primary school programme in Years 1-3. When the project commenced, in 1996, evaluation forms were included with each game. These forms gathered feedback on difficulty levels and enjoyment of the games. However, the games are now sent home without any formal means of communication between the parents and the school. Many of the parents who were involved in setting up the Maths Games Library have moved on from the Year 1-3 level of the school. Only one of the four key teachers remains at the school. The games remain as an artefact of this communication project.

The aim of this study was to investigate and describe how the games were used by parents and children. I wanted to look beyond whether or not the games were used and consider how they were used and what sorts of interaction were supported by playing the maths games. When we initiated the Maths Games Library we believed we were setting up a bridge between home and school that would communicate to parents about their child's mathematics learning and about the mathematics we taught. The missing factor was what the parents would do with the games. This study aims to fill that gap.
A child and a parent empty a schoolbag. Inside they find a reading log, home reading book and a brightly-coloured bag containing a maths game. The game is for the child and parent to play together over the coming week. It is part of a set of games which come home every Wednesday. Later, the child and the parent sit down and empty the contents of the maths bag. Together they read and discuss the instructions. They sort out the equipment. They begin to play.

A teacher sends the maths groups off to begin their tasks. A child remains behind to spend some time with the teacher. The teacher shows the child some dice and they discuss the number of dots. The teacher explains that the dice are for a game about numbers. The rules are described. They begin to play.

The interaction between the adults and the children in these two settings may have important implications for the child’s development. A theoretical viewpoint which highlights the importance of social interaction in development sees settings such as these as critical sites for the formation of concepts and the growth of cognition.

The sociocultural framework outlined in this chapter views development in this way. Based on the work of Vygotsky (1978) and later theorists, individual development is seen as occurring through social processes. We begin by examining how the ‘social’ becomes ‘personal’, and consider what this implies for research methodology. Discussion of activity as the unit of analysis and co-construction as a process for study follows this. Vygotsky’s (1978) notion of the ‘zone of proximal development’ is explored and extended, considering the ways in which activity in the zone of proximal development is situated in contexts, and the ways in which learning is mediated.
FROM SOCIAL TO PERSONAL

Vygotsky (1978) initiated thought and research from this perspective when he described internal mental functions as originating in social processes.

Every function in the child’s cultural development appears twice: first, on the social level, and later on the individual level; first between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary action, to logical memory and to the formation of concepts. All the logical functions originate as actual relations between human individuals. (Vygotsky, 1978, p. 57)

The child lives and works alongside more expert peers and adults. From the interaction and observation they are involved in, the child gains concepts and skills, which become part of their own intellectual functioning. We come to know what we have experienced, and our experiences are inherently social - "...the very processes or relationships that are involved in social interaction are eventually taken over and internalised by the child to form individual cognitive processes" (Wertsch, Minick & Aras, 1984, p. 157). What is experienced is social - it is socioculturally defined - and the means by which it is experienced is social - through an interactional setting (Wertsch, Minick & Aras, 1984). Viewing development in this way, rather than as an internally-driven, biological process which occurs without reference to its context, has significant implications for learning in the broadest sense. Researchers (Wertsch & Stone, 1985; Rogoff, 1995; Greenfield, 1984) have attempted to observe and elaborate the process by which the social becomes personal, to search for mechanisms by which this might happen, and to expand and define Vygotsky’s (1978) work in a range of contexts.

Greenfield (1984) compared two contrasting settings, in order to discover any similarities of process between the two. Comparing language acquisition by toddlers in Los Angeles with the learning of weaving patterns by adults in Mexico, "The aim (was) to show that, although a learner’s age, culture, native language and skill are totally different, the same developmental and educational process from interindividual activity to individual accomplishment applies." (Greenfield, 1984, p. 118). Greenfield was able to observe the acquisition of skill by the learners, and the help provided by the teachers/parents in these settings, through analysis of video tape. The help and information provided
through interaction between the participants, led to change in the functioning of the learners in both contexts.

Game playing can be a rich source of social interaction. Playing games which are designed to teach mathematical concepts should be an ideal site for learning as described by Vygotsky (1978). The interaction between players (social) will become understanding of mathematics (personal).

INTERNALISATION

The process of making understandings developed in social interaction into an individual understanding is termed 'internalisation'. How this occurs has been the subject of discussion and study, as it crucially describes the practicality of Vygotsky's proposal (Wertsch & Stone, 1985). The knowledge or skills acquired by participants in a social interaction are not stored as exact copies of the social experience. While aspects of the culture and social organisation are acquired within the learned item, each person's internalisation can differ in important ways. This notion of construction of understanding from social interactions leads to a view of learners as active 'constructors' of knowledge, and emphasises the interaction between the context (and its implicit cultural and social elements) and the learner's past experiences and knowledge framework. Wertsch & Stone (1985) examine the interaction between a mother and a child as they assemble a puzzle from a model. In early interactions the child asks where pieces should be fitted and is directed to look at the model. In later interactions, the child spontaneously checks the model and finds the piece's location. Elements of the mother's directives are reflected in the child's description of what they are doing. Both the strategy, and the language by which it was established, have been internalised. (Wertsch & Stone, 1985). These authors note that the 'internal activity', which they are attempting to view through problem solving, is itself "...quasi-social in nature" (Wertsch & Stone, 1985, p. 177). Even our internal constructions have a social structure.

By viewing a parent and child playing a maths game together we might see a similar process. Aspects of the task which are initially controlled by the parent could be seen as part of the child's functioning later
in the game. The child's changing constructs, about mathematics or about the game, could be revealed through game play.

Rogoff (1995) takes this notion a step further in her description of three "...inseparable, mutually constituting planes comprising activity" (Rogoff, 1995, p.139). Apprenticeship, guided participation and participatory appropriation are the labels Rogoff (1995) uses for the three aspects of her analysis. At a community level, activities are organised and selected. This constitutes apprenticeship. Learners acting together with more expert partners, or with materials and resources provided by others, are involved in guided participation. Participatory appropriation describes the mechanism discussed above, where the social becomes personal.

Rather than viewing the process as one of internalisation in which something static is taken across a boundary from the external to the internal, I see children's active participation itself as being the process by which they gain facility in an activity. (Rogoff, 1995, p. 151).

This definition brings the children's role in the activity into focus, and defines learning within that activity, rather than within the child.

Instead of studying individuals' possession or acquisition of a capacity or a bit of knowledge, the focus is on the active changes involved in an unfolding event or activity in which people participate. Events and activities are inherently dynamic, rather than being static conditions to which time is added as a separate element. (Rogoff, 1995, p. 152).

Participatory appropriation is development which occurs dynamically through activity. Activity is thus the key unit for further analysis of growth and change.

**ACTIVITY AS THE UNIT OF ANALYSIS**

Adopting activity as the unit of analysis poses methodological and theoretical challenges. That activity should be studied, rather than the change in participating individuals or the environmental stimuli, is a direct inference of the socio-cultural viewpoint outlined here (Wertsch, 1995). If change is brought about by social processes becoming individual processes, then the substance of the social processes (the activity) is the agent of development. Viewing activity in systematic ways can lead us to understanding the learning contained within it, as well as the ways in which that learning is established.
Leont’ev (1978) defines activity at three levels. Within what we see people doing are three components. The motivation to act provides a goal for the activity. Leont’ev (1978) terms this basic level ‘activity’. To reach the goal which motivated the activity, people choose ‘goal-directed actions’, the second level of Leont’ev’s (1978) analysis. The third level is ‘operations’. These are the situationally defined aspects of the activity; how people go about employing their choice of actions. In the context of this study, parents and children are motivated to play the maths games, so they begin (activity). Several parents may decide to use counting (a goal-directed action) to play the game, but the way in which they employ it may differ (operations). Wertsch, Minick and Aras (1984) elaborate: “...the ultimate goal of the theory of activity is to understand the interrelationship among the three levels of analysis - activity, action and operation” (p. 159). If we are to use activity as the unit of analysis, we must consider these three levels. Observed activities which do not differ at the level of motive, may be significantly different at the operational level.

Rogoff (1995) also proposes that activity, its content and processes, are the mechanism for the individual’s development.

The participatory appropriation view of how development and learning occur involves a perspective in which children and their social partners are interdependent, their roles are active and dynamically changing and the specific processes by which they communicate and share in decision-making are the substance of cognitive development. (Rogoff, 1995, p. 151).

CO-CONSTRUCTION

As the learner is an active constructor of knowledge, so are the other participants in the learning situation. “...A person who is participating in an activity is a part of that activity, not separate from it” (Rogoff, 1995, p.153). As the result of an interaction between a parent and a young child, the parent may introduce new vocabulary items to the child, and come away with an enhanced knowledge of the child’s perceptions of the event, through their dialogue. Both are working together to define the situation. “One may focus on the joint participation of two people in the completion of the task and the negotiation of the transfer of information, as they work together in an interdependent fashion to construct the event” (Rogoff & Gardner, 1984, p. 113). Learning is the result of a joint negotiation of meaning, through activity. Valsiner (1988) notes that it is "...a rather complicated intellectual task to try to concretize
development as a co-constructivist process” (p. 283) because of the complexity of activity viewed in this way. A co-constructivist analysis holds that "..the child necessarily is included as an active partner in the social process that guides his or her own development" (Valsiner, 1988, p. 289). Children do not just receive understanding through activity, they are initiators and adaptors as well. Co-construction is discussed more fully in the section on 'Operations in the zone of proximal development', where it can be seen to occur. The games used as a focus for this study were designed to be played by the parents and children together. Co-construction was expected to be an important feature of the observed activity.

THE ZONE OF PROXIMAL DEVELOPMENT

The ‘zone of proximal development’ (Vygotsky, 1978) has become a powerful description of how children’s potential is best defined. “It is the distance between the actual developmental level as determined by independent problem-solving and the level of potential development as defined through problem solving under adult guidance or in collaboration with more capable peers” (Vygotsky, 1978, p. 86). What the learner can do with assistance is seen as the best description of their potential. (Brown & Ferrara, 1985). When ’starting where the child is’ is suggested as the basis for teaching programmes, this level is usually set by assessment of their individual functioning. Seeing assisted performance as the point of diagnosis has many implications for the way both teaching and assessment are organised. The joint activity undertaken is crucial within this model. The ‘zone of proximal development’ at any given time is determined by the participants, the setting and the activity undertaken. Rogoff (1995) outlines the dynamic nature of this interaction in her concept of ‘guided participation’, where activity in the zone of proximal development is viewed. “The concept of guided participation refers to the processes and systems of involvement between people as they communicate and coordinate efforts while participating in culturally valued activity” (Rogoff, 1995, p. 142). Each of the elements of this description highlight key concepts in defining and observing activity within the zone of proximal development. Culturally valued activity implies that the activity is culturally determined, regarded as worthwhile by the participants, and does not stand alone - it has ‘come from’ somewhere. Communication and coordination of efforts suggests the use of language and symbol to negotiate meaning, and that this is a two-way process. The ‘processes and systems of involvement’ highlight the interaction patterns and arrangements with which
the task is attempted. If we are to make sense of our observation of joint activity, we must examine these ideas further.

ACTIVITY IS SITUATED

The activities we observe, in both formal and informal settings, do not occur in a vacuum, nor do they occur at random. An activity which participants choose to engage in is one which they both perceive as important. This importance may derive from cultural imperatives or from societal structures, from the participants’ past experience, from global or local media. “...The organisation of systems of activity at the societal level establishes important parameters that determine the manner in which an individual or group of individuals carries out and masters a particular type of goal-oriented action” (Wertsch, Minick & Aras, 1984). The activity is thus situated in time and place, within a cultural and physical milieu - the activity’s context. The activity and its context are bound together. If we remove the activity from its context, important factors in understanding it are lost. As framework or filter, the context determines what its learned from the activity. The knowledge and skills developed through activity are tied to their context in this view, and may not automatically transfer to other situations. Lave, Murtaugh and de la Rocha (1984) highlight the difference between laboratory tasks and observation of ‘everyday life’. Their study of grocery shopping involved subjects wearing portable tape recorders and describing and discussing their purchases with a researcher, as they did their weekly shopping, within the context of their local supermarket. This was of key importance as “…activity is dialectically constituted in relation with the setting” (Lave, Murtaugh & de la Rocha, 1984, p.73).

Activity, and therefore learning within this sociocultural framework, is thus context-bound in several ways. Activities arise from a cultural and social background; they are selected because they are important for that time and place. Participants learn not only the content of the activity, but also its structure and the processes of its construction, tying the learning to aspects of the physical and social context in which it occurred. Performance may differ across contexts, because of the ‘rules’ and experiences within each. This has particular implications for considering the links between home and school, which are examined in this study.
LEARNING IS MEDIATED

Between the learner and the concept, through the progression of activity, is a guide. In the "zone of proximal development" (Vygotsky, 1978) and in "guided participation" (Rogoff, 1995), the expert other provides assistance to the learner. For Vygotsky (1978), the guide is present; in guided participation the arrangement can be "...not only the face-to-face interaction, but also the side-by-side joint participation that is frequent in everyday life and the more distal arrangements of people's activities that do not require co-presence" (Rogoff, 1995, p. 142). In face-to-face or side-by-side interaction, the mediation is often provided through discourse. When the partners are physically or temporally distant, symbol use is employed. Considering early learning, when parents select and shape children's experience, "...mediated learning experiences are an essential aspect of development" (Brown & Ferrara, 1985, p. 278).

Mediation can be active, or it can be merely providing a model, as is often the case in the 'everyday' situations discussed by Rogoff (1995). "Using imitation, children are capable of doing much more in collective activity or under the guidance of adults" (Vygotsky, 1978, p. 90). Vygotsky sees imitation not as simple copying, but as active learning. He suggests that we cannot imitate what we are not developmentally ready for; providing a model is one way in which activities are mediated for children.

Wertsch and Stone (1985) note that "Vygotsky's account is based largely on an analysis of the semiotic mechanisms, especially language, that mediate social and individual functioning...semiotic mechanisms provide the bridge that connects the external with the internal and the social with the individual" (p. 163-164). Brown and Ferrara (1985) report on early studies of reciprocal reading, a group technique which "...mimicked the 'ideal' internalisation mode suggested by Vygotsky" (p. 299). Children were trained to take the role of questioner in a group reading situation; they became the mediators. Reading comprehension performance improved dramatically using this technique.

Language, be it written or spoken, is a powerful mediation tool or semiotic mechanism. The content and the structure of discourse in an activity both have implications for the learner. Whether or not one is 'allowed' to question, whether a turn-taking structure is adopted or whether one's presence is acknowledged are all structural aspects which influence what is learned, and become part of that
learning. The content of the discourse, such as links to prior experience, questioning, providing models or correcting and evaluating also influence what is learned.

Vygotsky (1978) emphasises the role of speech in solving problems.

A child's speech is as important as the role of action in attaining the goal. Children not only speak about what they are doing; their speech and action are part of one and the same complex psychological function, directed toward the solution of the problem at hand." (p. 25).

In addition it allows for a "superior form of activity" (Vygotsky, 1978, p. 28) - communication and cognition at more advanced levels. We can communicate and think using language and we can reflect on language items as objects themselves. In this way language as a 'sign' or 'psychological tool' provides mediation in two ways. Clearly defined, context-free language 'objects' are available for discussion, and language is available as a 'mediational means' (Wertsch, 1991). Other 'psychological tools', listed by Vygotsky, which can be employed as mediational means include counting systems and the symbols of algebra. (Wertsch, 1991).

Learning can be mediated in ways that are specific to settings. The way in which symbol and language are used may differ significantly between home and school. The interaction arising from the playing of maths games may highlight this. Greenfield (1984) notes that there is a difference between the mediation styles at home and in school. “Teachers more than parents allow children to work independently, learning from their own mistakes...one reason why trial-and-error learning may be more prevalent at school...is a difference of emphasis on learning vs getting the task done.” (p. 136-7). At school, the motive for the activity is for the child to learn, in the home situation the motive is to complete the task. Mediation of learning can thus take many forms. These forms are essentially the 'operations' of Leon'tev's (1978) theory of activity, the means by which the goal is reached. Observation of joint activity in the zone of proximal development suggests several key elements of these operations.

OPERATIONS IN THE ZONE OF PROXIMAL DEVELOPMENT

If development is proceeding through joint activity, certain observable interactions and actions should arise. Scaffolding (Wood, Bruner & Ross, 1976), where the more expert partner provides aid in response
to the learner's level and progress has been frequently observed (Rogoff & Gardner, 1984; Greenfield, 1984, for example). As the learner becomes more expert, the scaffold is reduced and the learner takes more responsibility for aspects of the task. This transfer of responsibility is also observable, although not always at a microgenetic level on one occasion as "...the transformation of an interpersonal process into an intrapersonal one is the result of a long series of developmental events" (Vygotsky, 1978, p. 57). An essential part of co-construction of knowledge is that participants in the activity come to agree on the meaning and purpose of the activity, as well as its progress. The establishment of intersubjectivity is thus one of the key requirements, and goals, of joint activity.

Rogoff and Gardner (1984) set up a problem-solving situation, where mothers were asked to help their children prepare for a memory test. Their observations showed that the mothers planfully structured their children's learning.

The structuring of the instruction serves as a scaffold for the learner, providing a framework for the solution to the problem. The learner can use this scaffold to support performance of new task components which he or she might not be capable of handling alone. (Rogoff & Gardner, 1984, p. 98).


This construction of a scaffold piece-by-piece constitutes an interactive situation in which the child's response plays a role in stimulating additional scaffolding by the mother. Hence, the scaffold results not simply from the mother's action, but also from the process of interaction between mother and child. (p. 121).

The scaffolding of learning can thus be described as a two-way process in which both participants are active (but not necessarily equal) in determining the nature of the scaffold provided. Integral to this is the transfer of responsibility for aspects of the task from the 'expert' to the 'novice'.

"Subtly testing the child's understanding by reducing the level of scaffolding and thereby allowing the child to participate to a greater extent" was observed by Rogoff & Gardner (1984, p. 110). It was seen to be "...a subtle process involving successive attempts by the participants to assay the novice's readiness for greater responsibility and negotiations of the division of labour" (Rogoff & Gardner, 1984, p. 107). The transfer of responsibility is not seen as a sudden 'handing-over' of the task. Elements of the task are transferred as the child indicates their readiness, through performance or discourse. Errors are a tool. They are "...important for the calibration of the level of difficulty ...and the transfer of responsibility..."
from mother to child” (Rogoff & Gardner, 1984, p. 110). In order to ‘make the most’ of these cues, both participants must understand each other, and share some understanding of the task at several levels. Establishing intersubjectivity is a key goal in discourse observed in the zone of proximal development.

“People who are concerned with jointly accomplishing a cognitive performance must possess or create a common framework for the coordination of information” (Rogoff & Gardner, 1984, p. 97). Wertsch (1984) emphasises this, stating “...though the adult and child are functioning in the same spatio-temporal context, they often understand this context in such different ways that they are not really doing the same task” (p.9). This must be overcome if participants are to effectively co-construct in the zone of proximal development. The use of language, particularly redundant terms, linking with past experience, using objects which are physically present and questioning are some techniques through which intersubjectivity may be established. Wertsch (1984) notes that “... intersubjectivity is often created through the use of language” (p.13). Without the establishment of intersubjectivity, participants will be at ‘cross purposes’ and will be unable to utilise the techniques described here. Clark & Brennan (1991) term this ‘grounding’. They note that partners in communication must coordinate on the content of the communication and on the process of its delivery. “Grounding is crucial for keeping (that) coordination on track” (Clark & Brennan, 1991, p. 148). Krauss & Fussell (1991) emphasise the role of prior knowledge of others and shared experience in coordinating communication. Constructing a ‘shared communicative environment’ is seen as a product of two information sources - “...prior beliefs and expectations about others, and feedback that derives from the dynamics of interaction.” (Krauss & Fussell, 1991, p. 173). A shared understanding of tasks and selves is necessary for learning to proceed. In the home, shared understanding of selves may be strong and the task unfamiliar. At the transition to school, the task and the adult mediator may both be unfamiliar. In game playing we may see differences in the types of assistance offered because of this.

The theoretical framework outlined here is largely that - a theoretical framework. Illustrative evidence is presented by some authors (Greenfield, 1984, Lave, Murtaugh & de la Rocha, 1984; Rogoff & Gardner, 1984; Wertsch & Stone, 1985) Others have examined activity in detail through the sociocultural
framework. (Brown & Ferrara, 1984; Rogoff, 1995). Much of the discussion is presented at a theoretical level. While giving a broad view of what is useful to consider in research, explication of methodology and analysis techniques is largely absent. The socio-cultural perspective demands that we view activity in a certain way. Translating this into practical research methods poses a challenge for researchers.

The adults and the children - described in the introduction to this chapter - sharing maths games together are participating jointly in a societally-determined and culturally-bound task. As they communicate and negotiate about the rules of the game, the strategy, and the mathematics contained within it they are actively co-constructing knowledge - about mathematics, about games and about each other. Although delineated by time and space, their joint activity may illustrate the principles outlined here. From a socio-cultural viewpoint, the sharing of these maths games could be an important setting for learning mathematics.
CHAPTER THREE
LITERATURE REVIEW

The socio-cultural framework described in Chapter 2 sees everyday settings as crucial for the development of both social and cognitive functioning. Learning does not just occur in formal educational settings. Increased recognition of this has lead to new research agendas, where children are regarded as bringing useful knowledge and skills with them to school, rather than arriving naive to the cognitive curriculum (Sulzby & Teale, 1991). Emergent literacy and emergent numeracy are used to describe this early development, which occurs outside the context of formal schooling. Taking this approach then emphasises the role of the home setting in children's cognitive development. What seems ordinary and commonplace in daily life can be an important mechanism for children's learning. What is done at home is important. This review considers work in emergent literacy and early learning of other tasks as well as emergent numeracy. The socio-cultural viewpoint suggests that the mechanisms by which understanding develops are similar across traditional subject boundaries. Therefore this review covers parent and child interaction and home-school links in literacy and other areas, as well as numeracy.

New relationships and roles develop when the settings of home and school meet (Bronfenbrenner, 1986). How each values the contribution of the other, and the degree to which they are similar has an key influence on children's learning (McNaughton, 1995). Viewing learning at home as inherently inferior to learning at school may be ignoring a powerful source of help for both teacher and child. How ideas about the roles of 'parent' and 'teacher' are constructed within social settings may vary in important ways.

This chapter will review research on the home setting as a key site for learning, establishing its place as a 'construction zone' (Lehrer & Shumow, 1997). Research on the influence of activity in the home on children's learning will be considered. Patterns of interaction emerge from this literature, which are distinct for parents and teachers. Having considered research on the nature of the home, we will turn to
research on bridging home and school settings. Attempting to account for differences between families in this context will be discussed. Research will be reviewed on the nature of parent-child interaction which highlights the importance of contingent responsiveness. In studies of both literacy and numeracy this has been found to be a key feature of more successful exchanges.

THE HOME AS A 'CONSTRUCTION ZONE'

The socio-cultural framework describes the home as a powerful place for children's development. Construction zones are defined by Lehrer and Shumow (1997) as "...activity settings in which the mutual construction of knowledge arises through collaborative interaction, shared meaning and assistance" (p. 43). Research on what occurs in the home shows that they can indeed be viewed in this way.

Literacy researchers have explored the home as a context for the development of emergent literacy (Sulzby & Teale, 1991). McNaughton (1995) outlines a 'socialisation model of emergent literacy' (p.2) which views the emergence of early reading and writing behaviours as developed through activity in the family setting. Families are seen as selecting, arranging and deploying resources to create joint, ambient and personal activities which lead to the emergence of situated expertise in the child (McNaughton, 1995, p.3). Literacy skills are acquired, practised and refined within the family setting. The agent of this development is activity, be it practising alone (personal), being around when it is done (ambient) or trying it with someone (joint). Thus, prior to formal instruction, children can be seen to have a range of skills, attitudes and knowledge about literacy, developed through their activity in the family setting.

Case study research presents a rich picture of the construction of understanding at home. While the results are necessarily limited and not able to be generalised, they do provide insight into how a child's understanding develops. Anderson (1993) reports on a case study of her daughter. Anderson discusses how she has

...mediated her mathematics development by counting the steps as we ascend the stairway or counting down the days until Christmas; pointing out and discussing geometrical shapes in the environment; comparing sizes of objects and people and exploring number patterns and operations' (Anderson, 1993, p. 27)
These simple, everyday events have been used to establish understandings, within the setting of the home.

Researchers observing parents at work with their school-age children also see a 'construction zone' in which children are learning. Pratt, Green, MacVicar and Bountrogianni (1992) and Lehrer and Shumow (1997) both present data which shows parents as establishing a pattern of support for children's learning. The home is not a neutral place where children operate independently. It is a place where social, cultural and cognitive forces come together to influence children's development. The present study observes children within this 'construction zone' to establish its nature and essential elements.

THE INFLUENCE OF ACTIVITY AT HOME

Researchers wanting to examine the effects of activities in the home on children's development in mathematics have taken one of two approaches. One group of studies (Reynolds, 1992; Wylie, Thompson & Kerslake-Hendricks, 1996; Wylie and Thompson, 1998) seek information from parents about what is done in the home and correlate this with other measures. A second group of studies (Anderson, 1993, Hewison, 1988 McNaughton, 1995; Phillips & McNaughton, 1990; Saxe, Guberman & Gearhart, 1987; Young-Loveridge, 1989 and Young Loveridge, 1996) looks more closely at what happens in the home that might be promoting development.

Asking parents to respond to a checklist of activities which occur in the home provides a measure of the children's experience. Wylie, Thompson and Kerslake-Hendricks (1996) asked parents to comment on whether their child had been involved in eight numeracy activities, for example counting out loud, telling the time, and using numbers in cooking. They were also asked if their children tried additional number activities. They found that all children had experienced some of the numeracy activities, indicating that children were exposed to numeracy activities before school.

In a follow-up study on the children when they reached six years old (Wylie & Thompson, 1998), mathematics in the home was also considered. Two hundred and ninety-seven families reported on
fourteen home mathematics activities. Twenty-one percent of the children in the highest income group were involved in all fourteen activities. Only 7% of children in the lowest income group were similarly involved. Evidently mathematics was still experienced in the home, but how it was experienced varied widely.

Using a parental self-report measure, as described above, gives results which may not tell the whole story. Parents may mis-report their child’s experiences. At a more complicated level, the parent may correctly report that the child had been involved in the activity, but no mathematics might have arisen. Reynolds (1992) uses parent, teacher and child measures of involvement as sources of information about parent involvement in school tasks. Parents were asked to respond, using a Likert scale, to nine “...potentially enriching interactions...” (Reynolds, 1992, p.446), such as ‘read to child’ and ‘cook with child’. In contrast to Wylie and Thompson’s (1998) findings, the correlations presented indicate that “...parents’ school involvement appears to be somewhat independent of home involvement...” (Reynolds, 1992, p. 450) and that measures of school involvement are related to children’s achievement, rather than home involvement measures. This finding is based on responses to four of the nine parent self-report measures. Reynolds (1992) does not supply any information about how these measures are assumed to ‘tap into’ key dimensions of parent involvement and behaviour at home. Results from Young-Loveridge (1996) highlight this.

Eleven mother-child dyads were asked to do some cooking together in their homes. They were asked to bake something with discrete items, such as biscuits, and were told that cooking was a standard context for the observations, but not that mathematics was the focus. The researcher recorded all the uses of number words during the interactions. The pattern of use differed quite markedly between the mothers and the children. Mothers used a wider range of number words and used number words more frequently, with an average rate of 35 words per hour. Children very rarely used any number above five, and their average word rate was 18.3 number words per hour (Young-Loveridge, 1996). There was a very weak correlation between the mothers’ number use and the children’s number use. Cooking may be a useful context for exploring mathematics, but it may not be used to its full extent by parents. The ability to use
contexts effectively is described by Anderson (1993). As a mathematics educator she was able to recognise the mathematics her child was using, and to utilise everyday happenings in mathematical ways. Other parents undertaking the same tasks may not recognise the mathematics involved. Young-Loveridge (1989) illustrates this further by investigating "the relationship between the home experiences of preschool children and their understanding of number on entry to school" (p.45). Mothers were interviewed about their children's number experiences and their own attitude towards mathematics. The children were given a standard number interview. The six subjects were chosen to represent achievement levels and socio-economic status. From these data, Young-Loveridge (1989) concludes that the number activities which high scoring children experienced were practical and often provided in response to their "spontaneous interest" (p. 55). This is the kind of interaction which characterises Anderson's (1993) description. Modelling of number use in the home was also related to the children's achievement scores. Young-Loveridge concludes "...parents can have an important role to play in arranging for appropriate opportunities which their children can use to solve problems with numbers." (1989, p.57). The importance of this is further emphasised by Saxe, Guberman and Gearhart (1987) who interviewed and observed 78 mother-child dyads about pre-school experiences with number. Their interviews "...revealed that, across (their) age and social class groups, children regularly participated in activities involving number" (p. 115). The 'everyday nature' of these was emphasised by the number of games which were invented by the dyads. "The structure of children's everyday activities and their numerical understandings mesh with one another" (Saxe, Guberman & Gearhart, 1987, p.116) suggesting a close relationship between home activity and number understanding in this sample.

Studies from literacy learning also highlight the influence of activity in the home. McNaughton (1995) provides an analysis which points out the significance of the activities which occur 'around' children, as well as those with which they are personally engaged. The breadth of the model is its strength, as it can accommodate the influences discussed above, in ways which can be observed and discussed. Phillips and McNaughton (1990) present data from tape recorded story book reading episodes. Interaction about the meaning of the story characterised the exchanges, and children were seen to be already expert at understanding narrative fiction at this level. The home activity of story-book reading, common amongst
the study participants, clearly has significance for the children's literacy development. Hewison (1988) investigates the next step in following up children who were part of a home-reading project, three years after the project was completed. Children who were part of the home reading interventions had made gains which were still apparent after three years. Children who had received remedial help from a teacher had not significantly improved, either one or three years after the intervention.

To understand the influence of home activity on children's development, we must understand the nature of the activity. While case study research (Anderson, 1993 and Young-Loveridge, 1989) begins to investigate this, we need to continue to go beyond the notion of what children have experienced at a superficial level, and understand what the key factors are in promoting development through interaction at home. Hewison (1988) notes that she does not know which of the aspects of her reading project caused the gains in children's scores. Further investigation into what actually happens, at a dyad level is needed. Phillips and McNaughton (1990) provide this for literacy learning. We need to know more about mathematics.

** PATTERNS OF INTERACTION AT HOME **

Research into joint activity between parents and children has lead to the description of several patterns of interaction. Some of these come from literacy research (McNaughton, 1995; Sulzby & Teale, 1991), some from studies of assisted problem solving (Wood & Middleton, 1975; Rogoff, Ellis & Gardner, 1984; Saxe, Gearhart & Guberman, 1984) and some from the introduction of specific tasks to parents and children (Anderson, 1997; Lehrer & Shumow, 1997; Pratt, Green, MacVicar & Bountrogianni, 1992; Young-Loveridge, 1993). A key theme from this research is the idea of 'scaffolding' (Wood, Bruner and Ross, 1976), where the more expert partner provides varying degrees of support for the learner as the task progresses. This idea will be discussed further in the section on 'contingent responsiveness' later in this chapter.

That "...variations in storybook reading patterns of interaction affect children's development differentially" (Sulzby & Teale, 1991, p.731) is an established research finding in literacy learning. "It is not merely the presence or absence of storybook reading that affects the child's literacy development....(it
is the) ... ways in which the mainstream parents mediated the book for their children. (Sulzby & Teale, 1991, p.736). Various patterns of support have been documented by researchers. McNaughton (1995) proposes three tutorial systems. 'Collaborative participation' is characterised by joint conversation and responsibility in exchanges, as participants work together to pursue the goal of reading the story. 'Directed performance' requires the learner to copy the model of the expert reader and learn to recite the text. 'Item conveyancing' is a tutorial system where the expert teaches items, such as spellings, to the learner, by modelling and evaluating their performance (McNaughton, 1995). These three systems each have a distinct form and their own rules about participation. McNaughton (1995) notes that parents can be flexible in their choice of strategy, and that they may chose a strategy appropriate to the material being read.

Giving parent-child dyads a specific task to complete allows researchers to see if patterns of interaction emerge. Wood and Middleton (1975) created a problem-solving situation for twelve mother-child dyads. A wooden pyramid was developed which had particular construction features. Mothers were asked to help their children to complete the pyramid in such a way that the children would then be able to do it themselves. A strong relationship was found between the child's performance and the mother's interaction pattern. "The most effective instructors were...those who were systematically most responsive to the effects of their instructions on the child" (Wood & Middleton, 1975, p. 186). There was no correlation between the number of interventions a child received and their performance, rather between the appropriateness of the interventions and their performance - "...a clear distinction between quantity and quality" (Wood & Middleton, 1975, p. 186). The interaction pattern which was most effective was described as 'contingent responsiveness'. This description was termed scaffolding in a paper by Wood, Bruner and Ross (1976) which employed the same pyramid puzzle, but used a researcher, rather than the children's mothers to help the children solve it. Rogoff, Ellis and Gardner (1984) set up laboratory tasks which paralleled a 'home' task and a 'school' task, to observe mother-child interaction in different settings. Both tasks involved sorting and classifying, one of groceries, the other of photographs. Mothers' interactions were coded as directives, open-ended questions and non-verbal instructions. Measures were also made of the child's involvement in the tasks and time spent reviewing for the test which was to come
after the instruction. The younger children received more instruction overall, with evidence that instruction was carefully tailored to the child's ages and needs. There was less interaction about the home task, suggesting that the context in which the task is placed can affect the interaction pattern.

A study which used a mathematical task to examine interaction in this way found differences in the way parents interacted with low and high ability children. Saxe, Gearhart and Guberman (1984) observed mothers and children attempting a task where pennies were matched to Cookie Monster pictures. Two sets were trialed - three monsters and nine monsters. The children were classified as high ability and low ability. Eleven levels of interaction were observed and analysed. On the simpler task, mothers with high ability children provided information about superordinate goals. They did not simplify the task. Mothers with low ability children, however, provided a step-by-step style of instruction, giving the child the necessary strategies. With sets of nine cookie monsters, both sets of mothers were more directive. The mothers of high ability children were able to present the task as an extension of the previous one - 'let's try this one now' - whereas the mothers with the low ability children continued to break the task down for the children. Repeating the last number word uttered by the child was more frequent for mothers working with low ability children. This behaviour increased in the high ability pairs when the task became more difficult.

These three laboratory investigations show parents adopting a style of interaction which is responsive to their child's needs. In the Saxe, Gearhart and Guberman (1984) study, the results could be interpreted as indicating that the parents made the task simpler because they thought their child would be unable to complete it otherwise. Alternatively, the type of help supplied by the parent could be in part determining the child's ability. Children's ability may be a significant factor in the selection of interaction style. For this reason a measure of children's ability has been included in the data collection for this study.

Research which focused on more authentic tasks has also found scaffolding to be a useful description of some parent interaction. These studies found additional patterns, however, which are hypothesised to be less effective (Pratt, Green, MacVicar and Bountrogianni, 1992). Anderson (1997) gave parents a box of materials to work with, and asked parents to tape their interactions with their child as they used them.
Lehrer and Shumow (1997) posed word problems for the children to solve, and asked the parents to help their children. Pratt et al (1992) asked parents to help their children with solving division problems. In each of these studies, the parents can be seen to provide assistance which ranges from very directive (completing the task for the child) to very open ended (making no comment at all). Both Lehrer and Shumow (1997) and Pratt et al (1992) found that parents were more directive with more difficult problems, but that the level of their help fluctuated with the child's performance. Anderson (1997) uses a more open-ended task, and thus has more complex findings. From examining transcripts of the taped interactions, Anderson found that "...parents and children capably co-construct activities in which a variety of mathematics is verbalised, with little intervention beyond the supply of selected materials" (1997, p.508). Although the sample consisted of middle-class parents, the mathematical events varied between homes and materials, suggesting that "parent mediator was a crucial element in creating a context for mathematical learning" (p.509). Parents differed in whether they or their child initiated activity, and how they 'injected' mathematics into the interaction. Anderson describes these differences, using examples, but does not identify any patterns of interaction in her data. The materials used in the study reported here fall in between these two extremes. They are not a problem-solving task nor are they completely open-ended. The nature of the games themselves may have an important influence of the styles of interaction observed.

The children play a role in determining interaction style. Young-Loveridge (1993) notes this in observing a gender difference in enthusiasm for game playing in the home. Boys appeared to take the initiative and make the parents play the games, whereas some of the girls are reported as not liking or enjoying the games. In this study, the home-based intervention, where parents borrowed games and picture books to share with their children, did not produce the gains that school-based interventions did. Anderson's (1997) data also suggests the importance of the child, as they initiated many sessions in her recorded data. The pattern of interaction used by a parent will be dependent on the child if they are working in a 'contingent responsiveness' framework. In a broader sense, the child's ability or willingness may determine the style used.
Open-ended materials and problem solving activities form the basis of most of this research. Considering the potentially special case of game playing would add to Young Loveridge's (1993) findings, and would reveal if a scaffolding model can be applied to partners in game play.

PARENTS AS TEACHING PARTNERS

Although research into interaction style shows parents acting in ways which will enhance their children's learning, this does not mean that they consider themselves 'teachers'. The roles that parents and teachers take are historically, culturally and situationally defined. In asking parents to be involved with their child on school tasks, we may be asking them to take on a role they may not be comfortable with. Alternatively, by sending home a game to play, we may be taking away a more structured teaching role which parents would prefer. Lareau (1987) states that it is only in recent times that parents have become involved in their children’s cognitive development during school years. “Family and school relationships are socially constructed and are historically variable. Home-school partnerships, in which parents are involved in the cognitive development of their children, currently seem to be the dominant model, but there are many possible types of family-school relationships.” (Lareau, 1987, p. 74)

A concrete example of parents choosing their role is provided by the work of Gelman, Massey and McManus (1991), who report on a study of an interactive science exhibition in a museum setting. Their observations showed that while parents were happy to answer their children's questions in areas such as a 'pretend' grocery store, they quickly redirected their children when they asked questions about the mathematics or physics displays. Gelman, Massey and McManus suggest that this may be due to the parents' reluctance to teach what they regard as 'school items'. They conclude that “…there are reasons to question the extent to which parents think they should serve in the role of teacher of all things” (Gelman, Massey & McManus, 1991, p. 239). This suggestion that parents actively define their role points again to the culturally and historically situated nature of these concerns.

In a culture like ours, adults might prefer to share or even divide the labour of knowledge transmission. It remains to be determined whether there are some tasks of knowledge transmission that parents prefer to give away and others that they claim as their own….Domains that focus on school matters are not claimed as readily as are those that bear on everyday scripts…(Gelman, Massey & McManus, 1991, p. 252-253).
How the parents and teachers view each other's roles is significant in literacy learning. McNaughton, Parr, Timperley and Robinson (1992) found that the parents and teachers of their sample of Year 1 classes shared similar views about the role of the parents - to support rather than teach.

By constraining the parental role to one of support the relationship between parents and teachers is defined in terms of the teacher having educational power. This maintains any uniformed pedagogical practices at home as inadequate or inferior. The problem with this form of relationship is that the participants do not have a rationale for, nor an opportunity to learn from, each other...It would be more conducive to connecting the systems if the role was conceived as adjunct teaching. (McNaughton, 1995, p. 190-191).

These role definitions come into focus when we consider communicating between home and school. Parents may resent or welcome additional tasks coming home from school. Their attitude towards their role, and the task sent home, will be reflected in the time they give to the task and the way that they choose to use it. Two questionnaires have been developed for this study to measure these attitudes. Questions about the use of the games and their appropriateness were also included in the telephone interview phase of the study.

**BRIDGING HOME AND SCHOOL**

The distinctions between the settings of home and school are many. Children at the transition to school face many new challenges, both in terms of learning and of social structure. Resnick (1987) highlights the contrasts between the school setting and the 'everyday'. In school, individual cognition is the basis of assessment and programming. Outside school, shared cognition characterises learning. "School is an institution that values thought that proceeds independently, without aid of physical and cognitive tools" (Resnick, 1987, p. 13). Tools are an integral part of most thinking outside school. In school, children learn to use symbols and to think in decontextualised ways. Context provides strong support for reasoning outside school. Finally, schools try to teach skills and knowledge which can be transferred to other settings. Performance outside school requires the development of competencies which are specific to the setting in which they will be practised (Resnick, 1987). These dichotomies have special implications for mathematics learning. Mathematics is a subject which is often regarded as highly abstract and 'pure', it involves the understanding and use of symbols and can be applied in a range of settings. The mathematics that children learn outside school may not be readily transferred to the school setting...
Maths which 'comes home' from school may be tackled in a different way to mathematics that arises in everyday life. Following Resnick's (1987) analysis, at the transition to school children face the task of 'converting' their knowledge and understandings to a new way of thinking. Knowledge acquired in the context of the family must be individually brought to bear on school tasks.

The type of help children receive may differ too. Greenfield (1984) notes that "...teachers more than parents allow children to work independently, learning from their own mistakes. Scaffolding, in contrast, leads to relatively errorless learning" (p. 136). In school, the learning process is emphasised, at home the task in hand also needs to be completed. Leaving a child 'to it' will not get the bed made. This style may flow over to tasks sent home from school. Finishing the book sent home in the available time may be more important than dwelling on reading skills or parts of the narrative. Children need to adjust to the types of help they will receive in each setting. Wertsch, Minick and Aras (1984) found similar differences between Brazilian mothers and teachers.

The analysis revealed substantial differences in the interactions involving mothers and teachers. In general, the mothers tended to perform task behaviours and use direct forms of regulation more frequently than the teachers did (Wertsch, Minick & Aras, 1984, p. 163).

Lehrer and Shumow (1997) also report that their parent participants were more directive than the teachers while helping children to solve word problems.

The socio-cultural framework on which this study is based sees the setting in which learning occurs as integral. Changing between settings requires certain conditions to be met for the transfer of knowledge and skills to be successful. School is an important setting for children's development, but as Bronfenbrenner (1986) notes"...although there have been numerous investigations of the influence of the family on the child's performance and behaviour in school, as yet no researchers have examined how school experiences affect the behaviour of children and parents in the home" (p. 727). Most studies have"...focused on techniques of parent involvement rather than on the associated processes taking place within family and classroom" (Bronfenbrenner, 1986, p. 727). "Well matched settings" (McNaughton, 1995, p. 176) are those where the parents understand the child's developing expertise and the ways in which it is being developed.
Improving the 'match' between settings is an important task. McNaughton (1995) thus proposes that:

"Development is enhanced by the degree to which settings are well co-ordinated in terms of practices, activities and systems of learning and development. This in turn depends on a number of boundary conditions, including how participants in settings relate to one another." (McNaughton, 1995, p. 176-177)

One way of increasing the degree of 'match' between settings is to send objects between them. Children who bring home a story or picture are communicating about what they are doing at school, and how they are doing it. One of the most frequently used tools in this kind of exchange is the 'home reader'. Children in schools throughout New Zealand take home a reading book each night to share with their parents (McNaughton, Parr, Timperley & Robinson, 1992). Commonly, parents are asked to sign a reading log to say they have heard their child read. While this practice intends to give the children extra reading practice and the parents information about their child's progress, McNaughton, Parr, Timperley and Robinson found that parents were working in an 'informational vacuum' about what they should do when reading with their child. Despite teachers feeling that they had communicated suggestions, these researchers observed that "...parents may develop their own theories in practice which may or may not match those of the school" (p. 245). Evidently more needs to be done than simply sending home materials if one is trying to bridge the settings of home and school. The present study investigates this further, in the context of mathematics learning. Observing how parents and teachers use the games will provide information about the degree of 'match' between the settings. In addition it will reveal what the parents do with the games when they get them. Parents may not know what is expected of them when playing the maths games with their child.

Two large overseas home-school communication projects in mathematics have spread around the world from their originating countries. These projects, Inventing Mathematics for Parents and Children Together (IMPACT) (Merttens, 1993) and Family Math (Stenmark, Thompson & Cossey, 1986) both attempt to share mathematics with families through activity. Both were also influences on the development of the Maths Games Library at North Primary (see Chapter 1).

IMPACT, "...both a research project and a major education initiative" (Merttens, 1993, p.3) is a system of home-school communication which hinges on take-home activities. The parents and children complete
the activities together; the results of this activity are used as the basis of a lesson the following week. Using the work done at home is a crucial aspect of IMPACT. Its aim is to value the work done at home, not leaving it unnoticed or unremarked, and to begin a dialogue between home and school. The 'Family Math' project originated at the University of California at Berkeley. It arose from teacher requests for material to give to parents (Stenmark, Thompson & Cossey, 1986). 'Family Math' courses are sessions wereparents and children do mathematics together. A team of leaders, provides activities and guides the families through the mathematics involved in them. Courses are usually six to eight weeks long, and focus on a problem-solving approach (Stenmark, Thompson & Cossey, 1986). While the approaches differ, both programmes seem to have addressed a need expressed by parents and teachers (for example, Ehnebuske, 1998). Both projects produce materials for purchase and training for teachers and parents. Although articles have been written describing the implementation of the programmes, or discussing their structure and content, actual research about the effects they have had on parents and children has been undertaken only by questionnaire. Exploring these issues in a very complex field would be difficult, but it is hard to describe their effectiveness in terms of children's learning. In so far as both projects bring the two settings of home and school closer together, they can be said to be enhancing children's mathematics learning. As Brown (1993) notes, with "...a rapid increase in the number and variety of initiatives that attempt to foster links between school and home, there has been little in the way of theoretically informed analysis of interaction between parents and teachers, between the home and the school" (p.190). The study presented here attempts to address this.

In 1995 the New Zealand Ministry of Education gave funding to an inservice contract for schools entitled Parent Education in Relation to Mathematics (PERM) (Cooper, Patrick & Whitehead, 1996). This is the contract under which the Maths Games Library was initiated, as outlined in Chapter 1. PERM grew out of a belief that "...the evidence was overwhelming that there was a proven need for parent involvement in schools" (Cooper, Patrick & Whitehead, 1996, p.10). The project aimed to develop a consultative dialogue between school and community in forty schools in Auckland and Wellington. Schools were encouraged to develop their own methods and resources to ensure appropriate activities for their community. Their findings are a collation rather than an analysis, but broad themes are reported. "The
overwhelming need identified by parents through the consultation process was the need to know the learning focus in mathematics and what they could do to support their child." (Cooper et al, 1996, p.29). Again, the link is not made between informing parents about mathematics and change for children. While this project could be said to be increasing the 'match' between home and school settings (McNaughton, 1995), the direction was largely from the school out to the parents. The work of Bronfenbrenner (1986) and Merttens (1993) suggests that a two-way exchange might make the initiative more successful. This study investigates the use of a Maths Games Library set up as part of the PERM project. Whether or not it has established a place as a bridge between home and school will be examined in Chapter 7.

ACCOUNTING FOR DIFFERENCES BETWEEN FAMILIES

Observed differences in interaction patterns and activity between families have been shown to be related to variables such as socio-economic status (Wylie, Thompson & Kerslake-Hendricks, 1996; Wylie & Thompson, 1998; Saxe, Guberman & Gearhart, 1987), ethnicity (Wylie, Thompson & Kerslake-Hendricks, 1996), maternal education level (Wylie, Thompson & Kerslake-Hendricks, 1996; Wylie & Thompson, 1998) family type (Wylie & Thompson, 1998) and maternal expectation (Bacon & Ichikawa, 1988; Hess, Holloway, Dickson & Price, 1984; Parsons, Adler & Kaczala, 1982). These factors have been considered in the present study, which aims to describe patterns in the activity surrounding the use of maths games.

While observing 78 mother-child dyads, Saxe, Guberman and Gearhart (1987) noted that “dyads in the different social class groups were creating somewhat different environments in their everyday lives, but, for each group, the process of creating those environments is the same” (p.119). Income level was a predictor of the number of mathematical activities five-year-old children experienced in the home (Wylie, Thompson & Kerslake-Hendricks, 1996) in a sample of New Zealand families. It was also predictive of the way in which the parents viewed their child's development in mathematics. “Those in the highest family income bracket were most likely to mention informal parental methods... Fewer 'academic' activities are seen to take place in the home environment by low-income parents with less school experience.” (Wylie et al, 1996, p.51). In a follow-up study, a year later, Wylie and Thompson (1998)
found that higher levels of income and maternal education were still associated with greater involvement in mathematics activities in the home. "Income related differences showed more in the mathematics activities than in the literacy activities". (Wylie & Thompson, 1998, p. 38). Pakeha parents put more emphasis on informal parent methods, Maori parents put more emphasis on formal Early Childhood teaching (Wylie et al, 1996).

Maternal education level was also found to be a predictor of children's involvement in number activities. Mothers with higher qualifications reported their children being involved in more number activities in the home. They also felt that they, rather than Early Childhood educators, were primarily responsible for their child's learning. (Wylie, Thompson & Kerslake-Hendricks, 1996). This effect persisted after the transition to school. (Wylie & Thompson, 1998). In the six-year-old data there was also an effect found for family type, with 27% of single parent families being involved in more than eleven of the activities, and 72% of children in families with two parents.

Studies investigating the effects of maternal expectation on mathematics development have found that it appears to be an important influence. Hess, Holloway, Dickson & Price (1984) used a longitudinal design to assess the effects of maternal expectation, communication, behavioural control and tone in interaction. Their finding, that "Maternal measures taken during preschool years...predicted at significant levels both school readiness and performance at grade 6" (Hess et al, 1984, p.1902) lead them to conclude "...that within the interaction of normal families, the essential ingredients for children's cognitive growth and school achievement may be found in any of several types of maternal behaviour" (p.1910). They were unable to separate the effects of each of their maternal measures on the children, but the effects they found had lasted for six years. Parsons, Adler and Kaczala (1982) found "...that parents do not influence their children's achievement attitudes and beliefs through their power as role models. Instead parents have their major impact as conveyors of expectancies regarding their child's abilities....Parental beliefs are even more critical mediators than the child's own math performance" (p.320). High expectations might then be assumed to be produce higher performances. Contrasting results come from the work of Bacon and Ichikawa (1988). This study concludes from its observations and interviews of
576 subjects that, "...high maternal expectations do not guarantee high levels of performance." (Bacon & Ichikawa, 1988, p. 382). Surprisingly, this study discovered lower expectations amongst the Japanese mothers than the American mothers. The authors suggest an explanation for this. "... Realistic expectations may produce a more effective style of mother-child interaction... an informal teaching style, focussed on building interest is a more effective way to teach very young children a variety of skills, including mathematics" (p. 382-383). This result points to the importance of the central finding of many studies into mother-child interaction - the role of contingent responsiveness.

THE IMPORTANCE OF CONTINGENT RESPONSIVENESS

In learning in the zone of proximal development (Vygotsky, 1978) and in guided participation (Rogoff, 1990), a key mechanism for development is the scaffolding of children's learning (see Chapter 2). "The actual path of effective instruction ... will be both task and tutee dependent, the requirements of the tutorial being generated by the interaction of the tutor's two theories (of task and tutee)" (Wood, Bruner & Ross, 1976, p. 97). This process is scaffolding, where the more expert partner uses information from the learner and the task to determine how to help. This form of instruction has been found to be more effective than other approaches (Wood & Middleton, 1975).

What was crucial was that their instructions and suggestions should fit in with the child's present interests and abilities; they must be geared to his prevailing needs and not administered without due regard to his reactions." (Wood & Middleton, 1975, p. 189).

Fifty-five percent of the observed interactions followed the hypothesised pattern: "If the child is correct give less help when next intervening, if incorrect give more help" (Wood and Middleton, 1975, p.188). Repeating interventions at the same level following failure seemed to be less effective than following this strategy.

The efficacy of this approach has led researchers to seek it as an ideal when viewing mother-child interaction. Providing too much help - being more directive than is necessary - is seen as disadvantageous. Pratt, Green, MacVicar and Bountrogianni (1992) feel that "...some parents are likely to be more effective tutors for their children because they follow ... scaffolding principles more effectively" (Pratt et al, 1992, p. 32). In addition, the highly-structured interactions between parents and children in
their sample were rarely appropriate in terms of the child’s ability, and thus "...were not reflective of appropriate scaffolding techniques..." (Pratt et al, 1992, p.32). McNaughton (1995) offers three models as alternatives, rather than as superior and inferior. While some models may convey advantages in terms of ‘match’ with school, perhaps parents’ directiveness could be viewed as part of a larger framework, rather than as inappropriate scaffolding.

Research from laboratory studies (Rogoff, Ellis & Gardner, 1984; Saxe, Gearhart & Guberman, 1984), and from observation and interview studies (Anderson, 1993; Anderson, 1997; Lehrer & Shumow, 1997, Phillips & McNaughton, 1990, Pratt, Green, MacVicar & Bountrogianni, 1992, Saxe, Guberman & Gearhart; 1987; Young-Loveridge, 1989; Young-Loveridge, 1996) shows that contingent responsiveness describes some of the interactions viewed. Some studies find an overall pattern of contingent responding which is very similar across subjects (Anderson, 1997; Lehrer & Shumow, 1997; Phillips & McNaughton, 1990; Young-Loveridge, 1996). Others find that the amount of contingent responding differs by social class (Saxe, Gearhart & Guberman, 1984; Saxe, Guberman & Gearhart, 1987), by task (Rogoff, Ellis & Gardner, 1984) or by family orientation to mathematics (Young-Loveridge, 1989).

Contingent responsiveness was measured by Wood and Middleton (1975) by coding the mothers’ behaviour into five levels of intervention "...characterised by the adoption of different degrees of control on her part" (p. 182). They proposed that mothers would ‘pitch’ their instruction at a level where the child was challenged, but still capable of completing the task, their "...region of sensitivity to instruction" (Wood & Middleton, 1975). From the data collected, Wood and Middleton (1975) determined how many times the mother used each of the five levels, and what happened when the child was successful or unsuccessful following the interaction. Using a problem solving task enabled these five levels to be readily identified. This methodology was used by Wood, Bruner and Ross (1976) (constructing a pyramid), and by Saxe, Gearhart and Guberman (1984)(matching counters to cookie monsters), Pratt et al (1982) (solving long division problems) and Lehrer and Shumow (1997) (solving mathematical word problems). All of these studies employed a problem solving task with a single solution, the path to which could be mapped through the interaction.
Pratt et al (1992) and Lehrer and Shumow (1997) look at parents assisting children with solving problems. Lehrer and Shumow (1997) asked parents to solve a set of problems with the children. They found that"...despite their general agreement with reform practices, parental assistance of children's mathematical problem solving was often very directive, controlling and inconsistent with school practices; parents provided few opportunities for self regulated learning in mathematics" (p.73). Pratt et al (1992), in contrast, report that significant relationships were found between measures of scaffolding and tutoring, and the child's ability and responses. Mean intervention level (how directive they were) was significantly correlated with the child's pre-test scores. Parents were more directive with less able children. Lower levels of support were provided for the subtraction components of the task, suggesting that support differed by task difficulty. The use of the child's region of sensitivity to instruction (where they were 75% successful) and the contingent shift rule (give more help if they fail, less if they succeed) were positively correlated, indicating that parents who were aware of where their child was working were better able to tailor instruction to their needs. Use of the region of sensitivity to instruction and contingent shifting were also associated with child success.

Both the Pratt et al (1992) study and the Lehrer and Shumow (1997) study use averages as data for comparison and correlation. However, they both also mention considerable variation in individual dyad performance. In averaging these variations, some important differences may be lost. Characteristic patterns may have important implications. Parents who are supplying consistently directive support may differ in important ways from those who are making more use of the contingent shift rule. The consequences and correlates of possibly distinct 'tutorial patterns' may be worthy of examination.

Studies without a problem-solving focus have had to look more closely at their data for evidence of contingent responding. Phillips and McNaughton (1990) cite the even number of initiations between parent and child as evidence of scaffolding, stating that this shows that there is a sharing between the partners. Semantic contingency is seen in their data, as the parents and child respond to the meaning conveyed in each other's statements. Phillips and McNaughton (1990) note that the children in these dyads were already relative experts in responding to narrative fiction at this level. This reduces the
amount of scaffolding seen in the data. Anderson (1997) gave parent-child dyads a box of materials to see what mathematics would emerge. Scaffolding in this context could be seen in a number of ways. Initial negotiation of the task may include elements of scaffolding in addition to scaffolding the mathematics that occurs. Types of interaction found were knowledge-based, explanations, clarifications, pointing out patterns and relationships, concepts and strategies. "For the most part, parents maintained a questioning stance, as evidenced by the actual wording or intonation they used...most parents' questions focused on mathematical knowledge" (Anderson, 1997, p. 504). The interactions varied depending on the type of equipment used, but all featured utilising the children's ideas and responses. The pattern was one of co-construction rather than direction. This extends Anderson's (1993) work with her daughter, in which her ability to respond contingently can be seen to aid in establishing mathematics concepts in her daughter. Anderson (1993) focuses on the role of children's questions in guiding their development. "We need to recognise that children's questions or comments are often insightful and knowledgeable; they are not always frivolous, off topic or inappropriate" (Anderson, 1993, p. 30). To be able to utilise these questioning opportunities, we must be able to recognise their relevance and respond contingently. This ability to respond to the mathematics which arises everyday is considered by Young-Loveridge (1989) who describes a literacy-oriented family with a child who is making slow progress in mathematics. This family had focused on literacy to the exclusion of numeracy, and did not utilise the opportunities presented by the environment or the child. Observing interaction rather than using an interview (Young-Loveridge, 1996) revealed that very little contingent responding about mathematics occurred in the context of cooking. This highlights that it is not involvement in cooking which builds mathematical understanding, but having mathematical ideas posed and responded to in this context. This may hold true for the Maths Games Library - it may not be using the materials that promotes understanding, but the interaction that takes place. Examining the nature of this interaction is therefore crucial.

TEACHERS

This review has considered the role of the home and the parent in promoting children's mathematical development. In considering the degree of 'match' between home and school, it is important to also look
at school variables. In terms of on-to-one interaction, the key person for the child is their classroom teacher. Only one study has attempted to describe and compare teachers and parents working on mathematical problems. Lehrer and Shumow (1997) contrast the assistance given by classroom teachers with that given by parents solving equivalent word problems. The results clearly showed that "...teachers tended to provide more indirect forms of assistance, whereas parents provided more direct forms of assistance" (Lehrer & Shumow, 1997, p. 61). In addition

...on occasions when the teacher provided more direct forms of assistance, the next move was likely to be one that provided less assistance - consistent with a pattern of fading scaffolding. In contrast, the parent was likely to follow more direct forms of assistance with further direct forms of assistance. (Lehrer & Shumow, 1997, p. 62).

The functions of teacher and parent assistance differed too. Teachers spent significantly more time on sense making and elaborating the problem; parents spent more time on defining the problem and suggesting strategies. "Hence, parents and teachers not only differed in the degree of scaffolding and fading but also were distinguished by the functions of their problem-solving assistance" (Lehrer & Shumow, 1997, p. 65).
THE PRESENT STUDY

The literature reviewed here suggests that parents can be an effective and powerful source of help for their children, particularly if they respond contingently to their ideas. The Maths Games Library at North Primary was initiated to harness that power in the service of children's mathematical development. Research into literacy learning suggests, however, that simply sending home materials to share may not be enough. How parents and children interact is culturally and situationally bound, and may not 'match' interaction in school. This study aimed to analyse interaction and activity to discover whether the Maths Games Library formed an effective bridge between home and school, and how the games were used by parents and children.
Examining joint activity in the zone of proximal development demands certain methodologies. The socio-cultural viewpoint outlined in Chapter 2 suggests what is important to consider, but does not provide methodologies which can be used in any research setting. As activity must be viewed as situated, with context-specific characteristics, no methodology can be applied to all situations. Researchers who believe that important evidence is lost if activity is not the unit of analysis must find ways of capturing that activity and analysing it, without losing its essential character, or its wider context. To look at development we must look at activity, rather than change in individuals or the nature of the intervention. Activity is complex: ever-changing and multi-faceted. Research solutions are therefore also complex. Developing a methodology for this research has been driven by the socio-cultural framework outlined in Chapter 2, and by the nature of the task and setting itself.

The Maths Games Library system sends games home for children to play with their parents. To understand what the child and parent experience, we must consider the interaction that takes place as they jointly construct understanding through activity. If development occurs through internalisation of social exchange, it is the content of the social exchange which must interest those who wish to understand development. The Maths Games Library project assumes that parent-child interaction and joint activity will occur if the materials are provided. The nature and effectiveness of this interaction is unknown. Thus, it is not enough to consider whether the games are used by families; we must know how they are used and what happens when they are used. To gain this kind of information, certain methodologies are implied. We must try to see the activity occurring without disturbing its usual configuration. We need to have a record of the interaction as it proceeds and we need to know how the participants view the activity. Each of these considerations - that data on interaction must be collected,
that how the games are used is critical and that observed activity should be as undisturbed as possible and as complete as possible - determined the methodology for this study.

GAME PLAYING AS A FAMILIAR ACTIVITY

This study aimed to view the regular pattern of use of the Maths Games Library. Rogoff (1995) emphasises the everyday nature of learning. If the games are used regularly they can be seen as a family practice. Phillips and McNaughton (1990) initially established the frequency of storybook reading in the families they observed, "...because it is the recurrence of an activity that defines it as a social practice, (and) it is important to determine the frequency of reading and the characteristics of the settings." (p. 199). The participants were used to receiving maths games through the Maths Games Library system, described in the introduction. Although this was not an activity which occurred naturally in the home (cf. Anderson, 1993; Young-Loveridge, 1989, 1996), it was part of the school routine, and part of the communication between home and school. Lehrer and Shumow (1997) suggest that alignment between home and school is an important influence on children's mathematical progress. It may be that it is not the everyday family mathematics events which have a critical influence on school-age children's progress, but those mathematics activities which are aligned with their learning in school. As these five-year-old children made the transition to school, a new set of routines and practices became 'everyday'. Bringing home the maths games was familiar to these families. It was hypothesised that families would have a way of dealing with receipt of these materials, be it ignoring them or using them daily.

To make sure that the game playing that was recorded on the tapes was as 'ordinary' as possible, the games used were selected from within the existing resource, and covered number concepts which were dealt with in over half the games (see Chapter 5). They were sent home according to the usual issuing system and received in the usual way. Parents were asked to rate how typical the recorded sessions were, on a five-point scale, in terms of the type of discussion, setting and participants and number of times it was played. The children's comments and responses on the tape also indicated that the sessions were familiar to them.
To be seen as a significant setting for children's learning, and as an effective bridge between home and school, the games would have to have become part of the families' routine. If participants did not usually use the games, and recorded game playing which was out of the ordinary, the data would not give any valid information about the interaction occurring in homes. This study aimed to collect data which was as close to the families' usual use of the materials as possible in order to draw conclusions about the patterns of use and interaction which resulted. In addition, McNaughton (1995) suggests that systems and patterns of use are important indicators of the value given to activity, and the organisation of the activity itself tells the researcher about its place in the family's life.

**ACTIVITY AS THE UNIT OF ANALYSIS**

That activity is the appropriate unit of analysis is a central tenet of the socio-cultural viewpoint. The activity in this study is the playing of maths games. To look closely at this activity it needed to be broken into meaningful units. The unit used in this study is defined by the games themselves. Both games proceed when players turn over a new card. The activity was thus coded into blocks of interaction which occurred after each card turn. This method was developed by piloting six games with two families (see Chapter 5) and listening to the resulting tapes. Interaction was not always in a turn-taking format, and games could last for lengthy periods, making transcription unwieldy. A further description of how the activity was coded is given in Chapter 5.

**CAPTURING ACTIVITY**

As participants in activity co-construct their understandings, communication proceeds through the use of language and physical actions. To capture the interaction a researcher must either be present as an observer, or use a recording device. The presence of an observer in a situation such as this would demand considerable time to establish familiarity, and would constrain game-playing to sessions where the observer could be present. Attempting to discover typical use patterns would be disrupted. Video recording would capture both the speech and body language of the participants. Practical issues preclude its use here. Sufficient recording equipment to collect the volume of data presented here was unavailable. In addition, parents may have found it more intrusive, and children more distracting, than a small audio-
recorder. The small tape decks used in the study had in-built microphones and were compact and unobtrusive. They were easy to use and efficiently recorded all the verbal interaction that took place, as well as picking up some of the physical actions, such as turning cards. Ninety-minute tapes were provided to allow for extended periods of game playing. Tape recording methods such as this are reported as successful by Anderson (1997) and Phillips and McNaughton (1990). In each of these studies the researchers aimed to collect similar data to that reported here.

ANALYSING ACTIVITY

In order to describe the activity in a useful way, and capture its progression, it was necessary to chart the path of interaction. As the basic activity was game playing, rather than problem solving, several issues arose.

Wood and Middleton (1975) provided analyses of mothers and children working on assembling a wooden block puzzle. Physical activity was a key part of this analysis, and video recording was used. Mothers' acts of assistance were coded into a hierarchy, from least to most directive. There was a problem to be solved, and the path to its solution was charted using this hierarchy. Pratt, Green, MacVicar and Bountrogianni (1992) and Lehrer and Shumow (1997) also develop a hierarchy of assistance for their analyses. In both cases, parents and children are working on problems to be solved which have been designed to be at the child's level of understanding. In such situations, parents' behaviour can be seen to range from completing the task themselves to sitting back and allowing the child to proceed without comment. Again, intermediate levels of help were readily identified. How directive the parent is can be seen as a measure of the transfer of responsibility between the parent and the child. We can identify aspects of the task which the parent controls and those which are left to the child. This can also be regarded as the scaffold which the parents construct in order to help their children. Other parent behaviours, such as indicating which part of the question is being answered or referring to previous work, can be seen as aiding the establishment of intersubjectivity.
Game-playing differs from problem solving in several key ways which have important implications for the analysis of the data presented in this study. The word problems employed by Lehrer and Shumow (1997) and the algorithms used by Pratt et al (1992) both sought single answers. Parents were guiding children towards a defined solution. Game playing proceeds according to the rules of the game, and finishes when participants decide to cease playing. Parents and children recognise the mathematics involved in word problems or algorithms, as it is presented in a familiar way. Mathematical tasks must be tackled in order to reach the solution. In game-playing, parents and children may not recognise the mathematics involved, or may take some of the mathematical content for granted. Rolling a die and moving the correct number of spaces may not be viewed as mathematics by participating families. Working within a game-playing, rather than a mathematics, framework may lead to behaviour which is markedly different from problem solving. Problem solving or algorithm activities require mathematical skills to be pulled in to the solution path. Mathematics which might arise from game playing may be omitted or not considered as it goes beyond the boundaries of the game, rather than being part of it. Only a part of the potential mathematics activity offered by a game may be utilised. Ainley (1988) discusses games in which mathematics is an add-on and those in which it is an integral part of the play itself. The two games selected for study were chosen as games which incorporated mathematics as part of the playing of the game. Further information on this can be found in Chapter 5. It was intended that one of the games would be difficult for the participating children and one would be easy, so that any differences in interaction could be observed. However, both games proved to be easy for the participants and required little problem solving or scaffolding of inexpert behaviour (see Chapter 6).

If a hierarchy of assistance was not a useful way to conceptualise parent and child interaction in game playing, then another system had to be found. Categories of assistance were developed from listening to the pilot tapes and noting that adding in additional mathematics seemed to be important, as did the way in which numbers were used and questions were asked. The function of each of these categories is of significance in the socio-cultural viewpoint, where evidence of the establishment of intersubjectivity and transfer of responsibility is sought. Each of these categories may contribute to this in different ways, rather than as part of a hierarchy of assistance (cf Rogoff, Ellis & Gardner, 1984; Anderson, 1997).
Interwoven with parent assistance is the child's responses. The methodology for this study need to include the role of the child in the interaction. Co-construction of understanding through activity is a central process in the socio-cultural viewpoint (Valsiner, 1988). The parents' behaviour, separated from the child's behaviour, is meaningless in understanding their joint construction of game playing. Contributions made by each player after a card turn were thus numbered, so the order in which they occurred could be recorded, as well as the category of contribution that was made (see Chapter 5).

SUMMARY

The methodological concerns which determined the methodology for this study arose from the theoretical viewpoint outlined in Chapter 2. Audio-recording was chosen as it was an unobtrusive way of capturing as much of the activity as possible, without disturbing its configuration too much. A coding system was developed for describing the taped material, as transcription was impractical and may be less helpful in finding patterns in the interaction between parent and child. The utterances of both parent and child were coded, and the order in which they occurred preserved by numbering them. The activity was broken down into units which made sense of the data in terms of the game. Thus task factors were also included in the analysis. While joint activity, or guided participation (Rogoff, 1995) was the focus for this study, the activity discussed must be seen as nested within a wider context, which contains several elements. School, home and game playing are three factors which impact on the activity viewed. Each brings rules and associations for both players which crucially determine the activity we see. At the same time we must also consider the individual's internal functioning, or participatory appropriation (Rogoff, 1995). We may not observe this through the externalisation of contributions to the game playing, but according to the socio-cultural viewpoint, the players will be changing their notions of the game, each other and the mathematics involved as they play.
PARTICIPANTS

The participants for this study were drawn from the fifty-four families in the two combined New Entrant (Year 0) / Year 1 classes at North Primary, the school discussed in the introduction, where the Maths Games Library was in operation. The school is a Decile 9 primary school on Auckland's North Shore. The school has 421 pupils. The ethnicity of the children is given in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>NZ European</th>
<th>Other European</th>
<th>NZ Maori</th>
<th>Samoan</th>
<th>Tongan</th>
<th>Southeast Asian</th>
<th>Indian</th>
<th>Chinese</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children</td>
<td>269</td>
<td>11</td>
<td>37</td>
<td>7</td>
<td>9</td>
<td>20</td>
<td>10</td>
<td>53</td>
<td>12</td>
</tr>
</tbody>
</table>

There were three groups of participants. The first group consisted of fourteen families who recorded their gameplaying episodes. The second group consisted of thirty-one families took part in an interview. The third category of participant was one of the two classroom teachers whose students and parents were involved in the study.

Selection of the First Group of Families

All fifty-four families who had children in the two classrooms were offered the opportunity to be part of the study. Ten families responded initially. Nine of the eleven target children from these families were girls and the remaining two were twin boys. To attempt to balance the sample for gender, and to establish why the participation rate was so low, a parent from one of the classes undertook to interview all the remaining families by telephone. This parent had been a member of the original PERM team, and also had a child in one of the target classes. As the school were eager to know whether the participation
rate reflected the overall use of the Maths Games Library, they gave permission for the parent to contact the parents of the children in both classes who were not involved. As a result of this survey, four further children joined the study. The remaining seven families could not be contacted, despite repeated attempts through telephoning and sending notes home with the children.

Parent participants were thus volunteers from within a defined group - all the Year 0 - Year 1 children in the school.

Participants who recorded their game playing

Fourteen families took part in recording their game-playing sessions. One family was given an incorrect game, making the recording unusable. This family has been removed from the analyses presented in Chapter 6, and from the descriptions below.

The thirteen families whose data from the game recording sessions are reported here differed on a range of variables, as shown in Table 2. Six of the children were boys and eight were girls. The study child's place in the family varied from being an only child, to being the sixth of six children. Two of the boys who participated were twins. Data from only one of these two boys is included in the study. Both twins had the same 'Checkout' scores and one questionnaire was completed by the parent on their behalf. Only two of the children had no pre-school experience, with seven children attending private pre-school in addition to public kindergarten. The children were all aged five at the time of the study, and had been at school no longer than two terms prior to the study.

The mothers' reported generally high levels of mathematics qualification, with only one mother having not gained a formal mathematics qualification. Six mothers had mathematics at University Entrance level, and three had tertiary mathematics qualifications. All the families involved in this part of the study were two-parent families.
Table 2: Participants who audio-recorded their game playing.

<table>
<thead>
<tr>
<th>Family Number</th>
<th>Place of Study</th>
<th>Gender of Child</th>
<th>Ethnicity of Child</th>
<th>Type of Preschool Attended</th>
<th>Length of Preschool Attendance</th>
<th>Age at Beginning of Study</th>
<th>'Checkout' Score (1)</th>
<th>Games Recorded</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>1/1 female</td>
<td>Samoan/ Maori</td>
<td>kindergarten</td>
<td>2 years</td>
<td>5 years</td>
<td>24</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td>3/3 female</td>
<td>NZE (2)</td>
<td>kindergarten</td>
<td>2 years</td>
<td>5 years</td>
<td>11</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Three</td>
<td>2/2 female</td>
<td>Maori</td>
<td>Montessori and kindergarten</td>
<td>3 years</td>
<td>5 years</td>
<td>29</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Four</td>
<td>6/6 female</td>
<td>Lebanese NZE</td>
<td>Creche</td>
<td>4 yrs 9 months</td>
<td>5 years</td>
<td>19</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Five</td>
<td>2/2 female</td>
<td>NZE</td>
<td>preschool and kindergarten</td>
<td>3 years</td>
<td>5 years</td>
<td>23</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Six</td>
<td>1/1 female</td>
<td>NZE</td>
<td>Montessori and kindergarten</td>
<td>2 1/2 years</td>
<td>5 years</td>
<td>26</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Seven</td>
<td>1/3 female</td>
<td>NZE</td>
<td>N/A</td>
<td>5 years</td>
<td>30</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eight</td>
<td>1/1 male</td>
<td>Chinese</td>
<td>kindergarten</td>
<td>1 year</td>
<td>5 years</td>
<td>14</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Nine</td>
<td>1/2 female</td>
<td>NZE</td>
<td>Montessori preschool and kindergarten</td>
<td>2 years</td>
<td>5 years</td>
<td>29</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ten</td>
<td>2/5 male</td>
<td>NZE</td>
<td>Nil</td>
<td>5 years</td>
<td>23</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eleven</td>
<td>3/4 male</td>
<td>Maori</td>
<td>Nil</td>
<td>5 years</td>
<td>18</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Twelve</td>
<td>2/3 male</td>
<td>Maori</td>
<td>preschool, playcentre and kindergarten</td>
<td>2 1/2 years</td>
<td>5 years</td>
<td>16</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Thirteen</td>
<td>3/3 male</td>
<td>NZE</td>
<td>Montessori kindergarten</td>
<td>1 1/2 years</td>
<td>5 years</td>
<td>17</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

(1). Maximum score for Checkout is 32.
(2). NZE = New Zealand European

One family (Family 8) had a first language other than English. This family was able to complete the questionnaires and taping in English, however. The target child was quite confident with English in the classroom.

Participants who were interviewed by telephone

Thirty-five parents from the two target classes were interviewed by a parent. These were the families who had not returned consent forms. As a result of the interview, ten further families volunteered to participate. Four of these families were able to be incorporated into the recording project, and their data was removed from the interview data. Of the remaining thirty-one families interviewed, nine spoke languages other than English (Iraqi, Indonesian, Mandarin). Further data on family characteristics was not...
collected, as the interview data serves as a background to the recording data, rather than a comprehensive investigation. The interview data is reported in Chapter 6.

The Teacher

The teachers of each of the classes offered to participate in the study. Ill health at the time of data collection prevented one teacher from recording her game play. One teacher is thus included as a participant in this study. Mrs North is a teacher who has returned to full-time classroom teaching in the last two years. She has worked part-time within North Primary for ten years, and has had two years experience as a New Entrant / Year One teacher. She is well known in the school community, as she is also a parent of children who have attended North Primary.

MATERIALS

The Games

Selection

Two games were chosen from the thirty-five games provided at this level. Inspection of the library materials revealed that the vast majority of the games at this level focussed on number skills. These games were of two types. Some were 'track' or 'board' games, where the children used their number sequence skills to count along the track. While other mathematics activity 'surrounded' this in some cases (for example, children have to say the number they have landed on, or take a card with a question and answer it), the core of the activity was enumerating in this way. The other type of game involved using mathematics as part of the game's progression - mathematics was the vehicle through which the game worked. Ainley (1988) notes this distinction in stating "The most effective mathematical games are those in which the structure and rules of the game are based on mathematical ideas, and where winning the game is directly related to understanding this mathematics." (p. 241). For this reason, games were selected from this second group. They involved the children using their number knowledge at each turn of the game, and in order to understand it.
The findings of Pratt, Green, MacVicar and Bountrogianni (1992) show that parental response patterns vary according to the difficulty of the mathematics problem presented. This reflects the use of the 'contingent shift' rule described by Wood and Middleton (1975), where parents supplied more help following failure and less help following success. Use of this rule would lead to distinctive patterns of support on materials of differential difficulty. Thus, in selecting the games, consideration was given to finding an 'easy' game and a 'hard' game, so that support patterns could be compared. English and Halford (1995) discusses the complexity of mathematical concepts in terms of "the number of related components" (p. 89) they contain. This analysis of complexity was used, alongside teacher ratings, to select three easy games and three hard games from the Maths Games Library for further trial.

**Pilot Study**

Six selected games were given to two families to trial. These two families were not part of the school community in which the study was undertaken. Both families had four-year-old boys who were used as the target children. These boys were to enter school in the month following the trial, and thus gave an impression of how the five-year-old children in the sample would respond, without reflecting any school-specific learning. The two families audio-taped their game playing sessions and trialed the questionnaires and post-recording forms. These tapes were analysed to determine which games produced the greatest amount of discussion from which the flow of the game could be understood.

Two games were identified as a result of this selection procedure. They can be found in Appendix 1. Both of the selected games had been sourced from Young-Loveridge and Peters (1994), although the initial set of six games came from a variety of sources.
'More Dots' and 'Oops!'

'More Dots' was selected as the 'easy' game, as it involved a binary relation (English & Halford, 1995). Players each turned up a card and the person with more dots on the card got to keep both cards. If there were the same number of dots on each card, they were set aside in a bonus pool for the next winner to collect. Cards had numbers of dots ranging from zero to four, in regular patterns. The master sheet of uncut cards can be found in Appendix 1. Players had to determine who had the larger number, an instance of the binary relation 'larger-than'. Binary relations relate two objects, in this case the two sets of dots, according to a rule, in this case 'larger-than'. As the cards featured numbers to four, it was assumed that this comparison would be the basis of the mathematics in this game, rather than counting the dots on the cards. This expectation was born out by the class teachers in initial discussion, and by the pilot study with four year olds. A variation of the game was suggested, where players could select which card to play from their hand, rather than turning over the next card in the pile. This suggestion was labelled 'Game Two' on the instruction card (see Appendix 1). This introduced an element of problem-solving strategy use which was not present in the first version.

'Oops!' was selected as the 'hard' game. In this game, players turned over a succession of cards with dots on them. The aim of the game was to collect a set of cards with a total of nine dots. When nine dots were collected, the player took a plastic chip. The winner was the person who collected five chips. Cards featured one, two or three dots, in regular patterns (see Appendix 1). In addition, there were 'sad face' cards. If a sad face card was turned up, that player's turn was ended, and the other player began. This game involved a ternary relation, a relation between three objects. The players had to deal with their starting number, the amount of increase indicated by the new card, and the total which had been reached. English and Halford (1995) discuss an 'accumulator model' of counting, where children count by including new items as members of the set of numbers they have counted. This game requires a similar method, as each new card's dots must be included in the set of dots to be counted, and a new total found. This additional cognitive load defined 'Oops!' as a harder game than 'More Dots'. Both the researcher and the class teachers identified it as harder. It also proved more difficult for the trial families. The total of nine dots to win a chip was suggested in the game's instructions, and varying the total to be...
reached was suggested as a variation. This idea was part of the instructions sent home to parents (see Appendix 1).

Isomorphs of the games were created for the children to play with the teachers. These involved the use of dice instead of cards. Some minor rule adjustments were needed to accommodate the new equipment, but the mathematics involved in the game was unchanged.

The Measures

**Participant questionnaire**

A questionnaire of ten sections was designed for this study. It included questions to gather data on variables which previous research had suggested were important factors in determining how parents might help their children. Seven sections required written answers. One section was a series of questions about their child’s preschool mathematics knowledge, which were to be answered yes or no. The final two sections used a Likert scale to assess the parents’ attitude to mathematics and to the Maths Games Library. A copy of the questionnaire can be found in Appendix 2. The questionnaire was sent home with the game bag when the families received their first target game. An envelope was included for its return.

Parents were asked to report on number skills their child had demonstrated before starting school. This was a retrospective report, although no child had been at school for more than two terms. Of 126 ratings made by parents, only four were marked ‘don’t know’, suggesting that parents felt they could report accurately on these items. The nine skills listed are statements of the Level One Achievement Objectives for Number from Mathematics in the New Zealand Curriculum (Ministry of Education, 1993).

Parents were asked to rate their child’s ability in mathematics, to determine if there was a discrepancy between parental perception and ability as measured at school. The parents were asked to say if they used mathematics in their daily lives. This was found to be an important influence on children’s mathematics before school by Young-Loveridge (1989). Information about parental education level and the child’s pre-school experience was also gathered from this questionnaire.
Parents rated the maths games library as a resource on a five-point Likert scale. This scale was included to determine whether they felt the games were useful communication device between home and school, and whether they were enjoyable in the family setting. Although these items were not weighted during test construction, the scale appears to measure a single factor (Internal reliability coefficient - alpha=0.88). Additional comments made by parents on the questionnaires and post-recording forms suggest that the scale is a sufficiently valid measure of their attitude to the games.

A measure of parental attitude and confidence with mathematics was devised. Items were written to measure their confidence in helping their child, their feelings about mathematics in their schooling and their perception of the usefulness of mathematics today. Together, these scale items have an internal reliability coefficient of alpha= 0.87.

**Post-recording Form**

At the end of their time with each target game, participants were asked to complete a post-recording form to summarise the recordings. Parents were asked to respond to seven statements using a five-point Likert scale, and space was allowed for any further comments to be made. The post-recording form can be found in Appendix 3.

The items were designed to gain specific feedback about parents' views of the Maths Games Library, to compare with the generalised feedback given in the Parent Questionnaire. Two items were included to measure the extent to which the game playing episodes were typical of their use of the Maths Games Library.
**School Entry Assessment Scores**

The School Entry Assessment (SEA) (Ministry of Education, 1997) was administered by the Assistant Principal of North Primary after each child had been in school for one month. This is a set of tasks which are designed to gauge children's skill in a range of areas. The tests cover language, literacy and numeracy skills. The tasks are given in a one-to-one setting. The numeracy section of the SEA is based on the work of Young-Loveridge (1991). The tasks are set in the context of shopping, and are designed to assess "...particular numeracy skills that appear to predict later success in mathematics" (Ministry of Education, 1997, p. 13). The assessment takes the form of a game, with either the teacher and child playing, or two children playing. Clear and comprehensive instructions are given for administrators, who are asked to follow a standard procedure. A total score is obtained by adding the totals for numeral recognition, pattern recognition, forming sets, number sequence knowledge and mental operations. The maximum total score is 32. Trials of the task indicate that:

- Children who score 10 or below are novices in using numbers,
- children who score between 11 and 24 are quite competent in using numbers,
- children who score 25 and above are experts in using numbers.


**The Tapes**

Participating families received the target games as part of the usual rotation of games sent home. Inside the game bags were the usual game materials and an additional snap-top bag. This bag contained a small tape deck (12 cm x 8 cm), a ninety-minute audio cassette, spare batteries, an instruction sheet, appropriate recording forms and an envelope in which to return the tape and questionnaires. Parents were asked to record all episodes of game playing which occurred during the week. These recordings were the major source of information on how parents and children used the games.
PROCEDURE

Consent to participate was obtained early in the second term, by sending home an information sheet and consent form to all families in the two classes. Once consent was obtained, sending home the target materials began.

Game Recording Data

Each child ordinarily received a Maths Games Library game bag every Wednesday. This was to be returned the following Tuesday. The school had set up this pattern so the families would have the game material over a weekend, which might provide more opportunities for them to be used. A teacher aide checked the materials on return, and marked on a class list the game each child should have next. The teachers issued the games again on the next day. All of the children in the study had had some experience of this routine.

The two target games had not yet been sent home to any of the participating families. The return and issue routine was used to insert the recording materials and to collect completed tapes and questionnaires. The children usually received the games in numerical order. This was disrupted for the study, as the researcher would specify each week which of the participating families was to receive a target game. In practice, this disruption would have made little difference to the families, as the games are not sequenced or graded in any way, and lost or incomplete games are omitted periodically. Families received target games a minimum of two weeks apart, in order to reduce the load on these families. Four target games were sent home each week in the first phase. New families who joined the study after the telephone interviewing could only complete one game, despite the use of six copies of the target games and associated recording materials. Data collection ceased half way through Term 3, at the end of August.
Data from the tape recordings was collated and analysed as described under data analysis below. Questionnaires and post recording forms were also collected and analysed. Results of both these analyses are reported in Chapter 6.

Telephone Interview Procedure

The interviews were conducted by one person, a parent who was closely involved with the setting up of the Maths Games Library, and who had maintained an ongoing interest in home-school liaison in a range of contexts. Questions were provided by the researcher, and were chosen to reflect the content of the questionnaire completed by game recording participants, and to gather comment on issues related to the Maths Games Library. A copy of the interview questions can be found in Appendix 4.

Care was taken to standardise the format of the questioning. Parents who could not speak sufficient English to record their game playing in English were not asked about further involvement in the project, but were asked the additional questions about the Maths Games Library. A summary sheet for each interview was drawn up, and all identifying participant details were removed prior to the information being passed to the researcher.

Procedure for the Teacher

The teacher was asked to choose two of the game-recording participant children from their classes with whom to play the games. They were provided with the instructions for 'More Dots' and 'Oops!', which were altered slightly to allow for the use of dice rather than cards. The teachers withdrew the chosen children and played both games with them in a withdrawal room space. As the teachers often took running records or other assessments in this way, it was not felt that the children would find this unusual. Teachers were asked to use the games in the way in which they would normally use an activity of this type. The game playing sessions were recorded on audio tape, using similar equipment to that used in the home recording sessions.
Data Analysis

A method of analysis was developed which permitted the interaction to be described in detail, but without transcription. The utterances of both parent and child could be captured, and the order in which they occurred recorded. Categories of utterance were derived and used to describe the interaction. Transcriptions were made of key exchanges.

Coding the activity

A pilot study was undertaken to aid in the selection of games, and to gain an appreciation of the type of interaction that might occur. From these pilot tapes, categories of utterance were derived. These categories were observed in both parents and children, and proved useful in coding the tapes, as they described the interaction well. The categories which arose from the parent/child interaction also echoed patterns of interaction described in the literature (Anderson, 1997). Table 3 presents the categories and summarises their parameters.

Table 3: Categories used to code mathematical statements in game-playing activity.

<table>
<thead>
<tr>
<th>Category name</th>
<th>Definition</th>
<th>Example</th>
<th>Inclusions</th>
<th>Literature references</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>More than one number, uttered in a sequence.</td>
<td>C: 1, 2, 3, 4</td>
<td>- sequences which do not start at one - counting in a pattern, such as by twos.</td>
<td>Anderson (1997)</td>
</tr>
<tr>
<td>label</td>
<td>Stating the cardinal number of a set or giving the name of a numeral.</td>
<td>A: Have you added up how many dots you’ve got yet? C: Nine!</td>
<td>- giving the answers to questions or number sentences using a single number - counting on by one by naming the next number - statements which use ‘and’ for the addition operation</td>
<td>Ministry of Education (1997)</td>
</tr>
<tr>
<td>number sentence</td>
<td>Using ‘plus’ or ‘and’ and ‘equals’ to pose a question or describe an action. Only the number names are used.</td>
<td>A: So four plus one equals? C: Five.</td>
<td></td>
<td>Young-Loveridge (1991)</td>
</tr>
<tr>
<td>repeat</td>
<td>Repetition of a contribution by the other player, without any alteration.</td>
<td>C: Makes five A: Makes five</td>
<td></td>
<td>Resnick, Bill, Lesgold and Leer (1991)</td>
</tr>
<tr>
<td>question</td>
<td>Utterances which requested a response from the other player, by tone</td>
<td>A: So how many have you got now?</td>
<td>- closed and open questions - questions about</td>
<td>Lehrer and Shumow (1997)</td>
</tr>
</tbody>
</table>
These categories are not hierarchical. The pilot study indicated that parents used few open questions, but also rarely told their child directly what to do. The game playing did not seem to follow a path in terms of the directiveness of the parent's utterances. This highlights the distinction between game playing and problem solving. While playing the game caused some problem solving to be undertaken, the overall structure of the interaction was that of a game. There was not a pattern of success or failure on the part of the child for the parent to adjust to.

The tapes were coded by the researcher. Twenty-five percent of tapes were coded by a second rater. Inter-rater reliabilities are presented in Table 4.

<table>
<thead>
<tr>
<th>Decision</th>
<th>Percentage agreement between two raters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclusion / exclusion of an utterance</td>
<td>99 %</td>
</tr>
<tr>
<td>Category of utterance</td>
<td>89 %</td>
</tr>
<tr>
<td>Order of utterances</td>
<td>95 %</td>
</tr>
</tbody>
</table>

Some interactions were extended and others were brief; some utterances appeared to stand alone. The two games used in the study both proceeded by the players turning over a card. Each turn of the card offered the potential for further interaction, as the new card changed the game's status. The interactions were thus coded in blocks of speech occurring after each turn of the card. When a new card was turned, the interactions were coded in a new column. A sample of the coding form can be seen in Figure 1. The complete form and a variant for use with three players can be found in Appendix 5.
In order to capture the way in which the interaction proceeded, rather than just what it consisted of, each utterance was numbered. An example is given in Figure 2. It was then possible to determine if certain adult behaviours led to certain responses by children, or whether there was a particular pattern of interaction. The length of each exchange following a card turn was represented by the last number recorded.
Figure 2: An example of an interaction and its coding.

M: You've got two.
J: And you've got three.
M: So?
J: You get one out.
M: Why do I get one out?
J: Because you've got the highest number.

M - adult
J - child

<table>
<thead>
<tr>
<th>Parent</th>
<th></th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td></td>
<td></td>
</tr>
<tr>
<td>label</td>
<td></td>
<td></td>
</tr>
<tr>
<td>numbersentence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>repeat (other)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>revoice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>question</td>
<td></td>
<td></td>
</tr>
<tr>
<td>explain/give strategy</td>
<td>3, 5</td>
<td>1</td>
</tr>
<tr>
<td>mm, ah, ok</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Coding did not commence until a card was turned. This excluded conversations about the instructions and the allocation of equipment. Notes were taken on these game beginnings. Irrelevant talk, such as about the telephone ringing, was excluded. Transcripts were taken of some passages.

In some recordings, play occurred in silence. This highlights the limitations of audio-recorded data. These periods of silence occurred in all cases after the game had been mastered, and the game was played
without further comment. Coding the number of silent turns accurately was impossible from the tapes. Periods of silence were marked on the coding forms, with comment about their length and the play which preceded them. Analyses were thus limited to the number of turns with verbal interaction that the child experienced. As discussed in Chapter 2, the use of language has highly significant role in the establishment of intersubjectivity and the internalisation of ideas. The analysis presented here focuses on this. Silent play is noted in the results section (Chapter 6), as it may be indicative of the framework in which the players are working.

Two of the twenty-one tapes could not be coded according to this system. The first of these tapes involved the participating child and three of her siblings playing the game. Distinguishing the children was impossible, and most of the interaction involved discussion of the rules and who was winning. The second of these tapes was a family playing with four players, where the rules had to be modified significantly, and the game did not work. In both of these cases notes and transcript data were taken, and any mathematical episodes were particularly noted. Analysis of this data appears in parts of Chapter 6, but not in analyses requiring counts of the interactions. Two further tapes involved three players. As mentioned previously, a coding form was developed to encode these tapes, and can be found in Appendix 5. On these tapes the children can be distinguished by their voices and by the parent naming them prior to their speaking. In analysing these tapes, only the experiences of the participating child have been included. In one case, both recorded children are participants (twin boys). As both boys experienced substantially similar interactions (as judged by the researcher and a second rater), data for only one child has been included. In the second case, the counting behaviour of the participant's younger brother has been omitted from further analysis.

Considering the codings

The encoded data was then subjected to a range of analyses, presented in Chapter 6. Considered alongside transcript data, and data from the questionnaire and post-recording forms, evidence for the co-construction of ideas was sought. Analyses presented attempt to describe the ways in which parents
and children work together on these tasks, and to highlight any patterns which may have significance for children's mathematics learning.

The analyses aim to build a picture of parents and children interacting in ways which can be described as having certain features. McNaughton (1995) presents three tutorial frameworks for supporting story book reading. The coded data and the transcribed extracts will be considered to see if there are any similar patterns in the ways in which parents support their child's learning of mathematics through the playing of maths games.
CHAPTER SIX

RESULTS

The results of this study are presented in five sections: 1. The Use of Games, 2. Parent, Child and Game Factors, 3. Activity in Interaction, 4. The Mathematics-Focused Framework and 5. The Teacher. In this way the results begin broadly, by considering the use of the games in the families and establishing that the game-playing can be considered a 'construction zone' (Lehrer & Shumow, 1997). The lens is then narrowed to consider the influence of the three parties to the interaction - the parents, the children and the game itself. An even closer look is then presented, with analysis of the activity of game playing, evidenced by interaction. Two frameworks are proposed, within which the families are working. These are game-focused and mathematics-focused frameworks and are described, in terms of the activity within them. The mathematics-focused framework is given closer consideration in the fourth section, which presents three approaches to establishing the concept of addition - modelling, single-strategy and multi-strategy. In the final section, the data from the teacher's use of the games is considered, and a third framework is proposed - that of an evaluative framework.

USE OF THE GAMES

Data on the use of the Maths Games Library comes from both the telephone interview data and the audio taped game playing and associated questionnaires. Thirty-one parents who did not agree to having their game playing taped were interviewed by a parent, as described in Chapter 5. Thirteen families responded to the parent questionnaire and post-recording form (see Appendix 2 and 3). Information was gathered on aspects of the use of the games that were seen as important in defining the game use in a socio-cultural context. Participants commented on the frequency of game use, and on the composition of the group playing the game.
Frequency of Game Use

Table 5: Percentage of families interviewed by telephone who use the Maths Games Library weekly, irregularly or never (number of families in brackets) n=31

<table>
<thead>
<tr>
<th>Percentage of families</th>
<th>Use games weekly</th>
<th>Use games irregularly</th>
<th>Do not use games</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>71% (22)</td>
<td>23% (7)</td>
<td>6% (2)</td>
</tr>
</tbody>
</table>

The data from the participants who audiotaped their game playing reflects the responses from the telephone interview. Table 5 shows the number of times each of the target games was played by each family, and gives the parents' rating of how typical this was.

Table 6: Use of the target games by the families who audiotaped their sessions (during one week).

<table>
<thead>
<tr>
<th>Family number</th>
<th>Number of times 'More Dots' used</th>
<th>Likert rating (1) of typicality of frequency</th>
<th>Number of times 'Oops!' used</th>
<th>Likert rating (1) of typicality of frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Two</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Three</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Four</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Five</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Six</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Seven</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Eight</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Nine</td>
<td>2</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ten</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Eleven</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Twelve</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Thirteen</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

(1) Likert rating 1 (strongly agree) to 5 (strongly disagree) that "We played this game more than other games we have had."

Most parents responded neutrally to this statement, indicating similar play patterns to ordinary weeks. Three parents agreed that they had played one of the games more frequently than was usual. Table 6 indicates that the game recording participants did use the games on a weekly basis, as reported by the majority of parents interviewed by telephone, and that this was typical of their normal use of the games.
Composition of Groups Playing the Games

Telephone interview participants were asked to describe how the games were used. A range of group compositions was found, and these are presented in Table 7. Although two families reported not using the games currently, one family provided information about their past pattern of use. The other family responded to this question by saying that they were not used, hence n=30 for this table. As they answered other questions, this is the only table from which their data is excluded.

Table 7: Percentage and number of families interviewed by telephone, who play the games with parents, with parents and siblings, with parents or siblings, or with siblings only (number of families in brackets) n=30

<table>
<thead>
<tr>
<th>With parent alone</th>
<th>With parent and siblings</th>
<th>With parent or siblings</th>
<th>With siblings alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of families</td>
<td>47 % (14)</td>
<td>30 % (9)</td>
<td>17 % (5)</td>
</tr>
</tbody>
</table>

Nearly half of the children play the games in a one-to-one setting with their parents. Nearly one third of the children play with parents and siblings. Eight families (27 %) specifically mentioned the game playing as a positive family time in which they all participated. Five families (17 %) described the play as occurring with either parents or siblings. Two of the families interviewed said that the children played the games with their siblings, without parent involvement.

Data from the tape recording families confirmed this pattern. Families organised themselves in a range of ways to use the target games. Table 8 lists these.
Table 8: Game-playing organisations for the families who audio recorded their game playing

<table>
<thead>
<tr>
<th>Family number</th>
<th>Participants with target child playing 'More Dots'</th>
<th>Participants with target child playing 'Oops!'</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>mother, then father</td>
<td>father</td>
</tr>
<tr>
<td>Two</td>
<td>mother</td>
<td>mother</td>
</tr>
<tr>
<td>Three</td>
<td>mother, father, brother</td>
<td>mother</td>
</tr>
<tr>
<td>Four</td>
<td>two older sisters</td>
<td>mother then sister</td>
</tr>
<tr>
<td>Five</td>
<td>mother</td>
<td>mother</td>
</tr>
<tr>
<td>Six</td>
<td>mother</td>
<td>mother</td>
</tr>
<tr>
<td>Seven</td>
<td>mother, then father</td>
<td>mother</td>
</tr>
<tr>
<td>Eight</td>
<td>-</td>
<td>father and twin brother</td>
</tr>
<tr>
<td>Nine</td>
<td>father and younger brother</td>
<td>-</td>
</tr>
<tr>
<td>Ten</td>
<td>-</td>
<td>mother (brother watching)</td>
</tr>
<tr>
<td>Eleven</td>
<td>older brother</td>
<td>-</td>
</tr>
<tr>
<td>Twelve</td>
<td>mother</td>
<td>-</td>
</tr>
<tr>
<td>Thirteen</td>
<td>father</td>
<td>father</td>
</tr>
</tbody>
</table>

Although many of the games in the Maths Games Library, including the two target games, were for two players, this did not automatically mean that the child and a parent played together. All of the group compositions mentioned by the telephone interview families were present in the data from the audio recordings. Amongst the families who audio-recorded their game playing, those who played with siblings alone were younger children in larger families. This reflects the organisational reasons given for children playing with siblings, by parents in the telephone interview.

Either one-to-one or the children help him to play - depends on time and difficulty.

THE PARENT, THE CHILD AND THE GAME AS INFLUENCES ON ACTIVITY

Each of the components of the game playing setting has a potential influence on the interaction that results. The players, both adult and child, and the game itself combine to determine the co-construction of ideas around the game playing event. This section examines the influence of these components separately. This separation must be artificial within the sociocultural framework, where each part is inextricably woven in to the whole. In considering the complexity of data in this study it provides a useful framework, however, for looking at what might determine patterns of interaction.
The factors considered were those highlighted by the literature (see Chapter 3) as being potentially important. In addition, factors relating to this study in particular were also considered. These relate to the games used. In this data factors related to the child and the game seem to be more important than factors relating to the parents. The child's attitude to game play is an important influence on the interaction, as is the difficulty level and nature of the game. In this study, parental education, parental attitude to mathematics, parental attitude to the Maths Games Library and children's ability as measured by 'Checkout' were not found to be important contributors to variations in interaction.

Parent factors

Parents who completed the questionnaire provided information on a number of factors which the research literature (see Chapter 3) suggested were influences on parents and children learning mathematics in the home. Scales were derived which were intended to measure attitude to mathematics, and attitude towards the Maths Games Library. Parents were asked to give their perception of their child's mathematics ability and to say if they used mathematics in daily life.

No significant relationship was found between the parents' attitude to mathematics and their attitude to the Maths Games Library (Spearman's $r = \bullet 368$), nor between their level of education and their attitude to the Maths Games Library (Spearman's $r = \bullet 715$). Parents' attitude to mathematics (Spearman's $r = \bullet 202$), to the Maths Games Library (Spearman's $r = \bullet 821$) and their education level (Spearman's $r = \bullet 607$) were also not related to their children's ability level (as measured by the SEA test) in this sample. Maternal education level varied from fourth form to tertiary, with 12 of the 13 mothers having School Certificate mathematics or higher. This restricted range may have reduced the significance of this factor.

Parent's perceptions of their child's ability were not out of line with their child's actual ability (as measured by the SEA test - scores on this test presented in Table 2, Chapter 5). All the parents listed areas in which they used mathematics in their daily lives. None of them indicated that they felt they
never used mathematics or that it was irrelevant to them. Thus the factors of parent perceptions and parental use of mathematics did not vary sufficiently to be considered as useful factors.

Child Factors

Children’s Attitude

Whether or not the child was willing to play had a profound effect on how the game proceeded. Despite not being specifically asked about the preconditions for successful game play, telephone interview families volunteered a great deal of information about the effect that the child’s willingness to play had on the game playing interaction. In several families whether or not the child felt like participating was the key to whether or not the game was used. Conflict between siblings was also mentioned. Other families noted that the child was extremely keen and demanded play. A similar variety of child responses was noted in the tape recording families, with two games terminated because of lack of cooperation by the child. Table 9 presents the comments made by the telephone interview families.

Table 9: Comments made about the effects of child attitude on game playing interaction by telephone interview families.

<table>
<thead>
<tr>
<th>Telephone interview families (n=31)</th>
<th>Telephone interview families (n=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Difficulties</strong></td>
<td><strong>Positive comments</strong></td>
</tr>
<tr>
<td>Fighting sometimes spoils games.</td>
<td>Demands we play a lot with her.</td>
</tr>
<tr>
<td>Fights sometimes.</td>
<td>Really keen.</td>
</tr>
<tr>
<td>Enjoyable family time when they</td>
<td>He really likes them. He wants to</td>
</tr>
<tr>
<td>suit her.</td>
<td>play, not be taught.</td>
</tr>
<tr>
<td>If M. doesn’t get to take charge</td>
<td>Always wants someone to play.</td>
</tr>
<tr>
<td>it can turn into a nightmare.</td>
<td>Asks for home maths game.</td>
</tr>
<tr>
<td>Don’t play every week, only when S. is enthusiastic.</td>
<td>Loves to play them.</td>
</tr>
<tr>
<td>Painful sometimes. Great if he can be the boss.</td>
<td>Keen to do it all the time.</td>
</tr>
<tr>
<td>Depends on mood. Lots of fights.</td>
<td>He likes games and enjoys it.</td>
</tr>
<tr>
<td>If she likes it it’s all go, otherwise she won’t play - will say ‘This is stupid’.</td>
<td></td>
</tr>
</tbody>
</table>
| If he enjoys it, it’s great.      | |}

There was no difference in the gender of the children who were said to be difficult or enthusiastic, with a mixture of girls and boys in both the 'keen' group and the 'difficult' group.
A further illustration of the effects of the child's mood is provided by the data from Family Thirteen (participants who recorded their game playing). In this family the two games were played with the father. On one occasion, the child is reluctant to play. On the second occasion he was keen to participate. Table 10 summarises the differences in interaction pattern between these two game playing sessions.

Table 10: Comparison of recorded game playing in Family Thirteen

<table>
<thead>
<tr>
<th>Game</th>
<th>Number of times played</th>
<th>Adult initiations</th>
<th>Child initiations</th>
<th>Number of turns</th>
</tr>
</thead>
<tbody>
<tr>
<td>'More Dots'</td>
<td>1 (incomplete)</td>
<td>8</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>5</td>
<td>45</td>
<td>105</td>
<td>150</td>
</tr>
</tbody>
</table>

There was a great deal more game playing activity during the 'Oops!' game, when the child was eager to participate. The child took a greater role in initiating interaction, and together parent and child completed more than ten times the number of turns. Clearly, the child's attitude has a significant role to play in determining the course of the activity.

**Children's Ability**

Children's ability, as assessed by 'Checkout', was not found to be a significant factor in any of the analyses performed. Children's ability was measured using scores from the SEA test 'Checkout - Rapua' (Ministry of Education, 1997). These scores are reported in Chapter 5, Table 2. It was not related to the type of interaction the child experienced, nor to the configurations used or any other interaction patterns. It did not affect the number of times a game was played, nor the amount of mathematics content introduced. This may have been because of the games selected for this study. These factors are considered below.

**Game factors**

The game factors which appeared to influence the interaction were the level of difficulty, the amount of mathematics potential the game contained and the nature of gameplaying itself.

**Level of Difficulty**

While the two games selected for the study were intended to be of two different difficulty levels, this did not prove to be a useful distinction for some participants. Although the 'Oops!' game is harder than 'More
Dots' in terms of the analysis discussed in Chapter 5, for these children both games were easy. This reflected a trend found in the telephone interview data, where participants were asked if the games were of appropriate difficulty. This data is shown in Table 11.

Table 11: Percentage of telephone interview families who found the Maths Games Library games hard, easy, or a good mixture (number in brackets). n=31

<table>
<thead>
<tr>
<th>Percentage of families</th>
<th>Hard</th>
<th>Good mixture</th>
<th>Easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>13% (4)</td>
<td>52% (16)</td>
<td>35% (11)</td>
<td></td>
</tr>
</tbody>
</table>

While most of the interviewed families felt there was a good mixture of games, the games were seen as easy by nearly three times as many families as found them hard. The difficulty level of the games was also commented on by the families who recorded their game playing. These families rated the games library in general, and each of the two games they played, in terms of its appropriateness.

Table 12: Rating of overall appropriateness of level and easiness of target games, by tape recording families. (Likert scale 1-5, where 1 = strongly agree, and 5 = strongly disagree).

<table>
<thead>
<tr>
<th>Family number</th>
<th>Overall appropriateness (1)</th>
<th>Easiness of More Dots' (2)</th>
<th>Easiness of Oops! (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>one</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>two</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>three</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>four</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>five</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>six</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>seven</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>eight</td>
<td>3</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>nine</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ten</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>eleven</td>
<td>4</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>twelve</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>thirteen</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

(1). responding to statement "The games are at an appropriate level".

(2). responding to the statement "My child found this game easy".

All families who recorded their gameplaying strongly agreed that their children found 'More Dots' easy. Three parents neither agreed nor disagreed (3) that their children found 'Oops' difficult, and three parents agreed (2) rather than strongly agreed that it was easy. This suggested that 'Oops!' was experienced as more difficult by some of the participating children. The tape data indicate that these children were capable of playing 'Oops', however.
Several parents in the telephone interview group commented on the need for graded material, rather than receiving games at a range of levels.

"Graded games are more likely to appeal to the child."
"Games should be at levels and given out accordingly."
"Games should reaffirm what they are learning at the time."
"Games are too inappropriate to what is learned at the time."
"Don’t see how they match what she is learning - she’s not ready for the concepts."
"No opportunity to evaluate jointly. Is it relevant? Does it relate?"

Families who recorded their game playing also noted the effects of inappropriately levelled games.

"I find that most of these games are a little too simple for G. She even knows how to cheat at most."
"Game was a bit too easy and lacked the interaction communication skills needed to really enjoy the game. Needs more challenge, even for five year olds."

**Relation to the mathematics curriculum**

While playing the games, parents and children ably covered a range of mathematics objectives which teachers would consider appropriate for children of this age. Each of the two target games contains unavoidable elements of mathematics. In 'More Dots', players must recognise the number on each card, compare these and decide which is greater. In 'Oops!' players must keep in running total by some means as they turn over the cards, and must recognise when they have reached the target number.

Families playing 'More Dots' covered between two and seven objectives or strategies. When playing 'Oops!' they covered between five and nine objectives or strategies. More objectives or strategies were covered playing the more complicated game. Fewer objectives or strategies were covered by families in which the siblings played together or more than one child of different ages played with the parent. While all families covered objectives and strategies which could be considered to be inherent in the game playing activity (following instructions, pattern recognition) a range of additional mathematics was covered. For these children, who could already recognise the patterns, the extent of this additional mathematics is of importance. In the 'Oops!' game, eight of the ten parents chose to introduce the concept of adding the numbers together, rather than using a counting strategy. Three parents also managed to introduce this to the 'More Dots' game, where it was not part of the play of the game. Posing comparison
problems occurred in three of the ten 'Oops!' games, and in five of the eleven 'More Dots' games. Three families went beyond addition and introduced multiplication concepts - two in 'Oops!' and one in 'More Dots'. Three parents talked about finding half a set as they divided up the cards before play in 'More Dots'. Children were encouraged to explain their thinking in 'More Dots', and to estimate and check in 'Oops!'. Tables summarising this data are included in Appendix 6.

The more complex game provided richer ground for the introduction of mathematics objectives, indicating the importance of the game in directing the activity. The amount of mathematics that was drawn from, or added to, the game was determined by the parents and, to a lesser extent, the children. All the mathematics undertaken was logically related to the game play, but the extent to which the families noticed and used this mathematics varied. Overall, this analysis shows that the tape recording families are ably covering 'school' objectives through this game playing in the home, although some are covering more than others.

This ability to cover mathematics concepts is also shown by adaptations to the games. Both games' instructions included an idea for adapting or changing the game (see Appendix 1). Although the games provided direction, it was possible for the families to use the materials in a range of ways. Parents and children might alter the game in response to its ease or difficulty, or to try something new. Altering the game suggests a responsiveness to the game's progress. Table 13 shows the alterations made by families who recorded their game playing.
Table 13: Variations on games initiated by families who recorded their game playing.

<table>
<thead>
<tr>
<th>Family number</th>
<th>Game</th>
<th>Initiator</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>More Dots</td>
<td>Parent</td>
<td>Lower card wins</td>
</tr>
<tr>
<td>Three</td>
<td>More Dots</td>
<td>Child</td>
<td>Lower card wins</td>
</tr>
<tr>
<td>Three</td>
<td>Oops</td>
<td>Parent</td>
<td>Change target</td>
</tr>
<tr>
<td>Five</td>
<td>More Dots</td>
<td>Parent</td>
<td>Choose cards</td>
</tr>
<tr>
<td>Five</td>
<td>Oops</td>
<td>Parent</td>
<td>Change target</td>
</tr>
<tr>
<td>Six</td>
<td>More Dots</td>
<td>Child</td>
<td>Hold cards differently</td>
</tr>
<tr>
<td>Six</td>
<td>Oops</td>
<td>Parent</td>
<td>Choose cards</td>
</tr>
<tr>
<td>Nine</td>
<td>More Dots</td>
<td>Parent</td>
<td>Choose cards</td>
</tr>
<tr>
<td>Eleven</td>
<td>More Dots</td>
<td>Parent</td>
<td>Choose cards</td>
</tr>
<tr>
<td>Twelve</td>
<td>More Dots</td>
<td>Parent</td>
<td>Choose cards</td>
</tr>
<tr>
<td>Twelve</td>
<td>More Dots</td>
<td>Child</td>
<td>Invents memory game</td>
</tr>
<tr>
<td>Thirteen</td>
<td>Oops</td>
<td>Child</td>
<td>Removing sad faces</td>
</tr>
</tbody>
</table>

More parents than children initiated alterations to the game. More alterations were made to the easier game, suggesting that adaptations are sought when the game is too easy for the players. While all the parents’ alterations were followed through in game playing, none of the children’s suggestions were taken up. Only one parental alteration went beyond the game instruction’s suggestions (Family One, More Dots). The others all followed the alteration suggestions provided with the games. Parental suggestions all altered the mathematics content of the game, while three of the four children’s suggestions dealt with new ways to play which resulted in them winning more frequently. The other child’s contribution was similar to that made by the parent in Family One - making the lower, rather than the higher, card the winner.

**Perceptions about Playing Games**

The use of games rather than problem solving activities or more open-ended materials has been commented on in Chapter 4. Parents and children brought expectations of ‘a game’ to their playing of the Maths Games library games, and this has had an important effect on their interaction (see mathematics-focused and game-focused frameworks below).

Games are perceived as being ‘fun’, they are supposed to be enjoyable activities; activities which often have a ‘winner’. Games usually involve a turn-taking format and have rules which cannot be altered while playing. These understandings about games, their purposes and procedures, were a theme throughout the
data from the telephone interview subjects and from the tape recording families. These comments from the telephone interview families indicate that parents consider that the game should be 'fun':

"I like the games. They're learning but having fun doing it."
"Makes maths social and fun rather than academic."
"Good way to learn maths concepts while having fun."

These parents highlight the distinction between a game-playing framework and a teaching framework still further:

"Let him consider this a game. Let him enjoy his learning."
"He wants to play, not be taught. More fun than anything."

Families who recorded their game playing also mention difficulties posed by the child being in a game-playing framework:

"T. enjoys the games on a board the most. She can see who's winning more easily I guess."
"J. even knows how to cheat at most which is not such a good thing. She only plays to win so the winning factor takes over the game."
"M. is very competitive and likes to win. He can become argumentative if he thinks he's losing, as in this case."

ACTIVITY IN INTERACTION

Parents and children played these target games in a range of settings and frequencies as outlined in the first part of these results. The interaction, which is the substance of the activity, has special characteristics determined by the parent, child and game as summarised in the previous section. Bringing these components together, we can view the game playing activity as a whole, and describe its nature. In this section, results from eighteen taped sessions are presented. Three tapes have been excluded. These are summarised in Table 14.

Table 14: Data excluded from the activity analysis.

<table>
<thead>
<tr>
<th>Family number</th>
<th>Game</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>three</td>
<td>More Dots</td>
<td>Attempted to play the game with four players, interaction about rules and difficulties, than played with sibling. Discussion about game rules.</td>
</tr>
<tr>
<td>four</td>
<td>More Dots</td>
<td>Three siblings playing together - impossible to differentiate children reliably. Discussion about game rules and irrelevant topics.</td>
</tr>
<tr>
<td>eleven</td>
<td>More Dots</td>
<td>Played with sibling in silent turns. Discussion about game rules.</td>
</tr>
</tbody>
</table>
All three of the excluded tapes involved play with siblings. This play was characterised by discussion about whose turn was next and who was winning. Most turns were silent. These tapes are indicative of the children's game playing framework, in which discussion of mathematics rarely occurs. Left to their own devices, it seems that children view the activity as a game and use it as such. In family eleven the two siblings went on to play 'Fish', another card game that they thought was 'better'. One other tape involved play with a sibling, but this game was sandwiched between two games with a parent. The parent's data has been retained, and the sibling data excluded from the following analysis. Again, play with the sibling involved minimal discussion beyond turn taking and describing the game's progress.

The eighteen tapes reported on in this section therefore involve an adult and one or two children. Two tapes (Family Eight, 'Oops!' and Family Nine, 'More Dots') involve three players. The recording of the category of utterances and the order in which they occurred allows reconstruction of the interaction for analysis. This data has been used to explore patterns and variations in the interactions around these games.
Amount of interaction

The number of coded turns in each of the audio tapes varies widely, providing the first type of difference in the experiences of children playing these games. The number of coded turns in each game ranged from 12 to 219. Some families had a consistent pattern across both games (Family One, Family Two). Others showed substantial variation by game (Families Five, Six and Thirteen). Some games included lengthy periods of silent play. Silent play occurred in games where the interaction lengths prior to silence were generally less than four exchanges, it did not arise in games where long interactions were occurring frequently.

Initiation Patterns

Parents and children divided the cognitive work involved in playing the games between them. While there are some trends in this data, many patterns are family specific. After each turn of the card, either the parent or the child would initiate any interaction which followed it. If parents and children each initiated discussion on their 'turn', initiations could be expected to be approximately half each. Graphs showing the percentages of initiations by parent and child can be found in Appendix 7. While six tapes show an approximately half-and-half pattern, twelve do not. Seven tapes show a greater proportion of initiations being made by the child. Consistent patterns across families are not found, for example Family Five, whose pattern of initiations in 'Oops!' is in direct contrast to 'More Dots'. In both games the most usual response to the turning of a new card would be to label the amount of dots on it. This was the same for both parents and children. Children were also likely to count when playing 'Oops!'. Asking questions after turning a card was characteristic of some parents, but not of children. An unusual pattern is found in Families Five and Twelve playing 'More Dots'. These dyads exchanged remarks about the progress of the game - a type of running commentary - rather than labelling the amounts on the cards.

Two taped sessions - Family One, 'More Dots' and Family 7, 'More Dots' - contain games played with the mother and then with the father. In Family One, the two styles are in direct contrast, and this is discussed more fully in the section on frameworks below. In Family Seven, the playing styles are very similar in terms of initiations and types of contribution. For the remainder of the analyses, data will be...
presented for the mothers only in both cases. The mothers played more often than the fathers on the tapes, and completed the post recording forms and questionnaires in both cases.

Sharing of Cognitive Work

Following the initial utterance after a card had been turned a variety of interactions occurred. The cognitive work undertaken during these interactions was shared between the parent and the child. This sharing took characteristic forms, depending on the type of task considered. Easier, lower-level tasks were performed more frequently by the children, whereas tasks such as questioning were performed by the parents.

It can be seen from Figures 3 to 8 that the work done by the parents and children in these game-playing sessions was not of the same type. In both games, parents did more questioning than children, although the amount of questioning in each dyad varies considerably. In one dyad, the child asked more questions than the parent, but the rate of questioning was low. Explanations are less uniformly distributed, with some dyads characterised by elicitation of explanations from the child, and others by parents providing explanations. In 'Oops!', the more difficult game, parents gave more explanations than children in all but one of the dyads, where a low rate of explaining took place. More counting was undertaken by the children in all cases. The picture for labelling is more mixed. In three dyads parents undertake more labelling than the children. Other dyads show a similar pattern to counting, with children undertaking more labelling. The differences between parents and children on this more sophisticated skill are not as great as those between parents and children on counting, however.
Figure 7: NUMBER OF LABELS GIVEN BY ADULT AND CHILD IN EACH FAMILY DYAD PLAYING 'MORE DOTS'

Figure 8: NUMBER OF COUNTS MADE BY ADULT AND CHILD IN EACH FAMILY DYAD PLAYING 'OOPS!'
Three other categories were used to code parent and child interaction. Repeating and revoicing behaviour are not considered in these diagrams because they occurred infrequently. Repeating was coded if either participant repeated exactly what their partner said. Revoicing involved using the partner's contribution and adding to it, for example replying 'one dot' when a child says 'one (see Chapter 5 for elaboration). Revoicing was never used by children, and only six instances of children repeating a parent's contribution are found in the whole data set. The parent in Family Eight used repeating and revoicing more frequently than other parents, whose rates were very low. This is considered in the section on the single-strategy approach to addition below. The use of number sentences, the final category, is also considered in the discussion of addition below.

Long Interactions

Longer interactions resulted in more discussion about mathematics, and seemed to occur more frequently in some tapes than in others. Each card turn began a new section of coding. Sometimes silence followed; on other occasions one utterance was made. Beyond this, patterns were found where turns were taken, or where one participant made a number of utterances of different types without the feedback of the other participant. A range of interaction lengths was found, from silence (0) to 19 contributions. If a participant contributed three sentences, each with a different purpose, these were coded separately (see Chapter 5). As well as being exposed to a wide variety of absolute number of turns, the children and parents created a range of interaction lengths. Interactions of four contributions or more were long in terms of the total data set, where most turns were one, two or three contributions long. Interactions of seven or more contributions were very long in terms of the data set, and tended to occur in some tapes and not in others.

The percentage of total coded turns which were long interactions (4+ contributions) varied from 3% to 91%. Longer interactions occurred more frequently in 'Oops!' than in 'More Dots'. Long interactions varied in purpose and structure, but always carried more mathematical content. Table 15 summarises the characteristics of these long interactions.
Table 15: Content and structure of long (4-6 and 7+) interactions during the playing of 'Oops!' and 'More Dots'.

<table>
<thead>
<tr>
<th>Game</th>
<th>Family number</th>
<th>Content / Structure of Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>'More Dots'</td>
<td>one</td>
<td>Questioning by adult and response by child</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>nine</td>
<td>Questioning and explaining by adult - keeping two children’s attention</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>seven</td>
<td>Questioning by adult and response by child</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>twelve</td>
<td>Exchanging comments about the game</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>thirteen</td>
<td>Parent questioning and explaining to keep child’s attention (conflict situation)</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>five</td>
<td>Summarising the game when complete</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>two</td>
<td>Summarising the game when complete</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>ten</td>
<td>Parent questioning and explaining to keep child’s attention (conflict situation)</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>four</td>
<td>Question and response using addition statements</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>three</td>
<td>Questioning by adult and response by child</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>eight</td>
<td>Question and response using addition statements and repeating contributions</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>five</td>
<td>Explanations by parent and child counts</td>
</tr>
</tbody>
</table>

Patterns in activity - contingent responses

A pattern of contingency could be inferred from the structure of the interaction. Contributions which were made in a turn-taking framework (one participant follows the other) can be distinguished from those in which a contribution is left alone (one utterance in a turn) or ones in which the same participant continues without waiting for the other’s contribution. Turns which continue to three or more contributions can be assumed to have an element of contingency. There were no occasions in the data set where the participants made unrelated utterances over three or more contributions. Families varied widely in the percentage of turns which had this contingent framework. Some contingent exchanges built on parent initiations, others on child initiations. Table 16 shows the percentages of total turns which followed a contingent framework, separated into those initiated by adults and those initiated by children.
Table 16: Contingent interactions as a percentage of total turns for each game.

<table>
<thead>
<tr>
<th>Game</th>
<th>Family number</th>
<th>Percentage of adult-initiated contingent interactions</th>
<th>Percentage of child-initiated contingent interactions</th>
<th>Total percentage of contingent interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Oops!'</td>
<td>one</td>
<td>1%</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>two</td>
<td>12%</td>
<td>7%</td>
<td>19%</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>three</td>
<td>59%</td>
<td>4%</td>
<td>63%</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>four</td>
<td>23%</td>
<td>9%</td>
<td>32%</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>five</td>
<td>1%</td>
<td>6%</td>
<td>7%</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>six</td>
<td>0%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>seven</td>
<td>4%</td>
<td>13%</td>
<td>17%</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>eight</td>
<td>33%</td>
<td>7%</td>
<td>40%</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>ten</td>
<td>24%</td>
<td>14%</td>
<td>38%</td>
</tr>
<tr>
<td>'Oops!'</td>
<td>thirteen</td>
<td>2%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>one</td>
<td>10%</td>
<td>7%</td>
<td>17%</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>two</td>
<td>23%</td>
<td>8%</td>
<td>31%</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>five</td>
<td>23%</td>
<td>6%</td>
<td>29%</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>six</td>
<td>11%</td>
<td>7%</td>
<td>18%</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>seven</td>
<td>19%</td>
<td>19%</td>
<td>38%</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>nine</td>
<td>9%</td>
<td>0%</td>
<td>9%</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>twelve</td>
<td>29%</td>
<td>0%</td>
<td>29%</td>
</tr>
<tr>
<td>'More Dots'</td>
<td>thirteen</td>
<td>42%</td>
<td>25%</td>
<td>67%</td>
</tr>
</tbody>
</table>

There is a significant correlation between the percentage of turns which have a contingent format and the percentage of turns which are longer than four contributions (Spearman's $r = 0.83$, $p > 0.01$). Responding contingently to one's play partner appears to lead to longer interactions. In this data set, these longer interactions contained the more elaborate mathematics. Thus families who were using each others contributions and extending their interactions were covering more mathematics content during gameplay.

Two frameworks emerge

All of the reported characteristics of the game-playing activity combine to form an overall impression of each taped game. Parents and children fall into one of two frameworks - some are working in a game-focused framework, others in a mathematics-focused framework. The characteristics of each are presented in Table 17.

Table 17: Characteristics of the game-focused and mathematics-focused frameworks.

<table>
<thead>
<tr>
<th>Game-focused</th>
<th>Mathematics-focused</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are many one-contribution</td>
<td>There are a greater proportion of long</td>
</tr>
<tr>
<td>turns and fewer long turns.</td>
<td>turns and fewer one-contribution turns.</td>
</tr>
<tr>
<td>Few questions are asked.</td>
<td>Many questions are asked.</td>
</tr>
<tr>
<td>The inherent mathematics content</td>
<td>Additional mathematics content is</td>
</tr>
<tr>
<td>is covered.</td>
<td>covered.</td>
</tr>
<tr>
<td>Silent turns are common.</td>
<td>Few, if any, silent turns.</td>
</tr>
<tr>
<td>There is a low percentage of</td>
<td>There is a high percentage of turns with</td>
</tr>
<tr>
<td>turns with</td>
<td>-82-</td>
</tr>
</tbody>
</table>
Players take their own turns, doing their own 'work' on their turn. Parents ask children to help them with their turns.

This overall pattern reveals a trend in parent support that is not obvious in closer analysis. While there is little failure by children, and therefore no chartable pattern of adjustment in adult level of support, parents who rated 'Oops!' as less than very easy for their child all adopted a mathematics-focused framework for their interactions in this game. While some parents adopted the mathematics-focused framework in games that their child found easy, no-one adopted a game-focused framework with anything other than a very easy game. Twelve playing sessions follow a mathematics-focused framework, and thirteen follow a game-focused framework. This data includes the peer-peer tapes and separates the game playing of Family One playing 'More Dots'. On this tape, the child plays the game first with her mother, and then with her father. Her mother is working in a mathematics-focused framework, and her father in a game-focused framework. This can be seen by comparing the two sets of encoded data, and by looking at transcripts of how the players interacted.

In the game-focused framework, players simply play the game. Issues which are directly related to the game's progress are discussed. Many turns pass unremarked, or are punctuated by laughter or sighing. There is less discussion, and each turn of the card is more likely to yield a short exchange. Players who are working in a mathematics-focused framework use opportunities to introduce and discuss aspects of mathematics which are not essential to the game's progress. More questions are used, and the playing of the game is commented on frequently. A 'running commentary' develops between the players. Longer exchanges occur more frequently, and play partner's comments are more often followed by a contingent response (as defined above). The data from Family One playing 'More Dots' illustrates these differences clearly, as the child and the game are the same, but the interaction pattern is different.
Figure 9: PERCENTAGE OF CODED TURNS THAT WERE ONE-CONTRIBUTION TURNS (Family 1, 'More Dots')

One-contribution turns

- 22%
- 13.5%

Percentage

Figure 10: PERCENTAGE OF CODED TURNS THAT WERE CONTINGENT-PATTERN TURNS (Family 1, 'More Dots')

Contingent-pattern turns

- 8%
- 22%

Percentage

Figure 11: PERCENTAGE OF CODED TURNS THAT WERE LONG TURNS OF 7+ CONTRIBUTIONS (Family 1, 'More Dots')

Long turns

- 2%
- 10%

Percentage
These diagrams show the differences between the game-focused framework and the mathematics-focused framework, in terms of interaction length and contingent nature. The mathematics-focused framework clearly yields longer exchanges and a greater proportion of contingent responding than the game-focused framework.

The father and daughter of Family One cover two mathematics objectives in their game play - pattern recognition and following instructions. These two objectives are inherently part of the game; you cannot play without covering these. In contrast, the mother and daughter cover six objectives - pattern recognition, following instructions, comparison, modelling addition, explaining ideas and subtraction. Covering addition and subtraction in particular required planful questioning by the mother, revealing her mathematics-focused framework.

The tone and content of the exchanges while the game progressed also reveal the characteristics of these two frameworks. In game-focused play over half the time was spent playing in silence. In mathematics-focused play turns are punctuated by comment and discussion.

In all transcript examples P = the parent and C = the child.

Game-focused play - Examples of interaction

Example 1.

P: What do you think this helps you with T.? Does it help you with counting?
C: Yup.

Example 2.

C: Dad, this is how you learn numbers isn't it?
P: (no response)

Example 3.

C: Two and two. Look Dad!
P: (no response)

Example 4.

C: Who wins that one?
P: It's two pairs.
These examples indicate the type of interaction occurring during game-focused play. These examples represent the additional mathematics talk undertaken by the father and daughter. The father attempts once to link the game as a whole to his daughter's mathematics learning (example one). This is done in an abstract way, rather than as part of the game play. T. later reflects this back to her father by asking if this is how you learn numbers (example two). This is not picked up on by her father. T. attempts to initiate dialogue in the two other examples. Both instances go no further than the examples given here, despite openings for further dialogue, such as what two and two might be, or what a 'pair' is. From the laughter and other talk present on the tape, it is clear that both father and daughter are enjoying the game, and enjoying it within a game-focused framework.

Mathematics-focused play - Examples of interaction

Example 1:

P: How come I win that?
C: 'Cause you got 3 and I got 1.
P: And how many more do you need to make 3 dots?
C: 3 more.
P: No.
C: 2 more.
P: Good girl. So if you had two more dots how many would you have?
C: 3
P: And how many would I have? Three as well. I've got three as well.

Example 2.

P: You've got to say how many there are
C: 4.
P: Four dots.
   (turns card) One dot.

Example 3.

P: How many dots does that make altogether?
C: Five.
P: So 4 plus 1 equals
C: Five.
P: OK. So four plus one equals five. Right? So if I take one away, how many does that leave?
C: Four
P: If I take four away, how many does that leave?
C: One.

These three examples from the mathematics-focused play of the mother and daughter are typical of a pattern of exchanges which continue throughout their playing of 'More Dots'. The mother poses questions for T. to answer, using the cards turned over. These questions relate only superficially to the playing of
the game, but use the cards to expand Tania's ideas about addition and subtraction. The mother then alters the rules of the game, to make it the lower card that wins on each turn. This leads to discussion about what 'the lower' is, and who will now win.

    P: Three, four. Who's got the lower number?
    C: Ummm. You - me!
    P: Are you sure?
    C: Yes.
    P: Why?
    C: Because I got three and you got four.
    P: And three is more than four?
    C: Yes.
    P: Is three more than four?
    C: No.
    P: Why isn't it?
    C: Because three is the lowest and four is taller.
    P: Higher.
    C: Higher.
    P: How much higher is four?
    C: That higher!
    P: No, I don't mean that higher, I mean....how...how How many more dots has four got than three?
    C: All together?
    P: No, like if I wanted to have four dots how many more dots would you need?
    C: Two and two
    P: No.

T. and her mother work towards clarifying the language and the concept behind the idea of the 'lower number' over several turns. This drive towards making the game more difficult and drawing the mathematics out of it is not seen in game-focused play. The mathematics-focused play described here results in a different experience for the child. While both parents can be seen as playing the game with the child, they are doing so in clearly distinct ways. The implications this has for children's learning will be addressed in Chapter 7.

**ADDITION AND THE MATHEMATICS-FOCUSED FRAMEWORK**

All of the parents who brought the language and concept of addition into interaction with their children were working in a mathematics-focused framework. These interactions about addition stand out as a distinct set of data. Although the parents appear to have the same motive in introducing the concept (they believe it is an appropriate next step) and they are all using a game to achieve it, they differ in the ways that the game is used. These correspond to Leont'ev's (1978) theory of three levels of activity. The
parents playing the games differ at the level of operations, the situationally defined aspects of their activity.

Interactions about addition occur in both games, although they are more common during 'Oops!' where addition is a useful strategy for working out the running total. In some families, conversation about addition characterises the whole game (Family 8, Family 10, and Family 4). In others there is only one instance of addition being mentioned (Family 2, Family 13). Drawing conclusions about patterns in interactions must therefore be done cautiously, as some are based on very infrequent occurrences. Across the whole data set, interaction about addition is not frequent, which serves to set it apart as an indicator of the mathematics-focused framework.

Three distinct modes of interaction about addition can be described. The first is modelling, the second multi-strategy and the third single-strategy.

Modelling
Two families (Family 3 and Family 7) used this interaction pattern when playing 'Oops!'. Both mothers used addition to keep their running totals on their turn. The children were not asked to try this method, nor was it pointed out to them what their mother was doing. The model was simply presented as part of the flow of the game. Neither of the children used this method during the playing of the game.

Single-strategy Interaction
Two families (Family Eight and Family Thirteen) used this style of interaction playing 'Oops!'. A single pattern of interaction was used, and did not vary in response to the children's answers. A clear 'agenda' was articulated by the parent, who was aiming for a particular model of competence in addition. This method was reiterated as the game progressed, with the use of addition statements to summarise the turns. In Family Eight, the game proceeded with the children (twin boys) turning over their cards and making a set of nine. These turns were then summarised by using addition statements. The parent explicitly asked for the children to work mentally, and not to count. In Family Thirteen, early turns were
characterised by counting, but on the second game the parent introduced the idea of using addition to find the totals. Extracts from these interactions are given below.

Family Eight playing 'Oops!'

Example One

C: 1,2,3,4,5,6,7 (turns card)
P: How many now? OK. How many now? You have got seven. Seven plus..
C: 1,2,3
P: NO! Don't count. I teach you how to add. You have got seven points now. Is that right? How much is seven plus three?
C: Makes ten.
P: Number one! Makes ten!
C: I have ten
P: So you don't have to count, OK.
C: OK.

Example Two

P: How much is one plus two
C: Three.
P: Three. Yep. Correct. How much is three plus two?
C: Ahh, five. Four.
P: Not four, five OK? Five plus three?
C: Six
P: Five plus three. No, five plus three again.
C: One, two...
P: No, no. Don't count. Think.
C: It's six.
P: Five...plus...three...is the thing. Five plus three.
C2: (brother) Eight
P: Yeah, alright.
C: Eight.
P: Eight dots. OK. Now how much is eight plus two?
C: Nine.
P: Eight plus two is not nine.
C2: Ten.
P: Yip. M. got it.
C: Ooh!
P: So T. Now you have to count it, OK? One plus two is...
C: Is three
P: Three plus two is
C: Five
P: Five plus two is
T: Is three
P: No
C2: Is seven
P: Is seven and seven plus three is
C: Is eight...ten, ten.
P: Ten
C: I win!
These examples illustrate how the parent directed the children to find their totals in a pre-determined way, using addition rather than counting strategies. Despite the child struggling to find the answer, the parent continues, and by repeating the sequence is able to make the child more accurate. Throughout the game the parent maintains this stance, and after the game has finished, drills the children on some addition and subtraction facts. In this drill the children are told to answer as quickly as possible and not to count or use their fingers.

Family Thirteen playing 'Oops!'

C: 6,7,8...
P: I want you to count them properly for me, Now that's plus...
C: 1,2...
P: Hang on! Let's do it another way. One plus one is two.
C:...one is two
P: (and C together): Plus one makes three
P: Three plus three makes
C: Five?
P: Three plus three?
C: What was it?
P: Three plus three?
C: What were these ones?
P: That's three.
C: 1,2,3,4,5,6. Six!
P: Six
C: Seven
P: Six plus one makes?
C: Seven?
P: Seven plus one makes?
C: Eight
P: Plus one?
C: Nine.
P: Makes nine. That means you get it.

This way of summarising the turns is used every time following this example. If the child responds incorrectly, the question is repeated, but the language is not altered in any way. The child is allowed to count in this example, but the strategy is initially set by the parent who says that they will now 'do it properly'.

One other family (Family Two) uses addition facts without using other strategies. They use this only once in the game, making it less characteristic than the interactions described above.

Family Two playing 'Oops!'

P: One dot for mummy.
C: One
P: So one plus one equals...
C: Two
P= Two dots
Multi-strategy Interaction

Five families (Family One, Family Five, Family Ten, Family Twelve and Family Four) use a range of ways to introduce addition concepts into the game playing. A variety of language is used, including informal (and, together, makes, more, total) and formal (plus, equals) addition language. Parents switch between these in response to the children's replies. In three families (Family One, Family Five and Family Ten) they begin with less formal language and finish with a formal addition statement. Two families (Family Twelve and Family Four) do not use formal addition language in their exchanges. This may be contingent on the child's level of responding.

Family One playing 'More Dots'

P: How many more do I need to make four?
C: Two more.
P: No - think about it. (PAUSE) How many dots have I got there?
C: Three
P: And how many have you got there?
C: Four
P: OK. So you count three dots on your card. OK. And how many have you got left to count?
C: One!
P: So...
C: So you need one more
P: Because three plus one equals..
C: Four!

This interaction is characteristic of exchanges between this parent and child, as discussed in the comparison above. This example shows how the parent initially poses a problem and, in response to the child's incorrect answer, changes her way of presenting the question. In this case she demonstrates a way of solving the problem by asking the child to count the dots on the card. After prompting the child to answer the initial question (So...), she summarises what they have done using formal addition language. The strategy used can be seen to change in response to the child's performance, but the final statement is the same as that promoted by the single-strategy interaction discussed above.
Family Ten playing 'Oops!'

Example One
P: What have I got?
C: A two and a two
P: Which makes?
C: Four...and a two
P: Which makes?
C: Six... and a three
P: Which makes?
C: Nine!
Example Two
P: Six plus two is?
C: Eight.

These two examples are from consecutive turns. In the first example, the parent chooses to use the phrase 'which makes' rather than the formal language of addition. The child can clearly add these mentally, so she continues with the pattern. In the next exchange, she switches to using formal addition language, which the child also responds accurately to. In this game playing episode, the child was very reluctant to play, and these exchanges represent attempts to keep him involved in the game's progress.

Family Five playing 'Oops!'

Example One
P: How many more do you need to make nine now?
(Not answered)

Example Two
P: And how many more to make nine?
(Child uses fingers to show how many)
P: That's right, three.

Example Three
P: Six, seven...how many more do I need?
C: Two!

Example Four:
P: Six. You've got a six. You just need one more and you'll have a seven.
C: Mum, that plus one equals seven. (Turns over a two) Two plus seven... Nah, I'll just count.

Example Five:
P: So one and two makes how many?
Not answered
Example Six:
C: What does that mean, seven and seven?
P: Well, you have seven and you have seven more.
C: 1,2,3,4,5,6,7
P: No, do that seven again.
C: 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16
P: You've got a seven...
C: Sixteen
P: No, J. Look. Seven. 1,2,3,4,5,6,7. And count seven more.
C: 8,9,10,11,12,13,14. Fourteen!
P: So seven plus seven equals?
C: Fourteen!
P: Fourteen. That's right.
C: Fourteen, fourteen, fourteen, fourteen!

These extracts are chronological, and changes can be seen as the game progresses. The initial question posed by the mother goes unanswered, so she tries again with the same question, which the child uses fingers to solve (noted on game response form). The third time this type of question is asked, the child responds immediately. In Example Four, the child rephrases the mother's comment into a formal addition statement. She becomes confused, however, when the card she turns over is not what she is expecting, and reverts to counting to solve the problem. Example Five shows a new type of question from the parent going unanswered, but in Example Six, the child asks for clarification about what 'seven and seven' means. Rather than answering by saying 'fourteen', the parent explores how to find the answer with the child. The child mis-counts the initial set of seven, and has to start again to get an accurate answer. When this is arrived at, the parent summarises with the formal addition statement 'Seven plus seven equals...'. The interplay between the parent's agenda of introducing addition concepts and the child's desire to master these results in a range of strategies being employed by both players.

Family Twelve playing 'More Dots'

Example One
P: How many have I got?
C: Four
P: And how many have you got?
C: One
P: Do you know what the difference between four and one is? How many more is four than one?
C: Umm, it's two more.
P: Two more? One, two, three more.

Example Two
P: How much more is three than two?
C: I've only got one card left.
P: Have you? Never mind, they're both the same.
Example Three
P: I've got four. How many more is four?
C: A winning card!
P: Two and what make four?
C: Two more.
P: Yes. Good boy.

This parent tries to ask a similar question three times during the game play. In the first example the child's incorrect answer is corrected by counting to get the correct answer. In the taped dialogue this had the effect of sounding like an incorporation of his incorrect answer, and then emphasising the three as the correct answer. The second time the child ignores the question, and the parent takes his lead and does not pursue it. The third example shows another attempt by the child to avoid the question, followed by the parent re-phrasing their question and reaching a successful conclusion. Formal language is not used.

Family Four playing 'Oops!'

Example One
C: Two
P: And?
C: And a one...that makes...
P: What does that make?
C: Twenty.
P: Pardon? Two and one makes?
C: Three
P: Three. OK.

Example Two
P: You've got a four there and three more, so how many does that make?
C: Fifteen
P: You work it out. Don't guess. You've got four and you add three more on. So how many do you have now?
C: Seven.
P: OK. Seven. If you add another three on after seven, how many do you have now?
C: Eight.
P: No, work it out my darling.
C: Ten.
P: Ten.

Example Three
P: Now, how many do I have here? Two...
C: One. Two, one
P: What does that two, one mean? Two, three, four.
C: Five
P: Five. Now. I'm trying to get to nine. Two. Five and two? Five and two more makes?
C: Eight
P: Can you work it out? You've got five and you add two more on.
C: Eight.
P: No. Two more. Five and two. You work it out. Five and two more.
C: 1,2,3,4,5,6,7,8
P: Where's the eight? There's only seven.
C: Oh!
Example Four
P: Three. So how many does that make in all? Three and three are?
C: Ten.
P: No. You work it out. You have to count them. You have three and now three more, so how many do you have?
C: Three
P: Count the dots. You have three and three more. That's how many in total?
C: Ahh, 1,2,...6!
P: Mmmm. And one more makes?
C: Seven.
P: Seven. How many more do I need to get nine? How many more dots?
C: Two more.
P: Very good. I wonder where a two is.....

These examples again show the use of a range of strategies in response to the child's replies. The child in the dyad tends to guess and need prompting to work out the answer. The parent's knowledge of this is evident, in that she does not assume that the child does not understand, but rather that she has not thought about it yet. This expectation leads the child to try again. In example three, the parent eventually gives the answer, unable to work out where the misunderstanding is occurring. In example four, she becomes more directive, asking the child to count the dots to solve the problem, and re-phrasing her questions using a variety of expressions for the addition operation.

These extracts from the taped interactions illustrate the three approaches to mathematics-focused game play found in this data set. The most frequently used approach was multi-strategy, where the parent uses feedback from the child's performance to select from a range of ways of promoting the addition concept. Even the parents using the multi-strategy approach were quite directive, however. They directed children to count to solve problems, and tended to ask closed questions resulted in brief answers from the children.

THE TEACHER

Only one teacher played the games with children as the other teacher was ill (see Chapter 5). She played the game with two of the target children from her class, using isomorphs of the games. These versions involved using large coloured dice instead of cards. The children were from Family Three and Family Thirteen. As each game was played once, the data set is very small, and caution must be exercised in
describing it. However, an interesting pattern emerges which is worthy of comment here. Where the parents’ frameworks can be described as game-focused and mathematics-focused, the teacher’s approach is evaluative. It follows the performance of the child closely and includes elements which allow the teacher to view independent performance. The teacher in these interactions does not attempt to teach anything. She follows the lead of the child’s responses to explore their knowledge, but does not add to this. Her stance is evaluative, and responsive to the child.

The teacher begins with each child by asking them to explore the equipment and say what they think they might be doing with it. This is in contrast to the parents who always began with reading the instructions. Questions such as ‘What can you tell me about these dice?’ and ‘What could we play?’ are used to begin the interaction.

Teacher and child playing ‘More Dots’

T: What do you think we are going to do?
C: Roll all of them and see how many there are and put down how many there are on each one.
T: That’s a good idea. You show me how you mean to play.
C: I mean, roll one, and if it doesn’t have a number on it get another one, and if it gets a number you still keep rolling them and if all of them have got a number on at the same time and one doesn’t you just throw them and see how many numbers and put down how many of those.
T: With the counters?
C: mmmhmm
T: I see. And what do I do while you are doing that?
C: Well, we’d have three each.

Time is spent on considering the possibilities of the game before it is played. All the parents began playing, and then reflected on the game. The time spent doing this ensured that the children understood the game fully, and contributed to the overall approach made by the teacher. Considering the strategies and possibilities of the game before beginning allows the teacher to see the child’s thinking about the mathematics of the game.

Teacher and Child playing ‘Oops!’

T: You might not get a three every time. What might you get? You might get a three one time, what else might you get?
C: Two
T: How many does that make?
C: Five
T: Supposing you get another three?
C: Right
T: What do you need to get to nine?

continued
C: One.
T: Yes. So if you get a one next time, you'd have got to your nine.

The teacher sought innovations on the game from the children and followed up on these by trying them out. This contrasts with the alterations suggested by children in the home context, where none were pursued. She knows what she is looking for in terms of the children’s responses and strategies, and can make this explicit to children.

Teacher and Child playing 'Oops!'

Example One

C: 6,7,8
T: I like the way when you got to five you didn't have to count them again. You went - you knew you had five there and you went 6,7,8 - that was very clever.

Example Two

C: 1,2,3 - I win again.
T: See if you can do it without counting this time. See if you can do it with looking and just see if you can add it up.

Problems were posed which went beyond the game play. This was done in response to the ease with which the children played the games. In both cases, the teacher moved quickly to make the games more difficult, and eventually used the equipment for another activity which was more challenging.

Teacher and child playing 'Oops!'

T: If we threw all the dice, what's the biggest number we could get?

As noted above, these observations are made on a limited data set. The effects of context are also felt here, with the child and teacher working within the framework defined by school. The child is less likely to tell the teacher that they will not play, or to refuse to answer questions about mathematics in this context. They have an expectation that they will be asked in this way. In this context, the child may more willingly adopt a mathematics-focused framework, while at home a game-focused framework is used, despite the similarities in materials. However the possibility of a third framework is indicated, with teacher-child interactions characterised by a focus on the child and their mathematics, rather than on the establishment of a particular concept.
CHAPTER SEVEN

DISCUSSION

The results presented in Chapter 6 show that the Maths Games Library is a frequently used resource, which most parents find useful for their families. Knowing whether or not the games were used does not tell us about what the child experienced, however. The contribution of this study is that it shows what the parents and children do with the games they bring home from school. Parent, child and game-related factors combine to determine the course the activity will take. Using games as the focus for interaction results in the emergence of two frameworks. A game-focused framework involves the parent and child playing the game for its own sake, without additional mathematics being added to it. Players in a game-focused framework discuss who is winning and play in silence for periods of time. They both understand the game, and play it as equal partners. There is little evidence of mathematics being learned when the focus is on playing the game. The other main framework was focused on the mathematics that arose from playing the game. In this mathematics-focused framework, parents take the lead, questioning and explaining. Players working in a mathematics-focused framework used one of three approaches to introducing addition in this study. Some parents provided a model of addition and made no further comment. Others used a single strategy to encourage their children to use addition. The third, and largest, group used a range of strategies to introduce the concept of addition. A limited set of data from a teacher was presented, which suggested that there might be an additional framework - a evaluative framework - which also had specific characteristics.

The results of this study extend the work presented in Chapters 2 and Chapter 3. The methodology and analysis fit in with a socio-cultural orientation, and the results propose the existence of interaction patterns in mathematical activity. This discussion will consider the results in terms of the literature and suggest further research that could be undertaken.
GAME PLAYING IS A 'CONSTRUCTION ZONE'

The analysis of data presented in Chapter 6 shows that game playing can indeed be considered a 'construction zone' (Lehrer & Shumow, 1997). There is dynamic and important interaction surrounding the games, which has consequences for children's learning. It is a construction zone with particular characteristics, however. Game playing is neither the same as problem solving (Lehrer & Shumow, 1997; Pratt et al, 1992) nor the same as open-ended activity (Anderson, 1997). The effects of game play on interaction emerge as a consequence of the influence of three factors - the parent, the child and the game itself. Wood and Middleton (1975) note that the path of interaction is dependent on the tutor's theories about the task and the tutee. Similar effects are found here.

The joint influences of parent, child and game determine the type of cognitive work undertaken by participants and the amount of mathematics covered. Together they determine the selection of a framework for the activity.

USING GAMES RESULTS IN TWO FRAMEWORKS

Observations of problem solving and open-ended activity (Wood & Middleton, 1975; Rogoff, Ellis & Gardner, 1984; Saxe, Gearhart & Guberman, 1984; Saxe, Guberman & Gearhart, 1987; Anderson, 1997; Lehrer & Shumow, 1997; Pratt, Green, MacVicar & Bountrogianni, 1992) have led to the description of a consistent pattern of responding across subjects. While variations have been found around this pattern, rather than looking for alternative patterns built on distinct beliefs, these variations have been averaged (Pratt et al, 1992; Lehrer & Shumow, 1997) or regarded as inferior versions of the same process (Saxe, Gearhart & Guberman, 1984; Saxe, Guberman & Gearhart, 1987). Using game playing as a focus for this study has resulted in two distinct frameworks being revealed. A game can be treated as a game, in the everyday sense. From the sociocultural viewpoint the emergence of this everyday view within the home is
important. Wylie and Thompson (1998) report that 89% of the 298 six year olds surveyed played board games at home, suggesting that for many it is a common occurrence prior to the introduction of the maths games. For some families, the game is a 'trigger' for playing with their child, finding a winner, enjoying themselves, playing by the rules. Other parents see the games as school mathematics activities in disguise. They take on the role of tutor, and actively seek to cover and extend possible mathematics concepts involved in the game. Either way the child gets to play the game, but their experiences are very different, as shown in Chapter 6. If the parents were asked to help their child with a mathematics task which had arisen from the classroom programme, as is the case in the IMPACT project (Merttens, 1993), all parents may have used a scaffolding technique as described by Pratt et al (1992) and Lehrer & Shumow (1997). The materials sent home to parents are a crucial determinant of what type of interaction will take place.

The existence of two frameworks fits in with the literacy research discussed by McNaughton (1995). McNaughton suggests that there are different tutorial configurations within which parents can work when reading with their children. While the 'collaborative participation' model has the most in common with what children will experience in school, McNaughton (1995) is careful not to describe other configurations as inferior. Recognition of the social and cultural influences on the development of tutorial styles is important when trying to understand how parents select an approach to use with children. Some tutorial patterns are found more frequently in particular cultural groups. This is an aspect which is not dealt with in this study, but would provide an interesting extension. The results of this study are specific to the children observed, and McNaughton's (1995) analysis suggests that generalising to other cultural groups would not be warranted. While several cultural groups are included in this sample, there are not sufficient participants for any conclusions to be drawn.

PARENTS MEDIATE THE TASK

This study demonstrates that parents are capable of selecting an appropriate framework in response to the child and the task. The cue for framework selection in this study appears to be the nature of the
materials supplied (games) and the ease of the game for the children. Parents who felt the game was less than very easy for their child used a mathematics-focused framework. Those who felt the game was very easy chose between a mathematics-focused framework and a game-focused framework. While a greater number of parents may have selected a mathematics-focused framework because they were being recorded and thought that was what they should do, nearly half of the audio recordings are in a game-playing framework. Phillips and McNaughton (1990) describe the interaction of preschoolers and parents reading stories. They describe the interaction as being characterised by an agenda shared by the parent and child. This contrasts with this study, where many of the children are working in a game-playing framework, rather than seeing themselves as learning mathematics. This can be seen in the pattern of initiations and types of cognitive work that each of the participants does. Some children actively resist attempts by their parents to work in a mathematics-focused framework, persisting in asking questions about who is winning and being angry about losing. This lack of a consistent agenda effects the development of intersubjectivity. The rules of interaction implied by the two frameworks are quite distinct, and can result and players misunderstanding each other or in the game finishing prematurely. In contrast, the teacher and the children may share a framework because of the context in which their game playing occurs. Following a script from mathematics-at-school, children answer questions and do not discuss who is winning. The intersubjectivity between the teacher and the child may be greater than that between the child and its parents.

That parent mediation is crucial to the introduction of mathematical ideas into activity with children at home was found by Anderson (1997) and Young-Loveridge (1989). The results of this study support those findings. Children who were left to play with their older siblings covered very little mathematics, although they were actively being apprenticed into the ‘game playing’ framework. Saying that they were not doing mathematics does not imply that they were doing nothing. However, the parent’s choice of framework and approach to mediating the game for the child was a key determinant of the nature of the child’s experience.
Within the mathematics-focused framework, three approaches to exploring addition were described. Two of these have commonalities with McNaughton's (1995) description of tutorial configurations. The multi-strategy approach has similar features to the collaborative participation tutorial configuration described by McNaughton (1995). Using a range of ways to present addition concepts in response to the child's contributions suggests negotiation of meaning. The turn-taking structure of the longer dialogues which characterise these audio-recordings reflects the pattern of initiation and response suggested by McNaughton (1995). There is not, however, evidence of the child using the same patterns as the parents in these results. There is only one instance of a child posing a question similar to a parent's one in the whole data set. Collecting additional data over a longer period might have shown such a change. Data from the fourth term may show children taking greater control of the process. Change might be occurring over a longer timeframe than the two week-long recording times. The families in the Phillips and McNaughton (1990) study used a collaborative participation tutorial configuration, but, as the authors note, there was not much observable transfer of task components from the expert to the novice during the readings. This was because the children were not complete novices at the task - in fact they were expert in aspects of it. The same can be said for these games. The children had control of the mathematics involved and quickly picked up the way the games worked. Once children had control of the game they tended to work in a game-playing framework, reducing the amount of dialogue about mathematics that they engaged in. The single-strategy approach to addition concepts has parallels with the item conveyancing tutorial configuration (McNaughton, 1995). Although it may appear as a directed performance, the parent in the two tapes characterised by this approach is attempting to instil a method to be used independently by the child - the 'item' is using formal addition language and mental addition strategies to keep a total. McNaughton distinguishes item conveyancing as "...the acquisition of...a way of acting which is required to be publicly displayed" (McNaughton, 1995, p. 71). This is a good description of the interaction in the single-strategy audio-tapes.
Parents in this study selected frameworks for using the game based on their theories of the child, the setting and the game. Flexibility was shown, with some families using a game-focused framework with one game and a mathematics-focused framework with the other. This ability to switch between frameworks suggests that parents are capable of adopting a mathematics-focused framework, if they think it is appropriate. If the multi-strategy approach within the mathematics-focused framework is closest to classroom practice (which cannot be determined from this data), then cuing parents to use this approach may enhance the degree of 'match' between school and home. Three main areas need to be addressed, according to the results presented here. The first is the attitude of the child, the second is the level of the games and the third is communication between home and school.

The role of the child
The child has a key role to play in the use of the games. Young-Loveridge (1993) proposed that boys made more gains than girls in her home-based intervention because they demanded more play and enjoyed them more. Although no gender difference was found in these data, differences in enthusiasm between children made a difference to the game play. The winning and losing aspect of the games sometimes created difficulties, but seemed to be an inevitable consequence of the children's game-playing framework. Encouraging use of the games in the classroom, and asking children to comment on the games or share their experiences with them may increase their commitment to the Maths Games Library and result in more demands to play at home. At present the Maths Games Library operates independently of the classroom programme (as described in Chapter 1). This may cause children to wonder why they get the games and reduce their enthusiasm.

The importance of game difficulty
The difficulty level of the material has been shown to have a large effect on the interaction surrounding it. The game constrains how much mathematics can be injected into it by its format and style. Parent comments (reported in Chapter 6) referred to this issue, asking that the games be levelled, or some information about difficulty included with the game. Game difficulty is not only a by-product of the
game however, as evidenced by the selection of an easy game and a hard game for this study, based on a separate sample and on the game's structure. Both these games were actually easy for most child participants. Labelling games as 'easy' or 'hard' will not tell parents how their child will find them. It would, however, give them some information about their child's progress. An alternative would be to label the games with the curriculum objective they met, so parents could see their child's performance against a criteria.

This issue has interesting parallels with sending home reading books. Reading books are levelled according to a well-defined system, and children usually take home a book they are familiar with and can experience success on. As McNaughton, Parr, Timperley and Robinson (1992) note, this leaves the 'teaching' aspects of reading firmly in the control of the teacher. Home reading is for enjoyment and practice. North Primary school sends home information stating this, describing how parents can help their child if they get stuck and emphasising enjoyment as the key to the reading session. No such material accompanies the maths games. Parents do not know if they are to act as teachers or play partners, or how the teachers see the games as fitting in to the school programme. The reading books that are sent home are an integral part of the programme. Providing more information about the intended use of the games, strategies and suggestions may increase the degree of match between parents' practices and the school's practice. McNaughton et al (1992) observe that parents in an 'information vacuum' make up their own practices, which may be counter-productive. The evidence from this study suggests that they fall back on a game-focused framework, and leave the tutoring role entirely.

Communication between home and school

The results of this study indicate that the Maths Games Library can be seen as a bridge between home and school. They are used by parents, who value them sufficiently to give time to them. They do cover mathematics objectives in playing the games. This bridge is largely one way, however. Although the games are reaching the homes, there is no flow of information back into the classrooms. Enhancing the communication about the Maths Games Library by involving the teachers and informing the parents would strengthen the linkages between home and school. A participant in the telephone interview said
that she did the home reading tasks because she had to fill in a reading log, whereas the maths games did not require any record that it had been done. Several other parents commented that there was a one-way flow of information. The IMPACT project (Merttens, 1993) emphasises the importance of the child's work at home being used in a class lesson. The children also complete IMPACT diaries, which record how they and their parents found the week's activity. A similar system added to the Maths Games Library might increase parent commitment enhance the match between settings for the children.

Several telephone interview participants asked for information about mathematics progress which was similar to the generalised information given about reading milestones and expectations. This would make parents more aware of the important elements of their child's development, as evidenced through game playing. Information about curriculum objectives would help parents to see where the teachers - and the maths games - were heading. Information from research into children's number learning would also be needed, however, as the curriculum objectives are broad and may not help parents notice potentially important aspects of their child's behaviour. Support for reading at home includes suggests about strategies for helping children, based on reading research. Information like this might help parents to respond contingently to their child's number understandings in gameplaying. Lehrer and Shumow (1997) have initiated a project following their research, where a set of parent newsletters of this type are available on the Internet for teachers to share with their class parents. These newsletters focus on older children's mathematics, but provide an interesting model for similar materials.

MATCH BETWEEN HOME AND SCHOOL

The data on the teacher presented in this study is very limited. Patterns found in the two tapes may be unique to the teacher, or to the children she selected. It does however highlight issues about the degree of match between the settings of home and school. Parents using the multi-strategy approach to addition concepts sounded like teachers, and the collaborative participation tutorial configuration with which it shares features was found to be most like that found in school (McNaughton, 1995). There are suggestions in the data, however, that teachers may differ from parents on another dimension in school
activity. The parents in this study were able to select an appropriate next goal for their child, and ably covered mathematics objectives. What they appeared not to have was an analysis of where their child was in terms of development of number concepts and what their responses meant in terms of this.

The teacher found the children's responses interesting because of the information they contained about the children and their understandings. This led her to follow up on their suggestions and to pose problems to solve. Parents could see that their child needed something more than the task was offering, and introduced a more advanced concept. Establishing the concept drove their interactions, rather than exploring the child's understandings. Further data is needed on this aspect. Taping a number of teachers using the games with children of varying abilities would give more reliable information about whether there is a characteristic pattern to their interaction. The nature of the task, being an add-on to ordinary class work may have prompted this teacher to use the opportunity to find out what the children knew. Observing the extent to which the exploring of children's understandings occurs in the course of ordinary teaching would add to this data. It may be that teachers seek more from the children than the parents, on this type of activity. To satisfy the teacher, the child must be able to explain its ideas and describe its understandings. To satisfy a parent, the child must be able to respond to questions about numbers and attempt the mathematics proposed.

CONTINGENT RESPONSIVENESS IS EVIDENT

Despite the fact that the interactions observed in game playing cannot be assigned hierarchal values and plotted in the manner of Wood and Middleton (1975) and subsequent studies (Lehrer & Shumow, 1997; Pratt et al, 1992; Saxe, Gearhart & Guberman, 1984; Wood, Bruner and Ross, 1976), contingent responsiveness is still a key factor in this data. Scaffolding on a 'minute-by-minute' basis is not observed, and a first glance at the data suggests that the scaffolding model does not account for this data set. Scaffolding is not occurring in the game-focused framework - it is not necessary. Players are equal partners in the game and act as such. Although children could be viewed as being 'apprenticed' into how to play a game (follow the rules, lose with grace, take turns), in terms of mathematics this framework
does not show parents supporting children’s learning. Considering the mathematics-focused tape recordings, we see the emergence of a pattern, described in Chapter 6 as three approaches. Beyond this other measures and observations contribute to a picture of parents as skilled responders to their child’s needs. Wood and Middleton (1975) are able to define a ‘region of sensitivity to instruction’ and a ‘contingent shift rule’ by ordering types of help in terms of their directiveness. A broader definition of contingent responding is more useful with data that does not have this type of order. Parents adapted the games. Although, with one exception, they did not go beyond the suggestions in the instructions, this can be seen as evidence of change in behaviour in response to the child’s performance. Choosing from a range of strategies to discuss addition concepts suggest that parents are attempting to match their explanations with the child’s responses. If parents responded to the mathematical content of the child’s utterances, this led to longer discussions and more exploration of mathematics. This result echoes that of Young-Loveridge (1996) who notes that ‘reciprocal numeracy episodes’ contain interactions which resemble scaffolding. The findings of this study are also similar to Young-Loveridge (1996) in that only a small proportion of the data collected shows evidence of this. In the course of everyday activity, we do not actively seek to respond and expand upon every utterance our companions make. In a laboratory problem-solving task, when we are being observed, we try our best to be successful. This distinction may explain the infrequency of contingent exchanges in the data presented here.

The cognitive work undertaken by parents and children had characteristic patterns, with lower-level tasks, that the children had control of, being completed largely by children. Parents asked questions and explained more often than children in most dyads. Each dyad had their own pattern, however, suggesting intersubjectivity and the shared negotiation of tasks. This may have been implicit, and the result of a history of game playing. The sharing of types of cognitive work in specific ways demonstrates sensitivity to the child’s responding.

How the parents perceives their role in the setting is a key influence here also. Parents cooking with their children in the study by Young-Loveridge (1996) may be trying to teach their children to use kitchen equipment safely, or to be tidy in the kitchen. Parents in the present study may not want to take on the
teacher role (Gelman, Massey & McManus, 1984), preferring to play for enjoyment, or to reinforce fair play.

An awareness of what is important or significant in children's statements also determines contingent responding. If you do not notice that what has been said is important, you may not respond to it. Anderson (1993) highlights this in discussing her work with her child. She, as a mathematics educator, is very aware of the significance of her daughter's questions and statements, and is able to respond to these in ways which enhance Terri's mathematics. In the exchanges she describes, Anderson (1993) notes occasions on which she overlooks errors in counting to reach the mathematical concepts behind the child's exploration. To do this requires a detailed knowledge of mathematics and of children's learning which is not available to most parents. Perhaps the call for more information made by the participants in the telephone interview section of this study could be answered with information about children's learning which would improve their contingent responsiveness. Lehrer and Shumow (1997) attempted this with parents following their discovery that parents were more directive than teachers, and less likely to give control back to children after errors. The teachers in the study had been part of a training project which gave them information about children's number learning. Possessing this information had led to considerable change in their practice (Fennema, Carpenter & Peterson, 1989). Lehrer and Shumow (1997) piloted giving this information to parents with two participants. In one it led to change in the direction of the teacher's practice. In the other there was no change. Sending the information home to a larger group of parents, in the form of a weekly newsletter with activity suggestions, resulted in improved problem-solving in their children. The lack of change in the pilot study participant could be attributed to a range of factors in the setting. Information about children's learning might make parents more contingently responsive, but it might not make them more open-ended. Teachers and researchers cannot define the direction in which parents should change. Their interaction practices are derived from the cultural and social milieu, their own background and their beliefs about the subject they are working in. The view that contingently responding to the mathematical content of children's contributions is the most effective way to enhance the child's development is culturally and situationally bound. It represents an ethnocentric view about how it is best to learn and about mathematics itself. If we are trying to enhance the degree of
match between home and school, to improve learning for children (Bronfenbrenner, 1986), then we need to know what 'home' and 'school' are like. This study can only describe a restricted sample, in a predominantly white, middle-class school.

FACTORS FROM THE LITERATURE

This study found no effect for parental education level, parental attitude to mathematics, children's ability or parental perceptions of their child's ability. These factors were all suggested by the research reviewed in Chapter 3 as contributing to interaction styles. Several reasons can be proposed for this. The first is that the measures of attitude, devised for this study, were not valid or not measuring the critical aspects of attitude. Parents were asked for their perception of their child's ability, rather than for their expectations for their child. This may have influenced the nil results. The SEA measure of children's ability is directly related to the study materials. However, the effects of children's ability may have been more indirectly expressed, through their responses to the game. Although there is no relationship between the child's SEA scores and the type of interaction they were involved in, children who found 'Oops!' less than very easy received mathematics-focused interaction from their parents. Their difficulty with the material at hand, rather than their ability generally seemed to influence interaction. Parent education level in mathematics varied from fourth form to tertiary. This may not reflect the parents' overall education level, which may be more critical than their education in mathematics. Wylie, Thompson and Kerslake-Hendricks (1996) report an effect for maternal education used a broad measure, rather than a subject-specific one. Overall, the small sample size results in data which does not have the spread that would be found in sampling a larger number of people. This necessarily restricts the ability of the data set to show relationships based on variables such as these.
THE SOCIO-CULTURAL FRAMEWORK IN ACTION

Using the socio-cultural framework to determine the methodology for this study posed several challenges. The results indicate that only an inclusive view of learning could begin to account for the complexity of the factors influencing interaction. If we had considered only change in individuals as a result of game playing, by measuring children's ability to complete tasks covered by the games, we would have lost the key influence on the establishment of mathematics understandings - the selection of an interaction framework. Considering only the pattern of use of the games would have similarly masked important differences in children's experience of the games. The socio-cultural viewpoint proposes activity as the unit of analysis, and it is in activity that the differences reported in this study are found.

The context (home or school), who plays the games (group composition), which games they play (difficulty level) and the participants' understandings about their role, the activities purpose and each other combine in unique ways to determine each child's experience. The socio-cultural viewpoint encompasses all of these as relevant and important, and thus accounts well for the data presented here. Care must be taken to see the guided participation (Rogoff, 1995) described here as nested within a broader social context. This broad context is evidenced by the parents and children having expectations of games before they encounter the Maths Games Library, and by their ideas about mathematics and about schools which come in to focus as the children start school. The activity of game playing cannot be seen in isolation. Although there was no evidence of children adopting the number sentence use of their parents, this does not mean that the game playing sessions did not alter their individual functioning. For Rogoff (1995), this kind of joint activity must result in change in individuals, because they are inherently part of the activity itself. How this could be assessed from a research perspective is a further challenge.

Taking a socio-cultural viewpoint and looking in-depth at the activity surrounding the use of the Maths Games Library has yielded a rich data set which serves to highlight the unique characteristics of each child's personal experience of the intervention. Families did not fall in to consistent categories across games, they did not always use the same approach or the same group configuration. In outlining possible
patterns which can inform improvements in the operation of the Maths Games Library, the diversity of the data must be acknowledged. The setting, the game, the group configuration, the child’s attitude, the school’s communication pattern, the parent (and each of these represent myriad variables) combine on each occasion to create a learning experience for the child. These factors crucially mediate the effectiveness of the intervention. A home-school communication cannot be ‘parent-proofed’, nor should it be. Opening the lines of communication both ways is an essential next task for this project. Continuing to consider interaction in context and in detail is necessary if we are to understand the complex interrelationship of factors that guide children as they develop mathematically.
OOPS

To Start
1. Shuffle the cards and place on the table face down.

2. Put the plastic chips in a pile in the centre of the table.

To Play
1. The first player turns up one card at a time from the centre pile. The player counts the dots on these cards and adds to the total for each card turned up.

2. The player may continue to turn up cards and try to get a total of nine. When the player reaches a total count of nine (or another agreed number) or more, the player then trades these cards for a plastic chip.

The turned up cards are placed in a separate discard pile face up. The player may continue the turn by starting a new pile of turned up cards and counting to nine again.

3. If a player turns up a ‘sad face’ card during the turn, then the turn ends immediately. All the cards turned up by the player in that turn are added to the discard pile.

4. The winner is the first player to collect five plastic chips.
More Dots

Each player gets an equal number of cards. The cards are kept face down and played off against each other one at a time. A card can take another card if it has more dots on it. Sometimes neither card will win in which case the cards remain on the table and are collected as a bonus by the player who wins the next card.

The game finishes when one player has run out of cards.

Game 2
Played as game one, except players are allowed to select cards from their hand.
Participant Questionnaire

Please complete this questionnaire and return it to school with your child, in the envelope provided. If you have any questions, please call Fiona Ell, ph 377 0267.

Family name:

Place of five-year-old in family (eg: eldest, second of three):

What kind of formal pre-school did your five-year-old attend?

How long did they attend for before starting school? eg: 1 year, 6 months

Please indicate whether or not your child did these things before they started school.

<table>
<thead>
<tr>
<th>Task</th>
<th>yes</th>
<th>no</th>
<th>don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>say the numbers to 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>count a group of less than 10 objects accurately</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>say how many things there were in a small group (2 or 3) without counting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>add things together</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>count to more than 20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>recognise numbers eg: on letterboxes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>find, make or notice half of something</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>count on their fingers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>talk about numbers of things or point out numbers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Do you think your child is above average, average or below average in their maths skills?

Do you use mathematics in your life now? If you do, please say briefly how you use it. Some examples might be in a work situation, sewing, cooking, shopping, home renovation, paying bills ...

Please circle the number which indicates your level of agreement with these statements

1= strongly agree
2= agree
3= neither agree nor disagree
4= disagree
5= strongly disagree

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maths was one of my favourite subjects at school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am reasonably confident about my mathematics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics is a very useful subject in all walks of life.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can’t understand any maths now.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I don’t mind mathematics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I worry about helping my child with more difficult maths</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I dislike mathematics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed mathematics at school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I will enjoy helping my child with mathematics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I was OK at maths at school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I don’t think I’ve ever used most of the maths I learned.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>I preferred reading to maths at school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am confident with mathematics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I hated maths at school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What is your highest maths qualification?
e.g: fourth form, School Certificate, U.E., Bursary, tertiary.

Have you found the Maths Games Library a useful resource for your family?

Please circle the number which indicates your level of agreement with these statements
1= strongly agree
2= agree
3= neither agree nor disagree
4= disagree
5= strongly disagree

<table>
<thead>
<tr>
<th>It gives me an idea of where my child is at with mathematics.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find it hard to work out what the maths is in the games.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>It gives me information about what the children are learning.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>It is too time consuming to be practical.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The games are at an appropriate level.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Our family enjoys playing the games.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I know more about my five-year-old’s progress in maths because of the games.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please add any further comments you wish to make about the research project, or the maths games library in general.
Thank you for taking the time to record your game sessions this week. This form is to summarise the recordings you have made, and should take about 5 minutes to complete.

Family name: 

Game number: 

Please circle the number which indicates your level of agreement with these statements

1 = strongly agree
2 = agree
3 = neither agree nor disagree
4 = disagree
5 = strongly disagree

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>My child found this game easy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Playing this game was enjoyable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think this game was worthwhile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We played this game more often than other games we have had</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can see the mathematics involved in this game</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We enjoy receiving the maths games</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We played this game in a similar way to the other games</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(setting, number of players, amount of discussion)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please add any further comments you would like to make:

______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Thank you again for your time.

Fiona Ell
1. Did you receive the maths game?__________________________________________

2. Did you receive the information about the research project?____________________

3. We have had a few people volunteer to be part of the research project and we are interested in why people did not want to be part of it, because part of the study is to evaluate whether the games library is a useful resource and we are not sure whether people did not want to be part of the research because they don't like the games or for other reasons. 
Would you tell me why you did not want to be part of it?
__________________________________________________________________________
__________________________________________________________________________

4. How do you use the games?______________________________________________

5. How useful are they for you and your family?________________________________

6. Are they of appropriate difficulty?________________________________________

7. Are there other ways in which you would like the school to communicate with you about your child's maths progress?______________________________

8. How useful do you find the daily home reading programme for you and your child?________________________________________________________
<table>
<thead>
<tr>
<th>Parent</th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>count</td>
</tr>
<tr>
<td>label</td>
<td>label</td>
</tr>
<tr>
<td>number sentence</td>
<td>number sentence</td>
</tr>
<tr>
<td>repeat (other)</td>
<td>repeat (other)</td>
</tr>
<tr>
<td>revoice</td>
<td>revoice</td>
</tr>
<tr>
<td>question</td>
<td>question</td>
</tr>
<tr>
<td>explain/give strategy</td>
<td>explain/give strategy</td>
</tr>
<tr>
<td>mm, ah, ok</td>
<td>mm, ak, ok</td>
</tr>
</tbody>
</table>

Family Name:
Game number:
Coded by:
Page of
APPENDIX SIX
MATHEMATICS OBJECTIVES AND STRATEGIES COVERED BY THE FAMILIES RECORDING THEIR PLAYING OF 'MORE DOTS'.

- rote count
- addition
- estimate
- explain
- devise instruction
- follow instruction
- half a set
- comparison
- multiplication
- pattern recognition
- count all
- count on
- number fact

MATHEMATICS OBJECTIVES AND STRATEGIES COVERED BY THE FAMILIES RECORDING THEIR PLAYING OF 'OOPS!'.

- rote count
- addition
- estimate
- explain
- devise instruction
- follow instruction
- half a set
- comparison
- multiplication
- pattern recognition
- count all
- count on
- number fact
PERCENTAGE OF CODED TURNS INITIATED BY THE ADULT AND CHILD IN EACH DYAD

Family one - Oops!
- 48% 52%

Family one (Mother) - More Dots
- 26% 44%

Family one (Father) - More Dots
- 41% 59%

Family two - Oops!
- 61% 39%

Family two - More Dots
- 69% 31%

Family three - Oops!
- 80% 20%

Family four - Oops!
- 68% 32%

Family five - Oops!
- 19% 81%

Family five - More Dots
- 39% 14%

Family six - Oops!
- 40% 60%

Family six - More Dots
- 59% 41%

Family seven - Oops!
- 42% 58%

Family seven (Mother) - More Dots
- 52% 48%

Family seven (Father) - More Dots
- 33% 65%

Family eight - Oops!
- 74% 17%

Family nine - More Dots
- 38% 10%

Family ten - Oops!
- 75% 25%

Family twelve - More Dots
- 81% 16%

Family thirteen - Oops!
- 40% 70%

Family thirteen - More Dots
- 62% 38%
REFERENCES


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