“We are the maths people, aren’t we?” Young children’s talk in learning mathematics

Submitted by Mrs Carol Marjorie Murphy to the University of Exeter
as a thesis for the degree of
Doctor of Philosophy in Education in March 2013

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature:
Acknowledgements

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I would also like to thank my husband Terry for his dedication in taking care of me during the last few months of the writing and for his help with proof reading and IT support. I could not have done this without him.
Abstract

The research for this doctoral study focused on children’s learning in mathematics and its relationship with independent pupil-pupil talk. In particular the interest was in how younger lower attaining children (aged 6-7) exchanged meaning as they talked together within a mathematical task.

The data for the doctoral study had been gathered as part of the Talking Counts Project which I directed with colleagues at the University of Exeter. The project developed an intervention to encourage exploratory talk in mathematics with younger lower attaining children. Video material and transcripts of the mathematics lessons from nine classrooms that were part of the TC Project were used as the data set for the doctoral study. The focus of the analysis was on the independent pupil-pupil talk from one pre intervention session and one post intervention session from these nine classrooms.

In using an existing data base, analysis was carried out in more depth and from a new perspective. A Vygotskyan sociocultural approach was maintained but analysis of the learning in the doctoral study was refocused in line with theories of situated meaning in discourse and with theories of the emergence of mathematical objects. Hence my examination of the children’s learning for the doctoral study went beyond the original research carried out in the TC Project.

Within an interpretivist paradigm the methods of analysis related to the functional use of the children’s language. Interpretations were made of the children’s speech acts and their use of functional grammar. This enabled a study of both social and emotional aspects of shared intentionality as well as personal, social and cultural constructs of mathematical objects. The findings suggested that, where the talk was productive, the children were using deixis in sharing intentions and that this use could be related to the exchange of meaning and objectifying deixis.
# Table of Contents

## Introduction

i. The focus of the doctoral study ................................. 13

ii. The Talking Counts Project ........................................ 14

iii. My research contribution to the Talking Counts Project .... 15

iv. Developing the aims and research questions for the doctoral study 16

v. Summary .................................................................. 20

vi. Outline of the doctoral study ..................................... 21

## Chapter 1: Context and Rationale

1. Introduction .................................................................. 24

2. Policy views on talk in mathematics ............................ 25

3. Social notion of doing mathematics and mathematisation .... 29

4. Becoming the maths people ......................................... 31

5. Exploratory Talk ....................................................... 33

6. Summary .................................................................. 35

## Chapter 2: Literature Review

1. Introduction .................................................................. 37

2. Research on collaborative group work in mathematics .... 39

3. Research on interventions to support group work .......... 41

4. Talk and learning in mathematics: The idea of a cognitive shift 44

5. Collaboration with diverse pupils .............................. 47

6. Summary .................................................................. 50

## Chapter 3: The Talking Counts Project

1. Introduction .................................................................. 52

2. Outline of the TC Project ............................................ 53

3. Design of the TC Project ............................................ 54

4. Data collection for the TC Project ............................... 55

5. Ethical considerations ................................................ 58

6. Research findings for the TC Project ......................... 59
Chapter 7: Presentation of Results for Level 1 Analysis

1. Introduction 153
2. Key aspects related to the different situations 154
3. Initial analysis of changes in the talk 159
   i. Changes in the amount of talk 159
   ii. Analysis of ‘what the talk was about’ 160
4. Summary 163

Chapter 8: Presentation of Results for Level 2 Analysis

1. Introduction 165
2. Analysis of the ‘non-maths’ speech acts 166
   i. Overall changes in ‘non-maths’ speech acts 168
   ii. Variations in ‘non-maths’ for each group 169
   iii. Group changes in ‘non-maths’ speech acts 176
   iv. Summary of the analysis of ‘non-maths’ speech acts 183
3. Analysis of the ‘maths’ speech acts 184
   i. Overall changes in ‘maths’ speech acts 186
   ii. Variations in ‘maths’ speech acts 188
   iii. Group changes in ‘maths’ speech acts 202
   iv. Summary of the analysis of ‘maths’ talk speech acts 216
4. Summary 218

Chapter 9: Presentation of Results for Level 3 Analysis

1. Introduction 220
2. Use of conjunctions 223
3. Use of deixis 227
   i. ‘It’s that one’: The use of ‘it’ and ‘that’ 232
   ii. What do ‘you’ mean 245
   iii. Summary of use of deixis 251
4. Use of modal verbs 253
5. Summary 256
Chapter 10: Discussion

1. Introduction ............................................ 257
2. The nature of the children’s talk ......................... 260
   i. The children’s social talk ......................... 260
   ii. The children’s mathematical talk .............. 262
3. The nature of the talk and learning in mathematics .. 263
4. The use of words as cohesive devices in objectification 270
   i. The children’s use of spatial deixis ........... 272
5. Summary .................................................. 273

Chapter 11: Conclusion ................................. 277

1. Introduction ............................................ 277
2. Contribution of the doctoral study to current understanding 278
   i. Contribution to theory ......................... 278
   ii. Contribution to research methods ........... 280
   iii. Summary of contributions to current understanding 282
3. Reflection on wider sociocultural perspectives .... 282
4. Implications for classroom practice ................. 285
5. Implications for further research ................. 287
6. Summary .................................................. 289

References .................................................. 291
List of Tables

Table 0.1: Contributions to the data analysis of the TC Project ........................................... 16
Table 0.2: Analysis carried out for the TC Project and for the doctoral study ....................... 19
Table 3.1: Descriptive Data for the twelve schools .............................................................. 55
Table 3.2: Summary of data collection methods ................................................................. 56
Table 6.1: Multi-level approach to sociolinguistic discourse analysis after Rojas-Drummond et al. (2003) .......................................................... 130
Table 6.2: Summary of the group sessions from the 15 lessons ........................................ 137
Table 6.3: The research questions in relation to the multi-level analysis ............................ 152
Table 7.1: Nature and content of the mathematics tasks ..................................................... 156
Table 7.2: Frequency of turns in independent pupil-pupil talk and proportional changes ........ 159
Table 7.3: Frequency of codes for ‘maths’, ‘non-maths’ and ‘off task’ talk and proportion of maths talk (from groups A, B, E, F, I, K) ......................................................... 161
Table 7.4: Proportion of ‘maths’ and ‘non-maths’ talk for each group session ....................... 161
Table 8.1: Percentage frequencies of ‘non-math’ speech acts and proportional changes ........ 169
Table 8.2: Percentage frequencies of ‘non-math’ speech acts for each of the fifteen group sessions .................................................................................................................. 170
Table 8.3: Proportional change of percentage frequencies of the ‘non-maths’ speech acts for the six groups A, B, E, F, I, K ................................................................. 176
Table 8.4: Percentage frequencies of ‘maths’ speech acts and proportional Changes .......... 187
Table 8.5: Percentage frequencies of ‘maths’ speech acts for each of the fifteen group sessions .................................................................................................................. 188
Table 8.6: Proportional change of percentage frequencies of the ‘maths’ talk speech acts ...... 202
Table 9.1: Frequencies, percentage frequencies and proportional changes of words explicit for agreement ................................................................. 221
Table 9.2: Frequencies, percentage frequencies and proportional changes of conjunction words .................................................................................................................. 224
Table 9.3: Frequencies, percentage frequencies and proportional changes of deictic words

Table 9.4: Ranking of use of function words

Table 9.5: Use of ‘that’, ‘it’ and ‘you’ in relation to deixis

Table 9.6: Frequencies and percentage frequencies of modal verbs
List of Illustrations

Figure 4.1 Four paradigms for the analysis of social theory (Burrell & Morgan, 1979, p. 27)  110

Figure 4.2: Theoretical compass (Weidman & Jacob, 2011, p. 14)  111

Figure 6.1: Multi-level analysis of the doctoral study  135

Figure 6.2: Data selection for the doctoral study  136

Figure 6.3. Further data selection in the multi-level analysis  138

Figure 6.4: Coding for ‘What the talk was about’  140

Figure 6.5: Speech acts coding for ‘non-maths’ and talk  142

Figure 6.6: Speech acts codes for ‘maths’ talk register  144

Figure 7.1: Levels of analysis, focus on Level 1: Situational analysis  153

Figure 8.1: Levels of analysis, focus on Level 2: Analysis of speech acts  165

Figure 9.1: Tag cloud for pre-intervention sessions showing the twenty most frequent function words  229

Figure 9.2: Tag cloud for post-intervention sessions showing the twenty most frequent function words  230

Figure 9.3: Word tree showing the use of ‘that’ in the post-intervention session A2  233.

Figure 9.4: Word tree showing the use of ‘that’ in the post-intervention session B2  233

Figure 9.5: Word tree showing the use of ‘that’ in the post-intervention session K2  238.

Figure 9.6: Word tree showing the use of ‘that’ in the post-intervention session D2  243

Figure 9.7: Word tree showing the use of ‘you’ in the post-intervention sessions A1 and K1  246

Figure 9.8: Word tree showing the use of ‘you’ in the post-intervention sessions A2 and K2.  247
List of accompanying material

1. Appendix 1: Findings from the TC Project Report 306
2. Appendix 2: Ethical Approval Form 323
3. Consent letter and form 326
4. Screen shot of earlier coding on NVivo 9 328
5. Table of notes from Level 1 Analysis 329
6. Example of observation notes from video 337
Author's declaration

The analysis of this doctoral thesis was carried out with data that had been gathered as part of the Talking Counts Project. I directed the TC Project with co-researchers Professor Rupert Wegerif and Dr Rosalind Fisher at the University of Exeter from 2009-2010.

In directing the TC Project I was supported in the research design by my co-researchers. I led on the data collection methods including the selection and development of the assessment tools. I was supported in the gathering of data by research fellow Tricia Nash and research assistant Emma Pipe. Analyses of interview data and standardised tests were carried out by the research fellow. Diagnostic assessments were analysed by me and the research assistant. Initial analysis of the video data material was carried by the co-researchers and me.

Whilst the data for the doctoral study was from the TC Project, the revised theoretical direction for learning in mathematics and the epistemologies supporting the methodologies are from my reviews of literature. These are presented in Chapters 4 and 5 and take a new perspective that went beyond the original research of the TC Project. The methods of analysis of the children's independent pupil-pupil talk and the interrogations that were carried out using these methods were my own work. The methods of analysis are set out in Chapter 6 and the results are presented in Chapters 7-9. The discussion of the findings, presented in Chapter 10, is also from my understanding of the children's learning.
INTRODUCTION

i. The focus of the doctoral study

The focus of this doctoral study is on children’s learning in mathematics and its relationship with independent pupil-pupil talk. By independent pupil-pupil talk I refer to peer discourse that takes place without the involvement of the teacher. That is talk that is directed from one pupil to other(s) and not teacher-pupil talk. The aim of the research was to understand better how young children exchanged meaning whilst they worked together on a mathematical task. This examination of a relationship between learning and language was underpinned by a Vygoskyan sociocultural theoretical perspective where language is seen as a mediating tool for learning (Vygotsky, 1986). Within this perspective learning in mathematics is seen to happen through “many socially situated conversations in different contexts with different persons” (Ernest, 1993, p. 62). One context for conversations in mathematics is the formalised learning setting in classrooms where the teacher directs and controls the discourse in the classroom. The word conversation could also be interpreted as exchange of knowledge with a written text, such as a work book. It is also acknowledged that other conversations in mathematics may happen in less formal settings such as out of school.

Whilst these contexts for conversations in mathematics are not seen as any less important, the interest of the doctoral study was in pupil-pupil talk where children work together on the same mathematical task independent of the teacher. I have focused on this context for two reasons. First, children are often seated in small groups within classrooms, so it would seem desirable that they collaborate in independent work in a way that engages them in the mathematics of the task. Second, the dialogue that happens within pupil-pupil talk is unlikely to be the same as the more formal teacher-pupil talk. Therefore this context provided an opportunity to further an understanding of learning in mathematics that was situated in conversations between pupils and hence to understand how children may be supported in engaging in mathematical tasks independently of the teacher.
The data set for the doctoral research came from the data that existed as part of the Talking Counts project (referred to as the TC Project). The project's aims were to develop and investigate a teaching intervention to promote pupil-pupil talk in primary mathematics classrooms based on Mercer and colleagues' studies into exploratory talk (for example (Mercer & Sams, 2006; Mercer, Wegerif, & Dawes, 1999). The TC project was funded by the Esmee Fairbairn foundation and I directed the research with colleagues at the University of Exeter in 2009-2010. The project was concerned with the opportunities that the development of talk and discussion in small group work would provide for learning in mathematics with lower attaining younger children (Key Stage One, ages 6 to 7). In reporting to the funding body the TC project had indicated educational outcomes, the perceptions of teachers. The findings also indicated some changes in quality of talk but these had not been fully analysed.

The interest of the doctoral study was in examining the mathematical learning that took place as the children talked together, and in particular how the children exchanged meaning in mathematics. In order to understand if the intervention had made a change to this learning I aimed to identify more closely the changes in the nature of the talk and how these changes may have influenced how the children exchanged meaning. Several studies have looked at interventions focusing on the quality of talk in collaborative group work, for example (Mercer & Sams, 2006; Wheeldon, 2006) but these studies have focused on the children's performance in solving problems. Other research has examined exchange of meaning in the mathematics classroom, for example Barwell (Barwell, 2005a, 2005b) has examined the discourse of bilingual pupils. However I am not aware of studies that have examined the mathematical learning that took place by investigating how the children exchanged meaning following an intervention based on exploratory talk.

ii. The Talking Counts Project

An account of the research methods, design and findings for the TC Project are presented in Chapter 3 but key points are provided here in order to set the context of the doctoral study, to outline my contribution to the research within
the TC Project, and to explain how the focus of the doctoral research has gone beyond the original research carried out for the project.

At the time of the TC Project there was a national concern in England regarding achievement in mathematics and for a greater awareness of how to develop mathematical understanding. Policy reports (Ofsted, 2006; QCA, 2007) had related to the lack of children’s confidence in mathematical ideas and to the lack of children’s use of talk in the mathematics classroom (Ofsted, 2008; Williams, 2008).

The TC Project aimed the intervention at lower attaining younger children for several reasons. First, it would seem appropriate to develop such classroom norms with younger children. Second, there was concern that some children were not making the expected progress from Key Stage One (six to seven year old) to Key Stage Two (eight to eleven year old) (DCSF, 2007) so the interest of the project was on supporting a band of children who, whilst not identified as needing intensive support, may not make the progress expected. It also seemed that little work on pupil-pupil talk and collaborative engagement in mathematical tasks had been carried out with lower attaining younger children.

The premise of the project was that children’s arithmetic could be supported through active engagement in mathematical tasks and that this active engagement could be developed through an intervention emphasising quality of talk. This premise was built on a wide field of research into the use of language and interaction in the classroom generally (Myhill, Jones, & Hopper, 2006), within writing (Fisher, Jones, Larkin, & Myhill, 2010), the use of productive interaction and dialogic teaching (Alexander, 2004; Littleton & Howe, 2010; Wegerif, 2006), and the effective use of collaborative group work and pupil-pupil talk (Mercer et al., 1999). Mercer’s work on discourse analysis had focused on types of talk; exploratory, cumulative or disputational (Mercer, 2008). Studies by Mercer and colleagues had shown that interventions supporting children’s development of exploratory talk could teach children to use talk more effectively, and to work collaboratively in small groups, for example (Mercer et al., 1999).
iii. My research contribution to the Talking Counts Project

The research team comprised myself as the principal director, with co-directors Professor Rupert Wegerif and Dr Rosalind Fisher (also my doctoral supervisor). We were also supported by research fellow, Tricia Nash. In directing the project I worked with the co-directors in designing the research plan.

The TC Project used research methods from both design experiment (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003) and from sociocultural discourse analysis (Mercer, Dawes, Wegerif, & Sams, 2004). In the design experiment we worked with twelve teachers (two development teachers and ten transfer teachers) in developing strategies and mathematical tasks to support children in engaging in exploratory talk over a three month period. Based on Mercer’s sociocultural discourse analysis, data collection and analysis were carried out with the same concern as Mercer and his colleagues in that the method combined educational outcomes with investigations into the processes of interaction. This entailed the use of mixed data. Data was collected from the ten extension classes in the form of video material of lessons and group work (in most schools this was three lessons over the 3 month period of the project). The teacher and pupil talk in 29 of these videoed lessons were transcribed. Pre and post standardised attainment tests were carried out using the Hodder Progress in Numeracy Test (Hodder Education, 2004) and pre and post diagnostic assessments were carried out to determine children’s changes in calculation strategies. Teacher interviews were also carried out to ascertain their views on children’s attainment. I led on the selection of the standardised pre and post test data collection instruments, on the design of the diagnostic test data collection instruments, and on the design of the interview schedules.

<table>
<thead>
<tr>
<th>My analysis</th>
<th>Research fellow/assistant Analysis</th>
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<tbody>
<tr>
<td>Diagnostic assessments</td>
<td>Diagnostic assessments</td>
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<td>Video data</td>
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<tr>
<td>Transcripts of video data</td>
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<td>Standardised attainment tests</td>
<td></td>
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<tr>
<td>Teacher interviews</td>
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</table>

Table 0.1: Contributions to the data analysis of the TC Project
The research fellow was employed to carry out the majority of the data collection of the pre and post testing with standardised written tests and the teacher interviews. The research fellow analysed the teacher interviews and the standardised Hodder Progress in Numeracy tests. I carried out pre and post diagnostic assessments with support from a research assistant. I analysed the diagnostic assessments and inter-rater reliability assessments were carried out with the research assistant. The research fellow had carried out two thirds of the video data collection; I carried out the other third. These videos were viewed by the co-directors and me in determining critical incidents in learning. Table 1 shows my contribution to the analysis of the data in the TC Project.

The main findings of the TC project as reported to the funding body are set out in Chapter 3 and the report can be seen in Appendix 1. Key points from the findings were that observations of the video material suggested changes in the way the teachers managed mathematical tasks and in the way the children interacted in small group work. However the exact nature of these changes was not clearly defined. Changes in educational outcome were reported from pre and post tests which indicated that children’s progress was above expectations and that the children were moving from process based counting strategies towards more object based calculation strategies in arithmetic. In the interviews the teachers suggested that the children were talking more to each other about mathematics, the children were more confident and engaged in mathematics and were making more progress.

iv. Developing the aims and research questions for the doctoral study

Within the time constraints of the project full systematic analysis of the video material and the transcripts had not been possible. It had not been possible to identify the types of talk and, although critical incidents of learning were identified, they seemed random. It was not clear how to define these, and it was not clear how to determine learning within the talk.

Further analysis was required to establish the exact nature of any changes in the talk in order to investigate the relationship between the talk and learning in mathematics. Critical incidents had been reviewed and initial analysis of these
had been presented at conferences (Murphy, 2010a, 2010b, 2011a, 2011b, 2012) and also in published texts, such as Wegerif (2010), but there was still a need to examine the relationship between talk and learning in a more systematic way and to determine any changes in the talk in relation to children’s engagement in and understanding of mathematics. Whilst in the TC project we had analysed learning as an outcome over the time of the project, an examination of the pupil-pupil talk in relation to learning within the talk required more in-depth qualitative analysis.

A large part of the data collected from the TC Project had been the video data set. This set of data was from over 30 lessons collected as part of the project over the course of the intervention. Transcripts had been made of 29 of the lessons from the ten transfer classes. Three lessons (one pre intervention and two post intervention) from nine of the classes and two lessons (one pre intervention and one post intervention) from one class.

In viewing the video material and studying the transcripts I had become interested in how the children talked to each other independently of the teacher whilst engaging in the tasks. I had become interested in understanding what was happening. To use Stake’s (2010) language I wanted to study how the children’s talk, as a phenomenon or as a thing, worked. I aimed, not to look for learning in a causal way over a period of time, but to examine any relationship with learning as it happened within the talk. I wanted to understand better if the talk had changed, and if so, how it was different. Were the children talking more about mathematics? Had the nature of the talk about mathematics changed and if so how? If there was a change in the nature of the talk, how did this relate to learning?

In studying the video data set from the TC Project for this doctoral study I was using an existing body of data. There were advantages in using this existing data as it enabled me to examine the unanswered questions from the project in considering the nature of the children’s talk and in identifying any changes in the talk. There was also an opportunity to examine the questions that had arisen in more depth. Hence I was able to observe the video data in more detail and to examine the talk from the transcripts systematically.
A further opportunity was to examine the data from different perspectives and to find novel interpretations of what was happening to the children’s talk and its relationships to learning. As such I was able to refocus the theoretical perspective and the doctoral study was more thoroughly underpinned by social theories of learning as proposed by Ernest (1998, 1999) and by Lerman (2001).

<table>
<thead>
<tr>
<th>Data</th>
<th>TC Project analysis</th>
<th>Doctoral study analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video data</td>
<td>Identification of critical incidents, disseminated in academic papers</td>
<td>In-depth analysis of two lessons from ten transfer classes</td>
</tr>
<tr>
<td>Standardised attainment tests</td>
<td>Findings reported to funding body</td>
<td></td>
</tr>
<tr>
<td>Diagnostic tests</td>
<td>Findings reported to funding body</td>
<td></td>
</tr>
<tr>
<td>Transcripts of pupil-pupil talk</td>
<td>Identification of types of talk (insufficient time to complete)</td>
<td>Discourse analysis</td>
</tr>
<tr>
<td>Transcripts of teacher-pupil talk</td>
<td>Identification of types of talk (insufficient time to complete)</td>
<td></td>
</tr>
</tbody>
</table>

Table 0.2: Analysis carried out for the TC Project and for the doctoral study

However there were disadvantages as the data set was restricted, I was unable to collect further data of the children’s talk or to check my interpretations with those of the teachers or of the children. Use of primary or secondary data is not unusual practice in educational research (Cohen, Manion, & Morrison, 2011). Often this is historical or documentary research using existing documents, and by documents this can include audio and video data. In these instances a researcher has the advantage of distancing themselves from the data. However I was in the unusual position of having been part of the intervention but I was now using the video data almost as a historical record of the intervention. In this regard I was more distanced from the main concerns that had been part of the TC Project and felt I could be more objective in examining what had happened. This enabled me to look at the data afresh and to interpret them in a new way. I also needed to be more accurate in determining findings and in interpreting what was already there.
In this doctoral study I present my examination of the children’s independent pupil-pupil talk. I carried out more systematic and in-depth analyses of the video material and the transcripts. I analysed where there were changes in the nature of the talk and what the changes were. Table 2 shows how my analysis of the doctoral study went beyond that of the TC Project. In studying the children’s talk in more detail and analysing the learning within a sociocultural framework the focus on the learning was further refined theoretically through the notion of emergence of mathematical objects (Font, Godino, & Gallardo, 2013; Radford, 2006; Seeger, 2011). The refocus was on how the children exchanged meaning about mathematical objects.

This new focus redirected the examination of children’s learning in the talk. Rather than looking at types of talk, as had been the case in previous studies of exploratory talk, I examined the children’s use of language in exchanging meaning. This entailed a study of the functions of language within the talk and how these functions were used in making meaning in mathematics. This was underpinned by functional approaches to discourse analysis, in particular to Gee’s (1996, 1999) discourse theory and language in use and to Halliday’s theories of systemic functional grammar (SFL) (Halliday, 1978; Halliday & Matthiessen, 2004).

The opportunity for more in-depth analysis and a different theoretical approach enabled a study of the children’s learning within the independent pupil-pupil talk to go beyond the initial findings of the original research in the TC Project. By examining the children’s use of language in talking about the mathematics I was able to investigate if the intervention had changed the children’s use of language. Underpinned by theoretical perspectives related to emergence of mathematical objects and language use, the key focus of my doctoral study became an examination of how the children exchanged meaning in mathematics and if the intervention changed the way that the children exchanged meaning.

v. **Summary**

This doctoral study presents the research that I carried out on the pupil-pupil talk that happened within independent group work both before the intervention
and in one group session following the intervention. The data base for the
doctoral study was from 20 of the 29 videoed lessons and transcriptions that
had been collected in the Talking Counts Project. In the doctoral study I used
one pre intervention and one post intervention lesson for each class. The
doctoral study was situated in an interpretive methodology and drew on
Vygotskyan perspectives on the social context of learning. This was related to a
social view of knowledge and learning in mathematics as proposed by Ernest
(1998, 1999) and by Lerman (2001). The research methods and the analysis
had been based on sociocultural discourse analysis methods developed by
Mercer and colleagues in examining the type of talk. The multi-level approach
was maintained but I adapted these to include the functional analysis of the
children’s language in use as related to Gee’s theory of discourse and
Halliday’s SFL.

The intention was not to generalise or to prove a hypothesis but to look for
emerging theories that might further our understanding of children’s learning in
mathematics. In pursuing the aim to understand better what was happening to
the children’s learning in mathematics I studied how the use of language
afforded (or hindered) opportunities for the children’s learning and studied the
nature of the talk in relation to how children were making sense of the
mathematics collaboratively.

vi. Outline of the content of the doctoral study

Chapter 1 Context and Rationale

This is an extended context and rationale that was developed for the TC Project
proposal. It outlines how the project was set within the context of a national
concern for achievement in mathematics. English curriculum and policy interest
in the use of talk in learning mathematics are reviewed. Reference is made to
mathematics as a Discourse and this is related to the perceived difficulties in
developing group work in mathematics classrooms.

Chapter 2 Literature Review

This is an extension of the literature review that was written for the TC Project.
In this review I show how national and international research informed the
research focus. It sets out the theoretical background and methodology that
had informed the TC Project. It explains how the TC project built on existing research and how it aimed to add to this existing knowledge.

**Chapter 3 The Talking Counts Project**

This chapter gives an account of the TC Project to further set the context for the doctoral study but also to set out the key findings from the project and to identify where there were remaining research questions. The account in this chapter is taken from extracts of the report that was produced for the funding body. The full report is presented in Appendix 1.

**Chapter 4 Discourse and Learning in Mathematics**

In this chapter I review some of the existing literature related to discourse in mathematics in order to develop the research questions for the doctoral study and to explain how they build on our existing knowledge of talk in the mathematics classroom, in particular with young children in learning arithmetic. This is informs the refocus of the theoretical perspective doctoral study towards a sociocultural perspective and the development of the research questions within this perspective.

**Chapter 5 Methodology**

In this chapter I set out the theoretical and epistemological framework that informs the doctoral study and indicate a level of coherence that is necessary to guide the research. It sets out a constructionist methodology and interpretivist paradigm that informs the approach to analysis.

**Chapter 6 Research methods for analysing the data**

This chapter sets out the methods of analysis used in the doctoral study. The purpose of the analysis was to examine the children’s learning as they talked to each other about the mathematics within the task. The chapter sets out the three different levels of analysis and the analytical tools used in coding the data.

**Chapter 7 Presentation of Results for Level 1 Analysis**

In this chapter I present the findings from the Level 1 situational analysis. This entailed details observation of the video data with the transcripts in order to examine the different classroom situations, the teacher management strategies and the nature of the tasks in relation to the intervention within each group.
session. This identified key aspects related to different situations within the fifteen group sessions and initial analysis of changes in the talk.

**Chapter 8 Presentation of Results for Level 2 Analysis**

In this chapter I present the findings from the Level 2 analysis of speech acts. The analysis investigated the nature of the children’s talk and any changes in the nature of the talk. This was carried out over the two categories of social (non-maths) talk and mathematics talk. The coded speech acts of the independent pupil-pupil talk are presented and reviewed.

**Chapter 9 Presentation of Results for Level 3 Analysis**

In this chapter I present the findings from the Level 3 analysis of the children’s use of words. In particular it examines use of functional words as cohesive devices and reviews how the children were using these words to exchange meaning.

**Chapter 10 Discussion**

In this chapter I review the findings from the multi-level analysis that were presented in chapters 7 to 9. I draw out key ideas regarding the relationship between the children’s talk and their learning and discuss these within a wider theoretical context and in relation to existing research.

**Chapter 11 Conclusion**

In the concluding chapter I summarise key findings from the doctoral study in relation to existing research. I identify the contributions of the doctoral study to our current understandings of children’s learning in mathematics in relation to theoretical perspectives and to methodology. I consider the implications for classroom practice and for further research.
CHAPTER 1 RATIONALE AND CONTEXT

1.1 Introduction

In presenting a chapter on the context of the doctoral study I also refer to the context of the TC Project. Hence this is presented as an expanded version of the context that was developed for the original research proposal.

As noted in the introduction, the TC project was set within the context of a national concern for achievement in mathematics. A key premise of the project was that pupil-pupil talk could be used more effectively in the mathematics classroom to support children’s understanding of mathematics. This chapter reviews how an English curriculum and policy interest in the use of talk in learning mathematics has been established over at least the last thirty years. The context examined in this chapter is considered from a national English perspective as this was where the TC project was carried out. However it is recognised that the use of talk in learning mathematics is an issue internationally and reference is made to research from further afield in the literature review in Chapter 2.

In the title I have used a quote from one of the children as they were talking together in solving a mathematics problem. She referred to their group as the “maths people”. I consider what this might mean in relation to a social notion of learning in mathematics. How active learning in mathematics is seen as doing mathematics or becoming part of a Discourse (Gee, 1996).

This is compared with the use of talk that has been interpreted in many mathematics classrooms in England and proposals are given as to why, despite the policy interest, talk is still not used effectively in mathematics classrooms, and how there are perceived difficulties in developing group work. It is then suggested that intervention strategies such as the one used in the TC Project can support children in working collaboratively (Blatchford, Galton, & Kutnick, 2005) and in developing effective talk (Mercer et al., 1999) and that the explicit strategies for developing a quality of talk can help to support small group collaboration in mathematics.
1.2 Policy views on talk in mathematics

It has been generally agreed that mathematics and language are ‘co-existing entities’ (Pimm, 1987, p. 196) and that language plays an essential part in mathematics education. Key to the premise of the TC project and hence the thesis is the assumption that there is a relationship between language and learning. This assumption has become prevalent within curriculum and policy documents. However the nature of this relationship and of how talk should be developed to support learning has been interpreted in different ways.

As far back as the 1960s, importance has been attached to the use of talk in the mathematics classroom in England. One of the earliest publications that looked at the value of classroom talk that included mathematics was Barnes, Rosen, and Britton (1969). The value of talk was re-emphasised in the 1980s with the Cockcroft Report (1982). This report stated that;

Language plays an essential part in the formation and expression of mathematical ideas. School children should be encouraged to discuss and explain the mathematics which they are doing. (para. 306)

and that;

Mathematics teaching at all levels should include opportunities for ... discussion between teacher and pupils and between pupils themselves. (para. 243).

The HMI series document ‘Mathematics 5 to 16’ (DfES, 1987) included working cooperatively as an aim, stating that “Investigational work and problem solving are often better done in small groups of two or three pupils” (para. 1.9) and that;

Cooperative activities contribute to the mathematical development of the pupils through the thinking, discussion and mutual refinement of ideas which normally take place. (para. 1.9)

Although policy documents and research in the 1980s had suggested that discussion was valuable in learning mathematics examples of discussion in the classroom were seen as rare (Pimm, 1987; Pirie & Schwarzenberger, 1988).

Curriculum guidance in England over the last ten years or so has focused on interactive teaching in mathematics. The National Numeracy Strategy (NNS)
(DfEE, 1999) promoted a high proportion of lesson time to direct teaching. Much of the interactive teaching and oral work was related to the development of mental calculations in conjunction with questioning that would give pupils the opportunity to demonstrate and explain their reasoning.

Alongside this the English National Curriculum (DfEE/QCA, 1999) directed how language should be used across the curriculum and that “Pupils should be taught to listen to others, and to respond and build on their ideas and views constructively” (p.83). In both documents there was the expectation that pupils should use the correct language and vocabulary for mathematics. These two documents presented an emphasis on speaking and listening, oral work and interaction, and the constructive use of talk. So talk was seen as a vehicle for learning. These documents also suggested that teaching should be at a brisk pace, that the teacher should direct the talk and that children should use correct mathematics vocabulary to build their ideas.

Research has shown that the NNS emphasis on interactive whole class teaching has done little to change the ‘deeper levels’ of pedagogy in primary classrooms or to impact on the way that talk was used (Smith, Hardman, Wall, & Mroz, 2004). Pratt’s (Pratt, 2006) study of primary mathematics classrooms examined how the tensions in delivering the curriculum as suggested by the NNS and the patterns of interaction that developed again showed that there was little effective pupil talk in the classroom.

In 2006 the Primary National Strategy (PNS) superseded the NNS. The PNS Framework for Mathematics (DfES, 2006) gave guidance on the development of communication skills and suggested that in problem-solving situations children should talk about the mathematical problem and that they discuss and explain their methods. Further resource material aimed at secondary teaching used the term ‘think together’ and suggested that pupils discussed, exchanged and revised their ideas with each other. This began to suggest a stance where pupils shared their mathematical reasoning and understanding. However studies such as the Evidence for Policy and Practice Information and Co-ordinating Centre’s (EPPI) review of teacher-initiated dialogue (Kyriacou & Issitt, 2008) indicated that the traditional initiation-response-feedback (IRF) still dominated in most mathematics classrooms.
Research such as Pratt and Kyriacou and Issitt above have suggested that, despite a curriculum and policy emphasis, talk was rarely used effectively in whole class interaction. It has been recognised that classroom practice is part of a wider range of constraints (Schwarz, Dreyfus, & Hershkowitz, 2009) that relate to social, spatial and bureaucratic perspectives. As such the teacher is often working as an individual in the classroom where teaching consists of discrete lessons and short sequences of work that lead to testing or examination. Schwarz et al. suggested that such constraints may affect teachers’ motivations and mould classroom practice so that much teaching is through teacher-led plenaries and individual activities.

Alongside these wider constraints there have been tensions related to the curriculum demands of the NNS/PNS in England and, in particular the emphasis on teacher directed talk and the correct use of vocabulary. Hence teachers have perceived the need to direct children’s social interactions, use of language and development of mathematical ideas. This has become prevalent in some professional development courses that relate to the use of Guided Group Work (DCSF, 2010) and High Quality Talk (HQT) that explains understanding clearly with explicit lexical detail and correct use of mathematical vocabulary.

A consequence of teachers’ use of group work is that they often direct the talk. Such teacher directed interactions could create a sense of dependency and passivity in children. The Making Good Progress reports (DCSF, 2007) identified children who did not make the expected progress in mathematics from Key Stage 1 (5 – 7 year old) and Key Stage 2 (8 – 11 year old) with respect to National Testing. These children were described as ‘passive’ learners who experienced education as something that was ‘done to them’. Such children were often tentative about their understanding in mathematics and had difficulties in explaining their thinking. Wheeldon (2006) noted in her own class of six to seven year olds that the children appeared to have a passive accepting role within group work. They relied on her as the teacher and did not refer to each other. They were influenced by what she wanted them to do; they tended to follow these as rules and referred to her, as the teacher, for confirmation of this.
Further evidence from The Office for Standards in Education (Ofsted, 2008) report *Mathematics: Understanding the Score* suggested a lack of pupil independence in many classrooms. The report had identified how some pupils, who started formal education with ‘relatively weak’ mathematical skills, did not make the expected progress. It was suggested that pupils “were generally not confident when faced with unusual or new problems and struggled to express their reasoning” (p.6). The report also indicated that “most lessons do not emphasise talk enough; as a result pupils struggle to express and develop their thinking” (p.5).

Alongside the perceived need for teacher-directed talk are the perceived difficulties by teachers of how to develop discussion and manage group work. Such difficulties have been evidenced in studies as far back as the 1980’s (Bennett, Desforges, Cockburn, & Wilkinson, 1984; Bennett & Dunne, 1992; Desforges & Cockburn, 1987). Galton, Simon and Croll (1980) study of the primary classroom had highlighted the paradox of children in primary classrooms sitting in groups but rarely working in groups. Twenty years later Galton, Hargreaves, Comber, Wall, and Pell (1999) repeated study of primary classrooms showed only a slight increase in pupil interaction in groups. Even then, task-focused interactions between pupils mainly involved exchanging information rather than discussing ideas.

A wide range of research has shown that the purpose of group work in primary and secondary classrooms was rarely strategic (Blatchford, Kutnick, & Baines, 2002). Teachers did not plan for pupil-pupil interactions and pupils had little support on how to interact effectively. Although the children may have talked to each other regarding instructions in how to complete a task they often ended up working on the mathematics individually.

It was within this context that we had approached the TC Project. The first few years of learning in school would seem crucial in establishing norms and practices in mathematics. The purpose of the TC Project was that teachers would be given strategies to help support lower attaining young children talk effectively in groups and engage in ‘doing’ the mathematics, with the assumption that this would diminish the dependent, passive nature of learning.
1.3 Social notion of *doing* mathematics and mathematisation

In doing mathematics children are learning to think mathematically by discovering and organising mathematical tools to solve a problem. Gattegno had referred to mathematical activity in 1958 (Gattegno et al., 1958) and had used the term mathemating in the 1960s (Gattegno, 1967). Freudenthal (1991) had also used the term mathematising as the use of mathematical tools within a problem-solving activity. Further to this definition Freudenthal saw mathematics as a human activity that children learn mathematics by *doing* mathematics.

The notion of doing mathematics suggests that children see mathematics as the *product* of their endeavour. This is contrasted with a view of mathematics as *ready-made* and passed on to children by their teachers (Freudenthal, 1983). Within a Freudenthalian perspective children experience mathematics as an activity. They are involved in the mathematics as active participants and problem solvers. Hence learning from a social perspective is not just about the social context of the classroom but also about mathematics as a social and historical abstraction from everyday phenomena. This suggests that doing mathematics is inherently *social*, both in the way that it is carried out in a social context and also as a social endeavour.

The idea of a ready-made set of mathematics to be transferred has traditionally been seen as the purpose of teaching. It relates to an absolutist or authority view of mathematics (Ernest, 2003). An individual child is seen to have the ability to acquire the absolute truth and the teacher’s job is to identify mistakes and eliminate them (Alrø & Skovsmose, 2002). Such an absolutist, Platonic notion sees the teaching of arithmetic as copy and practice in order to attain mathematical truths (van Oers, 2001). However the idea of mathematisation through the notion of doing mathematics suggests a human endeavour where mathematics is seen as an ‘inherently social activity’ (Schoenfeld, 1992). Mathematisation is seen as social. Through involvement in problem-solving situations “mathematical objects progressively emerge and evolve” (Godino, 1996, p. 419).
Views related to mathematics as human-centred and social have been developed by many theorists, for example Lakatos (1961) and Ernest (1991). (Hersh, 1997) proposed that;

... mathematics must be understood as a human activity, a social phenomenon, part of human culture, historically involved and intelligible only in a social context. (p.11)

More recently this was reiterated by D’Ambrosio (2001);

Mathematics is an intellectual instrument created by the human species to describe the real world and to help in solving the problems posed in everyday life. (p.67)

Whilst this social view of mathematics had been a premise of the TC Project, the theoretical underpinning in relation to social, emergence theories had not been fully developed. I return to these theoretical and philosophical perspectives in Chapters 4 and 5 but for the moment note that this social notion was not always reflected in English policy and curriculum.

At the time of the project, the revised English National Curriculum (DfEE/QCA, 1999) for mathematics had been in place for ten years. One strand included in the programmes of study was termed Using and Applying. This involved children in solving problems, communicating and reasoning. Such inclusion would suggest that children were actively involved in doing mathematics through problem-solving situations and that they were encouraged to communicate and reason about their ideas.

In the late 1990s the National Numeracy Strategy (NNS) ran in parallel to the National Curriculum with many teachers using the NNS to guide their teaching. Although there was an emphasis was on direct teaching there was encouragement for children to interact with the teacher and participate in the mathematics that was being taught. However my research on the use of a particular didactic tool, the Empty Number Line, suggested that calculation strategies were taught as a given or reference set of mathematics (Murphy, 2011b). The mathematics was taught as a set of procedures or as an algorithm that the children would copy and practice. Although the teaching could be seen as interactive a set of calculation strategies were passed on to children.
This ‘passing on’ of strategies suggests that the NNS might have recognised the sociable process of learning in seeing the classroom as a social environment where children interacted with the teaching, but it did not necessarily acknowledge the social notion of learning mathematics (Alexander, 2008). It did not acknowledge mathematics as a human activity where children found mathematics as the product of their endeavour.

1.4 Becoming the maths people

My understanding of children’s active engagement in mathematics aligns with the social notion of learning. It is not just a move away from children as passive listeners or individual textbook workers to the sociable interactive classroom, but as a move away from children’s receipt of a set of mathematics to the active engagement of children in mathematising, that is in problem-solving and sense-making. My interest is not in how well we can find interactive ways for children to memorise or practise skills and procedures that have been modelled to them but in how we help children do mathematics and how we help them see mathematics as a product of their endeavour. As such my interest is not only in the social context of learning but also in the social notion of learning, in children becoming doers of mathematics. That is in children becoming maths people.

Linguistically discourse is seen as a unit of connected speech or, to use Gee’s (1996) definition, a connected stretch of language that makes sense, for example a conversation. Gee made a distinction between discourse as connected narrative and a Discourse or quality of talk and interactions; “ways of behaving, interacting, valuing, thinking, believing, and speaking that are accepted as instantiations of particular roles (or ‘types of people’) by specific groups of people” (p.viii). “Discourses are ways of being ‘people like us’. They are ‘ways of being in the world’, they are ‘forms of life’. In particular they are, this, always and everywhere social and products of social histories” (p.viii). As such, Gee’s perspective would seem to relate to a Wittgenstein’s (1953) view of explicit knowledge as a common understanding within shared forms of life.

From a cultural perspective “mathematical learning is embedded in discursive processes between one generation and the next” (Brandt & Tiedemann, 2009, p.2557). Children encounter a cultural practice that is recognised as
mathematical (Sfard, 2001a) and that becoming mathematical means becoming fluent in the Discourse of mathematics. These perspectives suggest mathematics as enculturation defined as the induction of young people into their own cultural group (Bishop, 1988). Mathematics Discourse is different to social Discourse (Sierpinska, 1998) and to young children’s Discourse (Forman, 1992). So how do children engage in mathematics as a Discourse and form of life? How do they become people like us or maths people?

Wetherell, Taylor and Yates (2001) defined discourse as “language in use [for] making meaning” (p.3) and related to the action and interaction of participating social members where members have a shared interpretation. In developing children’s collaboration and talk, can we help children to participate in mathematics as language in use where they can make meaning and share interpretations?

A Concise Oxford Dictionary definition of talk is to ‘converse or communicate ideas by spoken word’. When used within a classroom context there is often an assumption that the talk is purposeful and that ideas are exchanged between at least two people, that is, there is a conversation. However, there is a general feeling that most talk in the classroom is non-conversational or the conversation is superficial or circumspect (Littleton & Howe, 2010). This has also been observed in the mathematics classroom (Kyriacou & Issitt, 2008). Hence talk is not often seen as effective, it is not purposeful and there is limited exchange of ideas.

Typically classroom talk is dominated by the teacher (Myhill et al., 2006). The teacher controls both the content of the talk and the voice of the pupils. As such pupils take on a defined role where they are cajoled to learn the discourse of mathematics (Thornton, 2007). This in turn suggests to the pupils that they are producers of work and that mathematics is something to be done. If the view is that learning in mathematics involves children doing mathematics then children are repositioned as mathematical thinkers (Bell & Pape, 2012). Rather than children seeing mathematics as something to be done or even done to them children are seen as doers of mathematics. The TC project had been based on the premise that encouraging talk where children exchanged ideas in
mathematics would promote children as active learners in mathematics. The intention was that the children became *doers of mathematics, or maths people*.

1.5 Exploratory talk

The strategies used by the TC Project had been based on Mercer and colleague’s studies in exploratory talk. Mercer (2008) studied the use of talk within independent group work and identified three different types of talk that can take place in small group work.

Mercer described disputational talk as talk that was characterised by disagreement and individualised decision making. Talk where there were interactions such as ‘Yes it is! No it’s not!’ The atmosphere was competitive rather than co-operative. Mercer characterised cumulative talk as talk that was positive but uncritical acceptance of what was said. Children did use talk to share knowledge, but they agreed with what each other were saying in an uncritical way.

Mercer contrasted these two types of talk with exploratory talk where children engaged critically but constructively with each other’s ideas (Mercer, 2000). Exploratory talk had first been identified by Douglas Barnes (for example, Barnes & Todd, 1995). Barnes has described exploratory talk as talk that is unrehearsed talk and has opportunities for spontaneous verbalisation. It is where spoken language is not used simply to express thoughts but to create them (Barnes, 1976). As Barnes stated, the learning needs of the speakers are paramount, they are sorting out ideas.

Exploratory talk has since been presented as an effective way of using language to think collectively. It has been acknowledged in discourses in science, mathematics, law, business and politics but has also been studied in subjects seen traditionally as more creative, such as art and literature (Rojas-Drummond, Gomez, & Velez, 2008). Key to exploratory talk is that relevant information is offered for joint consideration and that agreement is sought. In seeking agreement, ideas may be challenged and counter-challenged. Reasons are given and alternative ideas are offered. As such personal, individual knowledge is made public and accountable. In sharing and reasoning, personal knowledge is made ‘visible in the talk’ (Mercer, 2000; Mercer & Littleton, 2007).
Mercer and colleagues have presented this as a social mode of thinking or *interthinking*.

There would seem to be good reasons for wanting children to use exploratory talk in group activities in mathematics. In giving ideas, children would be making their thinking public. In challenging ideas children would give reasons and offer alternatives. This would encourage children to be active participants in learning mathematics. They would be listening actively, asking questions, sharing and challenging ideas and giving reasons for challenges. They could contribute to each other’s thinking and build on each other’s ideas. Use of exploratory talk within small group work would mean that all children were encouraged to contribute, they would be actively engaged. As Thornton (2007) suggested talk that is exploratory heightens a sense of agency;

> *a discourse that is exploratory, tentative and invitational, that contains emergent and unanticipated sequences, and that recognises alternative ideas even ones that are strange, enables students to see themselves as active participants in learning, having power over both the mathematics and the discursive practices of the classroom.* (p.718)

Engaging in talk in an exploratory way is an engagement with a type of Discourse, to use Gee’s definition. It is a way of thinking and behaving and as such there are rules for behaving in a way of talking. Mercer et al. (1999) developed explicit strategies related to exploratory talk that were designed to teach children to negotiate their ideas and direct their speech. The children learn a certain type or quality of talk. Ground rules in how to talk are developed to support children in developing this type of talk. Key to this is the rule to come to a consensus, to agree on a solution to a problem together. In relation to this the children are encouraged to use key words such as why, because, agree, disagree ... and so on, with the premise that the use of these key words would help children to challenge and counter challenge, to give reasons and to share ideas. As well as using these words as tools to support children in talking, the use of key words also gives a means to analyse the children’s talk. Research has carried out analysis in looking for resemblance against exploratory talk as a quality of talk (Mercer & Sams, 2006; Mercer et al., 1999).
1.6 Summary

As discussed above, primary teachers’ experience of talk has been influenced by curriculum documents such as the NNS/PNS, amongst a range of other constraints. Their experience has been directed mainly towards group work that is led by the teacher as a ‘guide’ where they encourage children to use correct mathematical vocabulary. One consequence of this is that the teacher presents an orthodox use of language and that the children appropriate the teachers’ talk (Bishop, 1985).

However, in collaborative group work, the intention is for pupils to communicate, share ideas and meanings. Such sharing of ideas often means the children use unorthodox language; they are thinking aloud and use spontaneous verbalisation (Bishop, 1985). If children are feeling constrained to use the orthodox language they may be unable to sort out and express their ideas. Barnes’ (1976) notion of exploratory talk has suggested that when talk is used to sort out ideas it is often spontaneous and this would seem to be part of children being actively engaged and doing mathematics. However it has also been found that group work is rarely used in this way, talk is rarely exploratory in nature. Also it seems that teachers are uncertain how to establish such talk in their group work or are concerned that they should be modelling the talk.

The explicit strategies developed by Mercer and colleagues would suggest a way that teachers could employ to use talk differently. They could plan for group work strategically and for interaction that would enable children to express thoughts and create them. The Talking Counts project used materials from the Thinking Together project at the University of Cambridge (Dawes, Mercer, & Wegerif, 2000). This provided the basis for the teachers by providing explicit strategies that they could develop for their use in the classroom.

The intention of the Talking Counts project was to work with young lower attaining children who were often passive learners and did not engage effectively in mathematical talk. Lower attaining children are those generally given directed support, say from teaching assistants (Blatchford et al., 2009), so they are less likely to have the opportunities to work independently within groups. Mathematics support programmes, such as the Mathematics Recovery...
Programme (Wright, Martland, & Stafford, 2006) and Catch Up Numeracy (Catchup, 2009), have targeted younger lower attaining children in giving early intervention and support through one-to-one teaching. Although it is seen as important to provide intensive support and instruction for some children in key concepts and skills, children in these situations may not have the opportunity to share their ideas using spontaneous language or to develop independence in their working.

In the TC Project the teachers were supported in using explicit strategies related to exploratory talk as determined by Mercer and colleagues. In the introduction it was noted that the intervention had supported the teachers in developing group work but that it had not been possible to determine the changes systematically. So it had not been possible to identify talk that was exploratory in nature with any confidence. Exploratory talk had been presented as a social mode of thinking or interthinking, a way of sharing ideas.

Earlier in this chapter I set out a key premise that, within the social notion of learning mathematics, children were doers of mathematics. Mathematics was presented as inherently social and could itself be seen as a Discourse, a quality of talk and of interactions. The intervention in the TC Project had encouraged children to use strategies key to exploratory talk such as consensus, challenging and giving reasons. This raised questions regarding if the children were able to take on these strategies and if they did how it changed the way they talked about mathematics. There had not been sufficient time to analyse the video data and transcripts in sufficient detail to answer such questions in the original research of the TC Project. The research in this doctoral study investigated these questions further. In particular I examined how the introduction of a new way of talking was adopted by the children and if it changed the way they talked about the mathematics. If it did change, how did this change the way children exchanged meaning about mathematical objects? Could it be seen that the children were sharing ideas and if so what did this tell us about children's learning in mathematics?
CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

The literature review in this chapter is an extension of the literature review that supported the proposal for the TC Project. In this review I show how national and international research informed the research focus and methodology for the project, how the TC project built on existing research and how it aimed to add to this existing knowledge. In Chapter 3 I outline the key themes of the project and the main findings. In Chapter 4 I present the literature and theoretical framework that supported the doctoral study.

In reviewing the context of teaching mathematics in England in Chapter 1 it was acknowledged that group work was not always used strategically and that support was needed to develop pupil-pupil talk in mathematics group work. In this chapter I review empirical research that has examined talk in mathematics, as well as research that has investigated interventions that have supported group work and collaboration more generally as well as in mathematics. This is then used to explain how the TC project aimed to add to this knowledge by developing and investigating an intervention to encourage exploratory talk with young lower attaining pupils in mathematics.

The TC project was based on the assumption that talk in mathematics classrooms is beneficial to learning but that, whilst pupil talk and discussion had been vindicated for some time, and hence included in policy documents, evidence of the strategic use of pupil-pupil talk in the mathematics classroom had been limited. A similar lack of evidence for group work and pupil talk had been recognised in other countries, for example in the USA Krummheuer and Yackel (1990) reported how small group work was often used for routine practice of mathematical skills rather than pupil-pupil discussion. The limited use of talk may have been due to the difficulties of managing discussion in classroom conditions (Desforges & Cockburn, 1987) but it is also possible that it has been due to the limited theoretical and empirical evidence that indicated how the use of pupil-pupil talk could support learning in the mathematics classroom (Desforges, 1989).
Since the 1980s there has been a wide range of empirical research that has examined the use of language and interaction in the mathematics classroom. For example, several edited books present empirical research that focused on language and communication in the mathematics classroom (Steinberg, Bartolini Bussi, & Sierpinska, 1997), classroom interactions and mathematical meaning (Cobb, 1995) and how changes in classroom interaction transform knowledge (Schwarz et al., 2009). There have also been special issues of research journals, such as Kieran, Forman and Sfard’s (2001) issue of Educational Studies in Mathematics on discursive approaches to researching mathematics education and the more recent special issue of the International Journal of Educational Research (Sfard, 2012b) on developing mathematical discourse.

Studies, such as those by Cobb, Perlwitz, and Underwood (1994), Goos, Gailbraith, and Renshaw (1996) and Wood (1994, 1998), have focused on the patterns of effective discourse and, in particular, on language as a game within classroom discourse (Bauersfeld, 1995). Murray (1992) has examined individual learning within social interaction and Richards (1991) found that the language in mathematics classrooms does little to relate to mathematical meaning but is often just exchanging words. More recently Pratt (2006) examined the challenges of whole class interaction and how children interpreted their role within the discourse. Further studies have looked at the change in discourse patterns following an intervention. For example, Alrø & Skovsmose (2002) investigated the development of investigative practices and the use of ‘what-if’ questions to provide opportunities for thinking aloud and reformulating ideas.

Other research has considered the interdependency of language and cognition. For example Pimm (1987) examined the use of language by teachers and “how language is modified as a result of attempting to communicate mathematical ideas and perceptions” (p.196). Rowland (1992, 1999, 2000) analysed pupils’ use of language and in particular the use of pronouns in pointing to meanings. Bills (2001, 2002) has further investigated the link between language and children’s understanding with research into the use of pronouns and causal connectives related to children’s mental representations of number.
More recently studies have considered language and mathematics from an ethnographic perspective (Barwell, 2005a, 2008) by examining how different languages express different mathematical ideas (Barton, 2008) and also from the perspective of bilingualism and second language acquisition (Moschkovich, 2010).

The above range of studies is just a small selection from what is now an established field of research into language and mathematics. Within this field there are many studies that had looked at children’s discussion and there is now a growing body of evidence that pupil-pupil talk that involves children in discussion can support children’s reasoning and meaning-making.

For example, the use of argumentation in children’s learning has been explored by Krummheuer and Yackel (1990) and studies have considered how children justify their thinking and how argumentation supports meaning-making (Schwarz, Nueman, & Biezuner, 2000; Schwarz, Prusak, & Hershkowitz, 2010). Yackel, Cobb, and Wood (1991) and Wright (1993) referred to the opportunity for children to articulate their thinking, explain and justify their reasoning and that in doing so they review and reconstruct their mathematical thinking. Also research has indicated that giving verbalizations or instructions to peers greatly benefits the child giving the instruction (Forman & Caszden, 1985; Petersen, Wilkinson, Spinelli, & Swing, 1984). Ryan and Williams (2007) have also looked at children’s mathematical discussions from the perspective of argumentation, suggesting a community of inquiry that combines conversation with reason and persuasion.

### 2.2 Research on collaborative group work in mathematics

However empirical evidence of the effectiveness of collaborative group work in mathematics has not always been conclusive. Discussion in small group work had been promoted in the Cockcroft (1982) and following this, there had been a developing interest into this phenomenon. Two studies in particular from the 1980s questioned the assumption of the efficacy of pupil discussion and collaborative modes of learning (Hoyles, 1985; Pirie & Schwarzenberger, 1988). The studies distinguished certain aspects of discussion such as the organisation and articulation of ideas and dynamic feedback from peers.
(Hoyles, 1985). They also found that occurrences of genuine discussion were rare (Pirie & Schwarzenberger, 1988). Later Pirie (1991) carried out closer analysis of episodes that were originally labelled as ‘incoherent’ and suggested that pupils were sharing meaning but that the ideas were poorly articulated through the use of personal language.

In the meantime research methods for examining collaborative group work were developing. The publication of a special edition of *Cognition and Instruction* in 1995 reported on a seminar on collaborative learning in mathematics and science (Hoyles & Forman, 1995). This further defined collaborative work and the outcomes of collaborative learning. The journal presented debates concerning methodologies and approaches to studying communication and cognition as well as factors such as task demands and the role of feedback. Further approaches to studying collaborative group work were given in Cobb’s work on mathematical learning in small groups (Cobb, 1995). This provided tools for observing interaction and learning and in identifying where relationships between children were productive in providing learning opportunities.

Other studies (Curcio & Artzt, 1998; Stacey & Gooding, 1998) have looked for the patterns and factors affecting small group work. Curcio and Artzt examined the problem-solving behaviours of small groups and how this might mirror the behaviours of expert problem solvers working alone. They concluded that small group setting “offers a fertile environment in which rich communication about mathematics may take place” (p.189) but that this was dependent on the nature of the task as well as the combined and individual character of the group. Stacey and Gooding looked at the level of participation and the mathematical content of the talk. They found that the more children participated, that is took turns, the more effective the learning with the consequence that those children who did not participate did not learn. Again group characteristics were found to be a factor but these characteristics differed even for the effective groups. Sfard and Kieran’s (2001) study of the pupil-pupil talk of two thirteen year old boys suggested that the collaboration between the two boys was not always helpful and that the merits of such an interaction should not be taken for granted.
The above research has looked at the children’s group work as it is in a given context. They are often ‘snapshots’ of a current practice. In doing so, the studies have shown that small group work can be productive but that there are factors impacting on this; the main factors being the nature of the task and the individual and group characteristics. The studies have also shown that interpreting children’s talk needs care as their ideas are sometimes poorly articulated.

Such studies also begin to show that there are problems in small group organisation and collaboration. Hunter’s (2007) studies with eight to ten year old pupils have recognised that, even though the teacher may be modelling effective discourse patterns in whole class situations, there are still problems with establishing independent group work. Talk can be competitive and non-productive. Hunter suggested that the teacher needed to give specific guidance to children on how to work collaboratively.

2.3 Research on interventions to support group work

Research investigating interventions look to initiate change in practice (Alrø & Skovsmose, 2002; Schwarz et al., 2009). The premise of the TC project was based on intervention studies such as Mercer and colleagues that claimed an intervention could be effective in supporting collaboration and pupil-pupil talk. Empirical evidence (Mercer et al., 1999) suggested that with such an intervention pupils aged ten to eleven years old increased the amount of exploratory talk that they used, and that those pupils who used exploratory talk more made greater gains in non-verbal reasoning tasks. This was further demonstrated within the academic area of science where the use of exploratory talk had a positive influence on children’s understanding and attainment (Mercer et al., 2004). Research on the use of exploratory talk has been complemented by work in other countries such as Mexico and studies by Rojas-Drummond and Mercer (2003), Rojas-Drummond et al. (2003), and Rojas-Drummond and Zapata (2004) concurred with the English findings that language, and in particular exploratory talk, can support primary children (aged ten to twelve years old) in reasoning tasks within social contexts and that instruction in the use of exploratory talk made the children’s reasoning more visible.
Mercer and Sams’ (2006) study has provided evidence that the use of exploratory talk can be effective in supporting children’s learning in mathematics. The researchers worked with nine to ten year-old children across different schools and classes with target and non-target classes. The target teachers were given prescribed lesson plans. The children’s progress was measured against attainment in problems from National Test papers. The study also examined video data in looking for change in the use of talk in gauging how the children’s talk resembled exploratory talk. The study showed that those children in the target classes made greater gains.

The above studies were with older pupils. Traditionally teachers have expressed concerns that younger children do not find it easy to share ideas (Galton & Williamson, 1992). Some obvious barriers are seen such as reading instructions and recording but also that young children may not be well socialised into group activities (Wright, 1994). This is particularly seen as a problem in mathematics as it is suggested that young children may lack the reasoning skills to discover and talk about the mathematics on their own (Voigt, 1995).

There is now a body of research that begins to show that young children can be supported in effective group work. Several studies are in disciplines other than mathematics. For example intervention studies that have given positive results in literacy with younger children are the Esmee Faibaim funded ‘Talking for Success’ project at the Open University (Wegerif, Littleton, Dawes, Mercer, & Rowe, 2004) and the University of Exeter based Esmee Fairbairn funded project ‘Talk to Text’ (Fisher et al., 2010).

Other studies that have not focused on the talk but have focused on planning, classroom organisation, supportive relationships and task development have also found that there are positive and social outcomes from small group work with young children. For example the SPRinG project (Blatchford et al., 2005), has shown interventions to be effective in teaching science across a range of ages from five to fourteen years old.

Some studies have shown that intervention has been effective in mathematics. Yackel et al. (1991) worked with one teacher in a class of second grade children
to develop small group problem solving in mathematics. Wright’s (1993) small-scale classroom-based project also showed that even younger five to six year-old children could collaborate in problem solving when working in pairs.

More recent studies have been carried out with young children in mathematics. Rojas-Drummond, Mercer and Dabrowski’s (2001) study compared teachers who used a formal directive approach with those who used an interactive collaborative approach in teaching their five year-old children mathematical skills. Kutnick, Ota, & Berdondini’s (2008) study focused on the explicit use of teaching and relational activities to improve effectiveness in group work with five to seven year-old children. Currently Kinnear (2011) is carrying out studies in South Australia to investigate classroom practices that promote reasoning and inquiry skills with five year-old children in data handling activities. Such studies have shown that the development of instructional activities can give rise to learning opportunities that were not typical of traditional classroom practices.

The above examples show that intervention studies have been effective in supporting collaborative group work across the curriculum as well as specifically in mathematics and that these interventions have also been successful with younger children. Several of the studies have shown that a focus on the quality of talk such as the use of explicit strategies to encourage exploratory talk can be effective. They also show that other interventions based on the development of tasks, supporting relationships and classroom management have been effective.

Studies with young children in mathematics have tended to take a wider perspective, beyond the quality of talk, in developing their interventions. Studies that have focused on the quality of talk, such as Mercer and Sams (2006) have been with older children. Research in mathematics with young children that focuses on quality of talk is limited at present. Wheeldon (2006) looked specifically at how two young children’s talk changed with explicit teaching and modelling of exploratory talk but as small-scale practitioner-based research it did not have the opportunity to look at talk across a range of children.

Whilst demonstrating that strategic intervention even can be effective in supporting learning with young children, including learning in mathematics,
intervention studies have tended to be causal in nature and to determine learning as a product, an educational outcome. Few intervention studies have examined the learning in the talk, what was happening cognitively as the children shared ideas. This raises the question as to what is meant by effective. As had been noted in Chapter 1 ground rules to encourage exploratory talk encouraged consensus and use of words such as why, because, agree, disagree. If use of these words is then seen as effective it suggests a circular argument. In developing the TC Project there had been an intention to examine the learning cognitively in the talk. Whilst pre and post tests were carried out to provide evidence to the funding body of the educational outcomes we had also intended to investigate children’s learning cognitively, both through diagnostic assessments and as the children talked together.

2.4 Talk and learning in mathematics: the idea of a ‘cognitive shift’

Much of the research into children’s mathematical learning has been related to traditional psychological perspectives. Mathematics education within the psychology tradition has looked at the structures and meanings of mathematics alongside the insights of psychology and constructivism. Piagetian theory of mind and conceptual development has been a main influence on these constructivist insights.

A main tenet of constructivism is that a person’s knowledge does not come from outside but is constructed by the individual. As defined by von Glasersfeld (1987) knowledge is not passively received but actively built up by the cognising subject. However this does not mean knowledge is discovered but that the individual adapts what they know to new experiences, hence a cognising being makes sense of experiences. Hence learning is seen as an individual construction of meaning.

The research interest into the use of language and discourse in the mathematics classroom has developed since the 1980s and has stemmed from an increased interest in the social aspects of learning. It is now accepted that teaching and learning in mathematics can be seen as both psychological and social products (Bishop, 1988). Social constructivism acknowledges the role of communication in sharing meanings and arriving at a consensus of individual
perceptions. In this regard the role of exploratory talk would be to instigate
cognitive conflict in further adapting what is known by an individual. Such a
perspective would meet with the notion of social learning in mathematics, which
is that the mathematics is not conveyed ready-made to the students but that the
social experience in a classroom is made sense of by the individual in
constructing knowledge. A social constructivist viewpoint sees “knowledge and
competence as products of the individual’s organisation of the individual’s
experience” (Von Glasersfeld, 1983, p. 66) but that the social has a role in
building an individual’s knowledge.

However further research into language and cognition in relation to
mathematics has developed in relation to Vygotskian theories and the mediating
role of language. This is intrinsic to Vygotsky’s (1978) zone of proximal
development (ZPD);

\[
\text{It is the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (p.86)}
\]

This perspective has also been acknowledged as a theoretical underpinning for
exploratory talk. For example Mercer and Littleton (2007) developed Vygotsky’s
notion further in defining the intermental development zone (IDZ);

\[
\text{For children to become more able in using language as a tool for both solitary and collective thinking, they need involvement in thoughtful and reasoned dialogue, in which their teachers ‘model’ useful language strategies and in which they can practise using language to reason, to reflect, to enquire, and to explain their thinking to others. (p.49)}
\]

Research in mathematics learning has taken account of these social aspects of
learning and several studies have now investigated the classroom context or
norms in which children learn mathematics. For example, Cobb and Bauersfeld
(1995a) have described learning mathematics as an “initiation into a pregiven
discursive practice and occurs when students act in accord with the normative
rules that constitute that practice” (p.6). From this social perspective
mathematical learning is viewed as a situated human activity where children learn through participation in mathematical practices within the classroom context. Learning in mathematics is seen as learning how to participate in the practice of mathematics. Such studies have attended to the social aspects of learning within the classroom but cognitive issues were studied within a Piagetian constructivist perspective. As such social Vygotskyan aspects were integrated into existing constructivist aspects.

In developing the doctoral study the use of the data from the TC Project meant that there was an opportunity, not only to look at the data in more depth, but also from a different perspective. This is discussed further in Chapter 4 where the issue of combining the study of social perspectives and existing Piagetian notions of cognition is examined and theorised further. However the TC Project had been underpinned by this integrated perspective. The TC Project had taken the social aspect of learning mathematics in relation to Vygotsky and ZPD along with Mercer’s development and examined the cognitive development of children from a Piagetian constructivist perspective.

A key theoretical stance of the Project was the notion of a ‘cognitive shift’ in children’s thinking in arithmetic. This was based on the neo-Piagetian notion of a process-object duality in relation to arithmetic. Gray and Tall (1994) proposed that the understanding of number is an elementary procept, an amalgamation of a process, an object and a symbol. The notion of a procept refers to Piagetian notions of assimilation and encapsulation (Tall, Thomas, Davis, Gray, & Simpson, 2000). The move from the physical act of counting to the use of number in arithmetic is achieved through ‘compression’ of the process of counting. In this way the word six is not just a counting word, it is also ‘compressed’ into the concept of six as an ‘economical unit’ that can be held both as a focus of attention and as an access to the process of counting. Hence a symbol such as six evokes both the counting process and the number six itself. Children who are able to work with both the concept of six as a unit and to access the process of counting are said to have a proceptual view.

Much research has been dedicated to the development of early arithmetic and progression in use of calculation strategies (Gray, 1991; Steffe, 1983). Such studies have indicated that there are ‘milestones’ that show progression from...
simple counting strategies ('count-all' and 'count-on' strategies) and the use of commutativity ('counting-on from the larger number') to the use of number facts (additive components) and place value. A child who is using count-all strategies would have a process view, whilst a child who was using count-on strategies or derived number facts would be said to have an object based or proceptual view. Low attaining children are seen to remain with process-based counting strategies.

The *procept* notion was used in the TC project along with Karmiloff-Smith’s (1992) theory of *Representational Redescription* (RR) whereby children learn to translate procedural representations in one context to representations in other contexts, enabling the development of more generic schemas. That is there is a conceptual change. This change requires increased levels of explicitness and conscious access to thought processes through verbal explanations. It was proposed that the use of exploratory talk in collaborative groups would allow for verbal explanations and a cognitive or conceptual shift. Hence the discourse would be key to the verbal explanations that children give in reasoning about the mathematics in collaborative work. Such a conceptual shift would support a proceptual view and the child would be able to use object-based calculation strategies.

This formed the theory behind the diagnostic assessment and also analysis of the children’s learning within the talk.

### 2.5 Collaboration with diverse pupils

Whilst the intervention studies related to exploratory talk had seemed effective, it was not always clear whether explicit instruction in collaborative group work would support children’s learning in mathematics across all attainments. Black (2004) indicated that many studies consider the pupils as a homogenous group in that they all respond to classroom interactions in the same way. The larger scale studies have not always reported on the success of intervention across attainment and often looked at mean class scores. Such studies are technical in their view of knowledge (Carr & Kemmis, 1983) and assume that educational processes are controllable. Children’s problems in learning are seen as blockages and that improved technology will overcome these.
Research that has examined collaborative group work with low attaining pupils is more limited. Where group work happens it is often with higher attaining pupils as teachers perceive that it is these pupils who will profit from group interaction. Research in the 1980s (Bennett & Cass, 1988) showed that low attaining pupils did not fare as well in group work as high attaining pupils and seemed to support the idea that such children lacked the necessary skills to interact and learn effectively in groups. However more recent studies have shown that all ability groups can gain from collaborative group work (Palincsar & Herrenkohl, 1999).

The SPrinG project examined the effectiveness of group work on pupil progress in learning science across a range of ages and across attainment. The results showed that progress did not vary by attainment but that gains were attributable to the quality of collaborative dialogue. A DCSF funded project on Effective teaching and learning for pupils in low attaining groups (Dunne et al., 2007) also provided evidence that the use of cooperative learning techniques is successful with low-attaining secondary pupils across the curriculum. A team of Primary National Strategy consultants (Anderson, 2011) worked with teachers of lower attaining pupils aged ten to eleven years old.

Such projects have provided evidence that collaborative group work can be effective with lower attaining students. In some ways this would seem appropriate. There is an opportunity to exchange and test ideas in a supportive environment in a small group of peers, away from the eyes and ears of the rest of the class (Walshaw & Anthony, 2006). But other research has shown that there can be problems for diverse children in such work. Hunter’s (2007) study showed how a teacher supported children from diverse backgrounds. The study was carried out in one school in New Zealand, and the children (eight to ten year-olds) were from low socio-economic backgrounds. Key components of collaboration were that the students took ownership of their reasoning and recognised collective responsibility. The study showed how the teacher ‘scaffolded’ the children in a shared perspective of a task. The children needed support in how to disagree and challenge each other so that they were able to see multiple perspectives. Barnes (2005) saw that within small group activity the communication patterns and social relationships can limit learning opportunities.
Specific children were actively positioned as ‘outsiders’ within the small groups; their contributions were interrupted or ignored.

More recent studies such as Hunter’s and Barnes’ begin to consider a sociocultural view of children’s learning that is not one of pathologising and remediation but where it is the social context of learning that needs to change, or that children are supported in working within the context. These latter views relate to a sociocultural perspective in learning mathematics. Not just in the sociable process of the classroom but as children as agents within the learning of a Discourse.

Such studies have begun to examine interventions within a practical view of knowledge. Education is seen as a product of language and interaction (Carr & Kemmis, 1983, p. 26). Social situations are complex and cannot be controlled in a technical way. Children’s problems are seen as part of the social situation and changes are made by decision making in practice by teachers rather than by implementation of a technique.

Recent research has furthered this notion of the social situation as the problem and linked low attainment to social inequality (Kerr & West, 2010). It is seen that there should be equitable opportunities for children to engage in productive classroom discourse (Boaler, 2006; White, 2003) and with small group collaboration (Hunter, 2007). It has been recognised that low attaining students often take a passive role in whole-class discussions (Baxter, Woodward, Voorhies, & Wong, 2002) and that specific pupils can become marginalised within classroom discourse (Black, 2004). Hence whole class learning situations may not give the support for the classroom discourse and participation in the practice of mathematics for diverse learners.

As noted in Chapter 1 low attaining children are often given direct one-one support. There is no denying that such children do need direct instruction in specific skills and understanding but if remedial instruction is always to pull pupils out and give intensive support, then the children will not have the opportunities to learn how to participate in mathematics. In supporting lower attaining children in collaborative group work we are supporting children in participating in a shared practice of mathematics.
2.6 Summary

The review of literature presented above extended the review that was developed to support the proposal of the TC Project. It has reaffirmed how the project built on the work of Mercer and colleagues in the developing an intervention whilst acknowledging that there was still little research with younger lower attaining children. It had also acknowledged how the Project aimed to analyse the learning that was happening as the children talked.

In developing the project we were not aware of studies that had looked at changes in quality of talk and also examined the mathematical learning that took place in the discourse. These studies had tended to look at attainment as a product (for example Blatchford et al., 2005; Kutnick et al., 2008; Mercer & Sams, 2006). Where the children’s discourse has been examined, such as Mercer and Sams, this focused on the quality of the talk and how it resembled exploratory talk. The discourse was not used to examine the children’s learning other than to note how the children had performed on a problem-solving task. This is considered later in Chapter 4.

Studies have looked at discourse and learning. Earlier studies such as Yackel et al. (1991) and Cobb (1995) have looked at the discourse in order to examine how the children’s interactions built on mathematical ideas from a constructivist perspective. From a sociocultural perspective, Sfard and Lavie’s (2005) study linked word use to children’s sense making in early number, and Sfard and Kieran (2001) have analysed interactions in relation to learning with older children. These studies did not relate to an intervention so have not looked at changes in the quality of talk.

If it is seen that pupil-pupil talk supports understanding by enabling children to enter the discourse of mathematics it would seem advantageous to work with younger pupils. An argument is that young children have not yet become part of the school mathematics community and hence have not yet been rooted into traditional classroom practices. It is recognised that working with younger children does pose a challenge. Although it has been shown that younger children can be encouraged to work collaboratively and to share ideas, their use of natural language and inexperience in academic dialogue may make the
analysis of their talk problematic. Pirie (1991) had found that data needed to be re-examined to determine the use of personal language and lack of articulation. Sfard and Lavie’s (2005) study of two four year old children also indicated a need to focus on the language and word use of young children in developing early numerical ideas.

Many of the studies have looked at the success in developing effective talk or in establishing collaboration. The interest has been in presenting examples where the interventions were effective in order to identify the conditions that supported or established a causal connection. They have been technical in their view of knowledge. Fewer studies have looked at problematising an intervention based on the use of talk or have examined the cases where there were difficulties in developing the use of talk and why there may have been difficulties. However we know from studies with diverse students that other factors may be involved concerning the dynamics of the group and participation of the children. Such studies have recognised the complex social situation of education.

In carrying out an intervention with younger lower attaining children we anticipated that there would be problems in encouraging children to work in this way and an interest of the TC Project was in realising the problems as much as the successes. Larger scale technical studies were often based on group tasks that had been imposed by the researchers rather than on group tasks that emerge as part of the teacher’s usual classroom practice. The teachers may have been given prescribed lesson plans. A principle of the Talking Counts project was within a practical view of knowledge. It encouraged teachers to develop their own way of introducing the talk alongside the mathematics tasks. They made the decisions in how to work with their pupils. This removed the variables needed for a large scale causal study but it did mean that within an interpretive research paradigm we could look at the challenges and idiosyncrasies in a multiple case study. It was not the intention to pinpoint particular teachers as carrying out the intervention well or not. It was recognised that the intervention happened in classroom practices that already have many influences.
CHAPTER 3 THE TALKING COUNTS PROJECT

3.1 Introduction
The doctoral study had used existing video data and transcripts from the TC Project and aimed to develop an in-depth analysis of the nature of the children’s talk, the changes in the talk and to examine how the children exchanged meaning in mathematics within the talk. Hence the doctoral study aimed to go beyond the scope of the original research.

This chapter gives an account of the TC Project to further set the context for the doctoral study but also to set out the key findings from the project and to identify where there were remaining research questions. The account in this chapter is taken from extracts of the report that was produced for the funding body. The full report is presented in Appendix 1.

3.2 The aims of the TC Project
The aim of the TC Project was to develop content-specific teaching strategies and activities that would support exploratory talk with young lower attaining children in mathematics. Based on previous studies as presented in the previous chapter, the assumption was that developing exploratory talk in small independent group work would change the nature of the children’s talk and encourage collaborative reasoning. This would instantiate a more active learning situation where children would question, explain and justify their actions to each other in carrying out mathematical tasks.

It was proposed that this would be a key component in engaging children in mathematics education at KS1 and would afford a cognitive shift in key ideas in arithmetic. Mathematical attainment was measured through standardised pre and post tests. A further aim was to examine the children’s learning by observing critical incidents from the video material. As fewer studies had been carried out with younger children, there was a need to adapt the strategies used by Mercer and colleagues in teaching young children to use exploratory talk in a mathematics specific content.

The aims of the project were:

- to develop a teaching intervention based on research that would have an impact on the teaching of arithmetic;
• to work with practising teachers to develop practical classroom strategies that will encourage exploratory talk within collaborative group work across a range of abilities within the specific context of arithmetic;

• to analyse the group interactions (verbal and gesture) that occur through exploratory talk, how the quality of the talk changes and how the change in quality relates to cognitive shift in arithmetic.

Further aims were:

a) to develop detailed guidelines and a professional development pack for use in teaching through collaborative group work within the specific content of arithmetic at KS1;

b) to evaluate the effectiveness of the teaching approaches through analysis of both quantitative and qualitative data;

c) to evaluate the effectiveness of the professional development pack in transferring the approach from the classrooms in which it has been originated to other schools and classrooms;

d) to disseminate the findings and products of the project in such a way as to have the maximum possible impact on the way in which arithmetic is taught.

3.2 Outline of the TC Project

The project was set out in three phases:

**Phase 1: Developing Resources (Term 1)**

In Phase 1 we worked with two teachers who had an expertise in teaching mathematics at KS1. The teachers were identified with support from consultants at Devon Curriculum Services. A research meeting was held with the two development teachers at the beginning of Phase 1 so that they were familiar with the principles of exploratory talk and to discuss how these principles might be introduced with KS1 children. The two teachers were asked to explore strategies to develop talk and to identify teaching strategies to transfer the talk to mathematics activities. Teaching strategies developed by the development teachers were used to introduce exploratory talk to the transfer teachers in the next phase.
**Phase 2: Evaluation and Transfer (Term 2)**

A research meeting was held at the beginning of Phase 2 where the development teachers explained the strategies that they had used in developing talk to the ten transfer teachers. Video material from the two development classes and focus groups were used to illustrate the strategies they had used. The teachers were presented with ideas on how to develop tasks in mathematics at KS1. The transfer teachers used the strategies to develop exploratory talk in their classrooms. They were asked to carry out collaborative talk activities twice a week at least with six focus children in their class. In the second research meeting all twelve teachers were invited to review and share the strategies work they had trialled and where they had adapted them further. At this stage few of the transfer teachers had applied the talk to mathematical activities and further resources for mathematics activities were presented by the research team.

Evaluations of the strategies developed by the development teachers and the transfer teachers were used to develop a resource pack.

**Phase 3: Dissemination**

This phase was intended for dissemination through the following:

- Production of the professional development resource pack
- Design and set up website
- Hold conference with ITE partnership schools in the South West

**3.3 Design of the TC Project**

We felt that the development of such teaching strategies meant a change in the pedagogical approach of teachers. To make this change would require a design based research methodology where teachers were acting as researchers.

**Sample**

The sample for the development and transfer phases of the project were as follows: two development teachers (schools G and L) and ten transfer teachers (schools A – F and H – K). All children were from Key Stage 1 classes. The
number of children within the classes for each year was: Year 1=156; Year 2=108; total N=264.

<table>
<thead>
<tr>
<th>School</th>
<th>Size of School</th>
<th>N in Class</th>
<th>Year Class</th>
<th>Year Focus Group</th>
<th>Teacher Years Teaching</th>
<th>Teacher Age/Specialism Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>54</td>
<td>14</td>
<td>Year 1,2,3</td>
<td>Year 2</td>
<td>21</td>
<td>7-11. Science/PE</td>
</tr>
<tr>
<td>B</td>
<td>~200</td>
<td>27</td>
<td>Year 2</td>
<td>Year 2</td>
<td>8</td>
<td>3-8, History</td>
</tr>
<tr>
<td>C</td>
<td>~250</td>
<td>30</td>
<td>Year 1</td>
<td>Year 1</td>
<td>1 (NQT)</td>
<td>Early Years</td>
</tr>
<tr>
<td>D</td>
<td>76</td>
<td>22</td>
<td>Reception, Year 1,2</td>
<td>Year 1</td>
<td>6</td>
<td>Primary, English</td>
</tr>
<tr>
<td>E</td>
<td>~450</td>
<td>30</td>
<td>Year 1</td>
<td>Year 1</td>
<td>2 (1 year supply)</td>
<td>5-12, Science</td>
</tr>
<tr>
<td>F</td>
<td>~400</td>
<td>21</td>
<td>Year 1</td>
<td>Year 1</td>
<td>5 as primary (secondary previously)</td>
<td>Middle School, Maths</td>
</tr>
<tr>
<td>G</td>
<td>~400</td>
<td>13</td>
<td>Year 2</td>
<td>Year 2</td>
<td>15</td>
<td>7-12, English</td>
</tr>
<tr>
<td>H</td>
<td>280</td>
<td>19</td>
<td>Year 1</td>
<td>Year 1</td>
<td>9</td>
<td>5-11, PE</td>
</tr>
<tr>
<td>I</td>
<td>~180</td>
<td>30</td>
<td>Year 1,2</td>
<td>Year 1</td>
<td>3</td>
<td>Primary, Science</td>
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<tr>
<td>J</td>
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<td>Year 1</td>
<td>Year 1</td>
<td>18</td>
<td>5-11, Maths</td>
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<td>Year 2</td>
<td>Year 2</td>
<td>10</td>
<td>3-8, Geography</td>
</tr>
<tr>
<td>L</td>
<td>485</td>
<td>24</td>
<td>Year 2</td>
<td>Year 2</td>
<td>5</td>
<td>Key Stage 1, English</td>
</tr>
</tbody>
</table>

Table 3.1: Descriptive Data for the twelve schools

The schools ranged from larger urban schools (Schools E, F, G, L) to small rural schools (Schools A and D). Some of the teachers’ classes were mixed years (Schools A, D and I). The experience of teachers also ranged from newly qualified to those with over twenty years’ experience. The teachers were asked to select a focus group of six children, who they saw as lower attaining, from one year within their class. The focus children comprised Year 1=42 and Year 2=30; total N=72.

3.4 Data collection for the TC Project

Both quantitative and qualitative data collection methods were used.
Phase 1
- Pilot of standardised group test in numeracy – whole class
- Pilot of diagnostic one to one tests in counting and calculations – focus groups
- Video material – whole lesson and focus group activities

Beginning of Phase 2
- Standardised group test in numeracy – whole class pre-test
- Diagnostic one to one tests in counting and calculations – focus groups pre-test
- Video of mathematics lesson and focus group – pre introduction of talk

Mid Phase 2
- Review of material from research meetings with teachers
- Video of mathematics lesson and focus group

End Phase 2
- Standardised group test in numeracy – whole class post-test
- Diagnostic one to one tests in counting and calculations – focus groups post-test
- Video of mathematics lesson and focus group
- Teacher interviews

Table 3.2: Summary of data collection methods

Data from the standardised and diagnostic tests were used to monitor learning as a product. The data from the research meetings, interviews and videos were used both to identify strategies for the professional development resource pack and to analyse the change in talk and impact on children’s learning in a qualitative way.

Pre and post tests

The Hodder Progress in Numeracy Test (Education, 2004) was used as a pre-test to set a baseline for the children’s arithmetic attainment at the beginning of the project and was repeated as a post-test at the end of the project. This enabled the identification of standardised scores and number ages. The intention was not to compare this with a control group but to establish if the children made expected progress over the project and potentially where children made greater than expected progress. These were group tests and were carried out by the class teacher with the whole class. Data from two of the schools (School G and School K) are not used as the teachers were unable to carry out the post-tests and one child was absent from the second test, so data was obtained from 59 of the 72 focus group children.
Diagnostic tests in calculations were based on tasks from the Shropshire Mathematics Centre (1996). These tests were carried out on a one-to-one basis with the children in the focus groups pre and post the intervention. As the tests were carried out by two researchers inter-rater reliability was carried out with results from two focus groups (12 children). Children’s responses were audio recorded in order to identify the strategies used. The intention was to investigate the progress in the specific use of calculation strategies were children used more object-based strategies.

It was not possible to carry out the diagnostic tests with all 72 children as twenty children were absent for either the pre or post test. Two children did not want to participate in the post test and for ethical reasons we accepted their refusals. We were able to collect data from 50 children.

Diagnostic tests were also carried out with the Utrecht Early Numeracy Test but it was not possible due to time constraints to carry this out in the standardised form so the analysis is not reported on.

**Teacher Interviews**

Interviews were carried out at the end of Phase 1 with the two development teachers and at the end of Phase 2 with the ten transfer teachers. The interviews were semi-structured and were set around questions related to:

- biographic details of the teacher, details of the school, organisation of the mathematics classes;
- reasons for joining the project;
- evaluation of the research meetings;
- how they introduced talk in their classroom;
- how the use of talk had changed their teaching of mathematics

**Video Material**

Video material had been gathered from the two development teachers’ classes and the ten transfer teachers’ classes. The video material from the two development teachers was intended to be used to provide illustrations of teaching strategies and of children as they approached collaborative talk. Approximately 11 hours of video material was collected from the two schools.
The material was used in the Phase 2 first meeting to provide evidence and illustrations for the ten transfer teachers. Some of this material was used to develop the professional development resource pack\(^1\). The material has also provided some insights into children’s learning and understanding in mathematics. These are reported in the research findings section.

Video material from the ten Transfer Teachers’ classes was gathered for two purposes. First to provide further evidence and illustrations of teaching strategies and children’s learning for the professional development resource pack but also to provide data for analysis of changes in classroom discourse and children’s understanding of mathematics.

At least three whole lessons, including the small group work were video-taped for each of the ten classes; one before the teachers had attended the research meeting, the second shortly after the introduction of talk in mathematics and the third at the end of the project. This happened in all ten classes apart from School C where the final recording at the end of the project was not possible. Also in School K the teacher did not teach whole mathematics lessons so the focus group work was videoed with teacher input when it happened. Further video material was gathered to collect evidence of strategies for the resource pack. Approximately 40 hours of video material was collected from the ten transfer schools.

### 3.5 Ethical considerations

Advice was sought from the University of Exeter, School of Education and Lifelong Learning Ethics Officer and ethical approval was obtained from the School Ethics Committee confirming that the proposed research met the ethical guidelines set out by British Educational Research Association (BERA).

It was intended that the work was carried out by the teachers in the TC project as part of their normal teaching role in the classroom. Voluntary informed consent was sought from the parents and carers of all the children in each class and not just the focus group children. A copy of this statement is in the Ethical Approval form and can be found in Appendix 2. Care had been taken that the children in the focus groups were those that the school normally had consent for

\(^1\) The TC Project resource pack can be viewed at [http://education.exeter.ac.uk/projects.php?id=490](http://education.exeter.ac.uk/projects.php?id=490)
taking visual records such as photographs and videos. Schools were also very aware of the issues of privacy and several schools put up notices on the classroom doors to make parents aware that videoing was happening in the classroom that day.

Children were given a simplified oral version of the voluntary consent statement and their oral consent was obtained. Interviewers were aware of the children’s desires and concerns. There were times when some children did not want to participate in the diagnostic tests. This was respected. Care was also taken not to distress the children at any time. If the children were finding the tests difficult the interviewer would move to other questions or terminate the test.

Data was stored in accordance with the Data Protection Act. All identifying features were removed from the data and pseudonyms used. All data were kept in confidence and not disclosed to unauthorised third parties. The right to publish and disseminate results of the research was agreed at project meetings. Further consent was sought from teachers, parents and children for data disseminated to a wider audience, such as the professional development pack, website and use in conferences. A copy of the letter seeking further consent can be found in Appendix 3.

3.6 Research Findings

Evidence from the teacher interviews indicated that the principles of ET provided an effective model for changing their practice. Teachers stated that this use of talk was different to their normal practice.

Teachers commented that they liked the non-prescriptive nature of the project.

'I didn’t have to follow anything specific, it was about my children and my class, so that was better.'

As such teachers managed the introduction of talk in different ways. Part of the strategy for intervention was that the children worked in triads. In some classrooms the would teacher would focus on just two triads as they worked on an activity, whereas in other classroom the all the children worked in triads. Year 2 teachers were more likely to use triads with the whole class but one Year 1 teacher also managed this.
Teachers commented on some of the difficulties in introducing ground rules for talk, with one teacher commenting how her class would not engage in developing such rules at all. Another teacher commented how her class had related ground rules to school rules such as no kicking or biting. Several of the teachers found that the prompts to ‘agree’ or ‘disagree’ caused problems. Teachers had to emphasise that it was not being unkind or hurtful if someone did not agree:

‘I think the majority of the children are of the opinion that they are right and that any other child disagreeing with them must be wrong. So a tricky concept to grasp.’

The teachers found they needed more time to develop the talk principles and ‘rules for good talk’ in other activities before they applied the strategies to mathematical tasks.

There were also some difficulties when relating the talk to mathematics. One teacher had used published mathematics schemes of work with little success.

‘No they’re not, they’re not built for talk, they’re built for, this is what you have to do, do it by yourself!’

It also appeared that in the classes where the children had been used to working individually the teachers reported more difficulty in encouraging collaboration.

‘...the children adopt a selfish approach to their work. Often they want to show me what they can do they don’t want to help other members of the class’

Despite some of these difficulties teachers commented how the children were more confident and engaged.

‘Yes, they are more confident to ask and question appropriately. And that is across the board, yes, it has been brilliant actually, for this group of children.’

‘I think they’re enthusiastic about the problem solving aspect and I think again that the task we did on Monday was a very interesting one and they were just so buoyed up by solving this problem.’
‘Yes, they’re definitely talking about their maths more, rather than just saying it’s this answer, they’re definitely thinking about what they’re doing more and trying to talk about what they’re doing. I think the quality of the talk has improved.’

Initial analysis of the video material indicated that in most classrooms there was a change in the interactions and eight of the teachers confirmed that they had noticed a change in the talk used in their class. The main observations were that the children worked more collaboratively, were less selfish and were thinking more about their maths.

There was also a change in the teachers’ approaches to managing the mathematics activities. Two teachers stated that they had used larger groups in the past but now realised that the children were not working as groups but as individuals within them.

‘quite often we would do things as a group of six sat around a table, you know, pretty much with me there instigating the talk, you know, sat there in the middle of them.’

One teacher recognised how the approach in the project was different. Whereas previously her focus had been on outcomes now her focus was on the process involved. Another teacher observed that it was not just the children’s talk which had changed but that her talk had changed with more focus on the vocabulary and questions being used.

Six of the teachers felt that their children understood at least some of the rules by the end of the project. Teachers with year 2 classes were more positive than those with Year 1 classes. One teacher commented that the children were using the rules to please her.

‘No I don’t think they really did actually. I think half the time they did it to please me.’

However, all of the teachers were keen to introduce exploratory talk with their new class in the next school year.

**Progress in learning**

Narrative evidence from teachers suggested that the children did make progress in their learning. Several teachers spoke of progress beyond
expectations in their own assessments (teachers in England give an assessment against the standards at the end of each school year). The analysis of the data from the standardised and diagnostic tests provided further evidence that the children made progress in their learning in mathematics.

The progress was measured over one term using the Hodder Progress in Numeracy Tests. These were carried out with the whole class but the data presented is from the focus groups of the ten transfer schools (59 children) (see report in Appendix 1) School K did not complete the post test so there is no comparative data. Data are given based on the chronological age (CA), number age (NA), raw score and standardised score for each child for both pre and post test, along with a National Curriculum Level. A key point to note is that the attainment of fourteen children had been identified at an ‘alert’ level at the start of the project and that this was reduced to five children by the end of the project.

The direction and amount of difference between the CA and NA was found to be an indicator of how the children were attaining against the norm and this is also reflected in the standardised scores. Further analysis has been carried out to investigate progress in learning regarding these two indicators (Appendix 1). Overall the children in the ten focus groups progressed 6 months above the expected progress in number age which suggested that overall children made greater than expected progress. This was not the case with all children but decreases in performance were smaller than increases in performance. It is noted that 25% of the children did not meet the expected progress (14 out of 59 children), so we need to be wary of a homogenous view.

The analysis of the diagnostic tests was carried out according to the principle of change from procedural counting based strategies to object based strategies. The pre and post test calculations were coded in relation to counting or part-whole strategies and compared against each other for each child. Changes in the types of strategies were identified as either procedural based (counting strategies) or object based (part-whole strategies). 74% of the children indicated a change to more object-based strategies, 14% of the children indicated a change to more procedure-based strategies and 12% of the children indicated no change. Six children indicated 70% to 100% change in their use of the
object-based strategies suggesting that they were able to use more object-based methods across all or nearly all the calculations.

The overall percentage change is approximately 30% towards object-based strategies across each calculation carried out by the 50 children who completed both of the diagnostic tests. There is no existing data to compare this with and there is no control group so we do not know if this progress is greater than expected. However it is noted that the children’s approaches to calculations are generally moving towards more object-based strategies.

3.7 Summary
Exploratory talk seemed to be an effective model for the design of the project. The explicit strategies gave the teachers the confidence to change their approach to teaching and the lack of prescription enabled them to adapt the strategies for the needs of the children in their classes. However, the teachers seemed less confident in applying talk to mathematics tasks.

The teachers commented on the impact of the intervention on children’s talk in relation to confidence and enthusiasm. The teachers claimed that the children were talking more about their mathematics to each other. However there was little evidence from the teachers that the children were engaged in reasoning, challenging and justifying that is typical of exploratory talk. Some teachers also felt where children did use the ground rules it was to please them as teachers, rather than in developing reasoning in their mathematics.

Our initial review of the video material had suggested changes in the quality of talk but we had been unable to analyse these systematically. It seemed that there was little evidence of the use of key words associated with exploratory talk and it was difficult to identify constructive arguments or explanations with lexically explicit detail in the children’s talk about mathematics. However from the teachers’ comments and our own observations it seemed that a change in use of talk had happened.

The teachers had experienced difficulties in developing the ground rules with younger children, particularly with the idea of disagreement and there were several instances where children’s talk focused on how the task should be carried out and who was doing what. Some of this became disputational as the
children *squabbled* about taking turns in using the resources, recording or in giving solutions.

Although there was evidence of increased attainment in learning as a product of the intervention, not all children made this progress. There was evidence that a *shift* was happening in the children’s use of strategies but it was not clear how this was happening in viewing the learning in the video materials. Some critical incidents suggested an impact on the learning towards abstraction were found and these examples have been reported in Wegerif (2010) and in my conference papers (Murphy, 2010a, 2010b, 2011a, 2011b, 2012). However this needed more systematic investigation.

Even though there was little evidence of exploratory type talk, the teachers felt that the quality of talk had changed and that the children were more engaged in learning in mathematics. I have been drawn to a comment from one teacher who said “They are definitely talking about their mathematics more”. But what does this mean? Does this relate to the quantity of mathematics talk? Surely just talking more about mathematics does not necessarily mean it will support learning mathematics. The teacher goes on to say “they’re definitely thinking about what they’re doing more and trying to talk about what they’re doing”. Although this did not relate to the notion of argumentation, justification and reasoning that would be expected in exploratory talk; it did suggest the children were engaging with the mathematics.

There was evidence from the video materials and from most teachers that there had been a change in the way that children engaged and talked about their mathematics, but this change did not seem typical of exploratory talk. So what was this change? Was it a change in the quality of talk or was it just more talk? How did this change relate to learning mathematics?

It seemed that this did not happen in all the groups. It is acknowledged that the teachers’ classroom norms and interactions with the pupils would have been factors in the idiosyncrasies of each group and these would need to be taken into account in explaining the contexts of the talk in the different groups. However the main questions remaining were related to the changes in the children’s talk and how these related to the children’s learning.
In the doctoral study I investigated the data in-depth to determine if the changes could be defined. I also aimed to investigate the relationship between the children’s talk and the learning in mathematics. I carried out a systematic analysis of the video data and transcripts from the ten transfer classes, with a focus on the independent pupil-pupil talk only.

The results from pre-and post-tests carried out in the TC Project showed an increase in performance overall. However in taking a heterogeneous and non-technical view of the intervention the interest was also in the social complexities and in understanding how the children were positioned within the learning from a social perspective.

Within this perspective how can we say that the change was effective in supporting learning in mathematics? Was it possible to determine what was happening to the children’s talk and to relate this to learning in mathematics? Was it possible to begin to understand the social complexities in the children’s use of language in learning? Not just to examine how they solved the problem, but what learning was happening. Was it possible to understand why the talk seemed productive in some cases as the children were able to arrive at a solution together and why it was not in others? These questions were beyond the findings of the original research of the TC Project and some answers to these questions would shed light on our understanding of young children’s learning in mathematics through talk.
CHAPTER 4 DISCOURSE AND LEARNING IN MATHEMATICS

4.1 Introduction

Whilst the strategies for developing exploratory talk had seemed helpful to the teachers in developing collaborative group work in the TC Project it was not evident that the children’s talk was characteristic of exploratory type talk. However the TC Project had suggested the children had overall made greater than expected progress in attainment in tests and the teachers were positive that the children were talking more and taking notice of each other’s ideas in mathematics.

So, whilst this suggested there did appear to be a difference in the nature of the children’s talk it was difficult to define it as a type. Attempts at coding sections of the children’s talk in relation to disputational, cumulative and exploratory talk had not been possible. So what was the change in the talk? The other unanswered question was what was the learning and did this change as the talk changed?

In this doctoral thesis I used existing video and transcript data from the TC Project to investigate the independent pupil-pupil talk in order to find some answers to these questions. As stated in the Introduction of this doctoral thesis, one advantage of using existing data was the opportunity to carry out a more in-depth analysis. As one aim of the doctoral study was to examine systematically the changes in the independent pupil-pupil talk, this entailed a more in-depth and systematic analysis of the transcripts from the ten transfer classes. These are presented in Chapters 8-9. In this chapter I review some of the existing literature related to discourse in mathematics in order to develop the research questions for the doctoral study and to explain how they build on our existing knowledge of talk in the mathematics classroom, in particular with young children in learning arithmetic.

Another advantage of using existing data was the opportunity to carry out the analysis from a different perspective. The second aim of the doctoral research was to examine the children’s learning in mathematics and its relationship with the talk and, in particular, if any changes in the nature of the talk had changed the relationship between learning and talk. In this chapter I review literature
related to theoretical and epistemological perspectives in learning in mathematics and explain how I examined the existing data from a different theoretical and epistemological lens. This enabled me to develop research questions that would aim to further our understanding of children’s learning in mathematics.

4.2 Discourse in mathematics education

As considered in Chapter 1, Gee (1996) made a distinction between discourse as a unit of connected speech and a Discourse as a way of behaving, interacting and thinking.

A Discourse is a socially accepted association among ways of using language, other symbolic expressions, and ‘artifacts,’ of thinking, feeling, believing, valuing and acting that can be used to identify oneself as a member of a socially meaningful group or ‘social network,’ or to signal (that one is playing) a socially meaningful role. (p. 131)

This suggests that discourse or talk in mathematics is more than the linguistic terms associated with mathematical objects. Whilst mathematical discussions are seen to involve mathematical objects (such as numbers, operations, geometric features, and functions) and processes (such as generalising, conjecturing, explaining, and justifying), talk in the mathematics classroom involves learning the ideologies associated with mathematics (Cobb, Stephan, McClain, & Gravemeijer, 2001).

Hence discourse practices in mathematics are seen as both social and cognitive (Moschkovich, 2007). They are social as they happen within communities, in the case of this study the community is within a primary school classroom but it could be a community of mathematicians or other professions such as engineers or pre-service teachers. Taking part in these Discourses marks membership of the community. Discourse practices are also cognitive as they involve use of mathematical objects or mathematising, in other words thinking about the signs, tools and meanings of the object. Moschkovich has also indicated that there are multiple Discourses within the different communities, from a more academic, formal Discourse to a more informal spontaneous Discourse. Also, these multiple Discourses are not static.
From a social dimension, children are required to master these different forms of Discourse appropriate to each activity and setting within a mathematics classroom, for example whole class teaching or small group work. They learn to orient to each other, linguistically and socially according to the setting (Kumpulainen & Wray, 1997). Ideologically the children are required to master what Cobb and Bauersfeld (1995a) have called the microcultures or norms of the classrooms. Cobb compared school mathematics, with an emphasis on symbol manipulation acts, and inquiry mathematics, where teachers and children challenge explanations. Cobb et al. (2001) explained how the discourse would be different according to the ideologies and that the discourse in an inquiry mathematics classroom would involve “taken-as-shared ways of reasoning, arguing, and symbolizing established while discussing particular mathematical ideas” (p. 126), and that these would not be the norm in the discourse of school mathematics.

Within this discursive perspective, children learn mathematics by participating in the Discourse, in order to do this they are required to match their Discourse to the classroom Discourse socially, ideologically and cognitively. Learning is seen as participation in a collective practice rather than acquisition of personal knowledge and from this perspective low attainments are viewed as communication failures rather than personal failure in the form of ‘mis-acquired’ representations.

Such a discursive view of learning in mathematics has become prevalent in the research literature in mathematics education. As stated in Chapter 2, there is now a well established and growing field into language and discourse in mathematics education that has examined the role of discourse as a mediator of learning (Vygotsky, 1978, 1986; Wertsch, 1985). These have drawn from both socio-constructivist and sociocultural theories of learning. I deal with these distinctions more thoroughly in the next section but to state briefly here; whilst socio-constructivist theories view mathematical practices and meaning as emerging within classroom cultures (for example, Cobb & Bauersfeld, 1995b) sociocultural theories see the mathematical practices that emerge as socially and culturally produced (Sfard, 2001b, 2008, 2012a).
Within both these perspectives, research into mathematics education has focused on patterns of interaction and the discourse within activities. Most research has been carried out in asymmetrical interactions, that is the research is on talk with a child and a more experienced other. This is still often the case with small group work which is teacher led or where the researcher is involved as a participant. In symmetrical interactions that are characteristic of the talk in peer group talk, children have different opportunities for reasoning about the mathematics. However research in peer group interaction is not so prevalent and, as it had been indicated for the TC Project, little research had been carried out with young children’s peer group interaction in learning arithmetic.

The TC Project’s premise and research methods had been informed by other studies related to exploratory talk. Whilst there had been some distinctions methodologically (as explained in Chapter 2) the study by Mercer and Sams (2006) had been influential in developing the project. Further similarities and distinctions are considered here in identifying how the doctoral research in looking at the data from the TC Project in more depth has approached the study of the children’s talk differently.

Mercer and Sams’ study had determined which groups of children were using talk effectively in problem-solving activities using the computer program Function Machine. As such the talk was related to children’s reasoning in arithmetic as they determined the functions that were used. Exploratory talk was typified by talk that encouraged children to reason and to reach an agreement in solving a problem. If the talk was seen to include evidence of reasoning and agreement then it was seen to be exploratory and hence was effective. The transcripts provided by Mercer and Sams were used to illustrate one group of children (Group A) that did not collaborate effectively (transcript 4, p. 522) and another group that did (Group B) (transcript 5, p.522-523). Indicative of the ineffective talk in Group A was the lack of collaboration in not attending to each other and in not reaching an agreement, in other words the talk was not productive as the children did not arrive at a solution. This is contrasted with Group B which was more collaborative in its approach and the children were successful in solving the problem. These points would seem important, such differences were evident in the TC Project and in the doctoral study I have also
regarded group sessions where the children attended to each other and arrived at a solution as productive.

However there is a danger in leaping to typifying talk in this way in explaining talk that was effective. The explanation for why the talk was effective is given because it resembled exploratory talk and exploratory talk was seen to be effective. This would seem to be a circular argument and does not examine the relationship with learning. Whilst the analysis in Mercer and Sams has looked further at the children’s attendance to suggestions and agreement, the analysis did not consider how or why the talk was effective as the children talked about the mathematical objects, in this case the functions. A more detailed analysis of the nature of the talk in collaborating and in talking about the mathematics would help to move away from such a circular argument.

The talk in Group A was not seen as effective and this would warrant further examination. The comment was that the first group “does not have an effective, shared set of ground rules for productive interaction” (p.523). This seems unsatisfactory as an explanation of what was happening and leads back to the circular argument. Closer analysis suggests that the children did listen to each other but with regard to the turn taking. Although they were not following the ground rules associated with exploratory talk, it seemed that they were following the rules of another discourse. Also it is not clear if any learning took place with this group and if this learning was different to that in Group B. This would determine further the relationship between discourse that involved reasoning and agreement and talk that did not.

From Gee’s definition, one can describe exploratory talk as a Discourse. Whilst it was evident that the children in Group A were not using the ground rules effectively, and the lack of modelling by the teacher could well have been an ideological factor here, there was little explanation as to why the children were having difficulties in adopting exploratory talk as a Discourse. These difficulties would seem to merit further investigation.

Whilst the findings in Mercer and Sams’ study were not inconsistent with some of the aspects of the findings in the TC Project, for example the children’s focus on turn-taking, an analysis according to type of talk would seem to lose the
detail of what was hindering or supporting the collaboration. It would also deny
the opportunity to examine the children’s learning. Analysing the children’s
discourse in more depth, looking at the nature of the talk from both social and
cognitive perspectives would provide further insight into young children’s
cooperation in group work, their discourse in mathematics and the effect that
the discourse had on learning.

Within the first aim of the doctoral study the intention was to focus further on the
nature of the children’s talk. Research on peer collaboration, such as that
described above, focused on effective joint problem solving and but has not
focused so much on the dynamics and patterns of the talk. Rojas-Drummond
(2008) has focused further on the nature of the talk itself in looking at literacy
but this has not been carried out in mathematics. Other studies of children’s
discourse have given further insight and focus on the nature of children’s
learning within their talk. Little of this has been with younger children but there
are aspects that have informed the doctoral study and I present the most
relevant ones.

Sfard and Lavie’s (2005) research was one of the studies that had focused on
very young children and their learning in arithmetic. Their study examined the
discourse of two four year-old children as they talked together in deciding which
box had the most marbles and as they interpreted what the adults were saying
and doing. Analysis of the children’s discourse was on how the children were
making sense of what the adults were saying and how they expressed their
meanings. In particular, they examined how the children used content words
such as ‘more’, ‘less’, ‘bigger’ and ‘smaller’. It was seen that the children’s uses
of the words differed to those of the adults.

Other research had been with older children but was still influential in
developing the doctoral study. Sfard and Kieran’s (2001) study was with two 13
year-old boys and examined the interactive pupil-pupil talk within their
partnership as they worked on graphical representations. The discourse
between the two boys had not seemed effective. Initial impressions were that
little mathematical learning was taking place and this study had been used as
an example in Chapter 2 to indicate that the merits of pupil-pupil talk should not
be taken for granted. Whilst the discourse was not seen as effective, Sfard and
Keiran had felt that the children’s discourse warranted more attention to find out what was meant by effective or ineffective and what was meant by success or failure in communication. Sfard (2000) had been aware of the dangers of using a circular argument. Such a circular argument would be that communication is effective if meanings are exchanged, so if meanings are exchanged then the communication is effective. However they had determined that a more detailed method of analysis would avoid the circularity and focal analysis was used to investigate the dialogue as a multi-level communication. Rather than just seeing where meanings were exchanged the study had considered the focus of the children’s talk. Sfard’s use of focal analysis is discussed further in section 4.5.

Other studies have looked at how helping as a behaviour is productive in peer group tasks (Webb & Mastergeorge, 2003), and that as long as children stay on task and help each other the talk is seen as effective or productive. However Wood and Kalinec’s (2012) study suggested that this relationship between behaviour and the productivity of a group may not be that straightforward and that there are other social issues. Wood and Kalinec examined how talk that was not related to the mathematics may be indicative of what motivates on-task talk. Their study was with a peer teaching session with 4th grade (9-11 year old) children and it examined the utterances that were not about the mathematical objects (subjectifying) and those that were about the mathematical objects (mathematising). Their interest was in how the subjectifying talk played a role in promoting or hindering learning, hence relating cognitive and social interactional issues. Coding according to talk that was on or off task and to different elements of subjectifying, such as identifying or action oriented, were carried out and used to determine the nature of the discourse and if it changed over the lesson. What was found was that learning occurred despite limited mathematising talk. It also determined how children identified as mathematics learners.

Heyd-Metzuyamin and Sfard (2012) study of subjectifying talk, with 7th grade (13 year old) pupils acknowledged the emotional element in the talk. They regarded “cognition, affect and social matters as aspects of the discourse that takes place when people learn mathematic” (authors’ italics) (p.129). They had also found some moments when children arrived at a moment of insight but
where the argument had appeared incoherent. An examination of the mathematical flow of the children's talk was not helpful in understanding how the children's talk had helped them to arrive at a moment of insight. This was consistent with the findings of the TC Project. Although communication may not have been related to mathematical ideas in an obvious way it still seemed that communication was effective. In analysing the mathematical talk they looked at how the focus of the pupils' talk may have been helpful in processing the problem solving.

Whereas exploratory talk studies have demonstrated where the talk was effective or productive they have not helped to determine why some groups do not constitute a productive environment for collaboration and learning. They have not analysed the interpersonal and social mechanisms as well as the cognitive. They also have not fully examined what makes effective or productive communication and how this relates to learning.

From the studies reviewed above in examining children's discourse other aspects such as social and behavioural issues have been examined in order to more fully understand what effective or productive talk might mean in relation to learning. In order to determine the learning the studies have examined the children's focus within their talk. Moschkovich (2007) had stated that two important features of discourse practices were the meaning of utterances and the focus of attention.

In the doctoral study I focused on the functions of the children's utterances, what the purpose of the intentions of their talk was, whether it was within talk about the mathematical objects or talk about the social cooperation within the group. Analysis for the doctoral study was carried out to investigate the nature of children's discourse in independent pupil-pupil talk. What were the children's intentions or the functions of their utterances? This gave a more detailed analysis of the patterns of talk both before the intervention and after. It also gave an analysis of the patterns of talk across the different groups of children.

As indicated for the TC Project little research has been carried out with young children's peer group interaction in learning arithmetic. The TC Project had shown that, following the intervention, there had been evidence of some change.
in the talk but it had not been clear what that change was. The Project had
provided evidence that the intervention had supported attainment in
mathematics by looking at the outcomes of learning. It had also suggested that
there were moments of insight in learning but that these did not seem to appear
within children’s coherent reasoning.

The doctoral study, in taking a different analytical approach in studying the
functions of the children’s speech, enabled a more in depth analysis to be
carried out that could be used to examine the nature of the children’s talk and
how the nature of the talk changed over the intervention. This approach also
enabled an acknowledgement of the social aspect of the children’s discourse. It
gave an opportunity to examine the social behaviour of the children in relation to
group collaboration and in relation to talk about the mathematics.

The doctoral study did consider if the talk was productive. It would seem
desirable that the children arrived at a solution for a problem (even if not
correct) and it would also seem desirable that the children collaborated in doing
this. But this was not carried out by looking for resemblances to types of talk.
This was arrived at through an interpretation of the function of the children’s
utterances and an examination of the patterns of these functions. In some
cases it was then possible to relate the patterns to the resemblance of a type of
talk.

This different approach allowed for the development of research questions for
the doctoral study

- Were there similarities or differences in the nature of talk, both social and
  academic, between different groups of children?
- Were there changes in the nature of talk, both social and academic,
  between the pre-intervention and the post intervention sessions?
- Was there evidence that these changes, both social and academic,
  supported the children in working collaboratively and productively on the
  mathematics tasks?

In looking at collaboration the analysis was loosely based on Gee’s (1996)
discourse theory and the notion of connection building and coherence within a
discourse. Hence to further determine the collaboration the utterances were
examined to determine the sorts of connections that were intended both socially and academically and whether they were helpful in building coherence. This is outlined further in the summary section 4.10 and in the research methods chapter, Chapter 6.

4.3 A shift in perspective: Re-focusing the lens

It would seem that the main purpose of discourse in the classroom is the development of "common knowledge" through interaction in order to support learning (Edwards & Mercer, 1987). So key to the research in the doctoral study was to examine how the children were learning with the independent pupil-pupil talk. In other words, how was this discourse supporting a common knowledge?

In the following sections I explain how this key question is underpinned by theories of learning in mathematics. As I stated in the introduction the use of the existing data from the TC Project had enabled a different theoretical perspective to be taken and I explain the theoretical position that this doctoral study has taken in relation to learning in mathematics, and particularly in learning arithmetic. I also explain how and why it was different to the TC Project.

As indicated in the literature review in Chapter 2, an increased interest in the social aspect of learning has meant that both constructivist and sociocultural perspectives are now accepted as ways to examine teaching and learning in mathematics. As presented in Chapters 2 and 3, the TC project was framed within an integrated approach. A Vygotskyan sociocultural perspective related to the norms of the classroom discourse and a Piagetian constructivist perspective related to the children’s learning.

The theoretical framework of the TC Project was based on an integration of these two theories. Other studies had integrated constructivist perspectives within the social context of the classroom. Much of this synthesis was developed by researchers and theorists such as Cobb and Bauersfeld (1995b) and Cobb (2000). They considered how the social context of learning mathematics is ‘interwoven’ with individual cognitive achievements (Cobb et al., 1994). As such integrated theories recognise the situated nature of cognition and have supported research into the classroom context and social
mathematical norms, and have related this to individual cognition from a Piagetian perspective.

Carrying out a further literature review for this doctoral study led me to question the relationship between learning and talk in an integrated approach. Lerman (1993, 2001) noted that, although an integrated perspective acknowledges the role of the social and learning within a context, this acknowledgement is superficial; it does not account for the behaviours of the individual apart from the classroom social norms. An integrated approach does not ‘privilege the social’ in accessing knowledge, the focus of cognition remains with the individual process of constructive activities (Lerman, 1993, 2001). In an integrated approach communication and language have “no power to enculturate or to position individuals” (Lerman, 1993, p. 22). Propositions that relate to sociocultural Vygotskian theories see the role of language as central to learning and that human consciousness and knowledge is fully cultural and social (Lerman, 2001).

The perspective taken for the TC Project was to examine how the talk instigated an individual shift in perception of a mathematical object through Representational Redescription (Karmiloff-Smith, 1992). Piagetian theories are seen to relate to learning as an individual’s “inner change” (Sfard, 2012a, p. 2) and Karmiloff-Smith’s notion of Representational Redescription was concerned with the individual’s representation of mathematical objects, an ‘inner change’. Within a social constructivist approach the role of the talk was acknowledged but the focus of cognition remained with the individual child. It may have acknowledged talk as a social aspect of learning but did not view learning as social.

In order to view learning as social required a shift in the theoretical perspective from the TC Project and to re-focus the relationship between learning and talk, where the learning is social. I think there are two ways of looking at this relationship. The first is how individual inner change happens through talk (learning through talk) and the second is how the talk is the learning (learning in talking). The first would relate to Karmiloff-Smith’s neo-Piagetian theories and the approach of the TC Project. Talk is seen as a way of bringing about individual constructions. The second would relate to Lerman’s proposition that learning is
intrinsically social and cultural and that language is central to this. These ideas are related to Seeger’s (2011) proposition that “we do not understand through discourse”, but that “we understand in discourse” (p.217). This is the perspective that is taken for the doctoral study.

The re-focus on the relationship between talk and learning has provided a new lens that is underpinned by a fuller or more thorough social perspective (Ernest, 1999). From a social perspective mathematising is viewed as social. Understanding mathematics involves active engagement in problem solving and it is historically evolved from solving practical problems in the real world (Freudenthal, 1983). Based on the ideas of Lakatos, Ernest (1991) has proposed that mathematics knowledge is generated by a social mechanism. Therefore if cognition is social and knowledge is socially constructed then mathematics itself is social, suggesting a cultural ontological position as well as a cultural epistemological position. As such not only is cognition regarded as social but mathematical knowledge itself is regarded as social (Ernest, 1991).

From this it is seen that the basic tenet of a social perspective is epistemological and ontological in that knowledge and, hence mathematics, are social and cultural. Philosophical positions for the doctoral study are considered further in the Methodology (Chapter 5), but here it is acknowledged that traditional constructivist views of mathematics relate to a different onotological and epistemological position to social views of mathematics. The Piagetian prioritisation on the individual as a cognising subject relates to a view of knowledge as objectivised and detached from the knower. Vygotskyan prioritisation is on social experiences as having an essential role in the growth of knowledge; as Ernest (1991) has suggested the mind is social and conversational (Ernest, 1993). As such there are epistemological tensions in integrating constructivist and sociocultural perspectives (Ernest, 1999; Lerman, 2001).

Ernest made this distinction clear in defining a more thoroughly social perspective; a social constructivist rather than a social constructivist perspective. Ernest used italics to indicate a shift in the emphasis. Lerman has also emphasised a thoroughly social perspective and developed his view of a discursive psychology, originally phrased by Edwards and Potter (1992), where
communication is seen to have power in learning. Re-focusing on such a social position would provide a lens for examining the talk as a social force in mathematising. In other words the mathematical thinking of an individual child, the organisation of mathematical tools and abstraction, would be seen essentially as a social change and not an inner change. In re-focusing the theoretical perspective the doctoral study takes a different approach to examining the learning of the children within the independent pupil-pupil talk in this case in relation to a social view of mathematising.

4.4 Defining the sociocultural view of the doctoral study

The theoretical perspective for the TC Project had been informed by my views of learning in mathematics developed from my initial training and practice as a classroom teacher that has since been rationalised through my research in mathematics education. Whilst the focus on use of talk and communication related to the social context of learning and the mediation of language from a Vygotksyan perspective, a key aim of the TC Project was how mathematical learning was supported through the pupil-pupil talk. In focusing on the learning of an individual the theoretical perspective was related to the construction or acquisition of concepts. A view of individual learning from a traditional Piagetian perspective relates to knowledge that is personally constructed where the teacher's job is to facilitate a child's personal construction of knowledge. Hence the theoretical perspective of the TC Project related to the social context of talk in small collaborative groups and how this could facilitate children in the personal construction of concepts.

My early research in mathematics education was concerned with children's development of calculation strategies and I had related this to the children's learning in arithmetic for the TC Project. Based on Gray and Tall's (1994) work, the interest was in how children moved from a procedural use of number to a proceptual view. As described earlier, this was related to Karmiloff-Smith's (1992) theory of Representational Redescription. However initial reviews of critical incidents from the video material did not make sense in relation to a proceptual view or Representational Redescription. It was not possible to see how the children's gestures in pointing and their repetitions of counting processes could reflect development of proceptual understanding. Instead it
seemed that, rather than using the talk to *redescribe* representations, the talk was a mediator in exchanging meaning of *what was going on* as the children worked and talked together. This suggested that a view was needed that underpinned the children’s individual learning as both participative and cognitive, not in a complementary way but as intertwined. That is to look at individual cognition from a Vygotskyan sociocultural perspective, where the origins of thought are seen as social and language is central to learning (Wertsch, 1985).

A change of theoretical orientation towards Vygotskyan theory enabled the examination of the children’s learning in this doctoral study to move away from Piagetian and social constructivist theories of learning. In order to consider the individual’s psychology from a social perspective I turned to Vygotsky’s (1986) ideas of concept formation. Vygotsky’s theory of concept formation referred to higher functions as “internalized relations of a social order, transferred to the individual personality” (p.58) and that, even when internalised psychologically, higher functions are still quasi-social. The notion that anything psychological has been at some time social and cultural provided an insight into how participation in talk is related to cognition from a sociocultural perspective.

> *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 attention, to logical memory, and to the formulation of concepts. All the higher functions originate as actual relations between human individuals* (Vygotsky, 1978, p.57)

Whilst socioculturalism has a basis in the Vygotskyan notion of language as mediation, there is now a wide theoretical field with a range of views that attend to different aspects of social and cultural learning. In order to frame the theoretical perspective of the doctoral study it was necessary to define more closely the aspects of social and cultural learning that I would focus on. In developing the focus for the doctoral study I present a particular view that has drawn on two aspects of sociocultural theory, semiotic mediation (Radford, 2002) and Systemic Functional Linguistics (SFL) (Halliday & Matthiessen,
2004), as a way of examining the emergence of concepts where language is a resource for meaning making. Whilst my view has drawn specifically on two aspects of sociocultural theory, I acknowledge that my view is also related to aspects of the wider field.

In order to illustrate why I have focused on certain aspects I have attempted to classify sociocultural approaches at four different levels of perspective. I have used these levels of perspective to make sense of how I understand some of the different sociocultural views and how I understand my view as distinct from these. I accept that there could be other ways to develop levels (for example Hwang and Roth’s (2011) conceptual levels) and I also accept that the theoretical views that I have included in these levels are not an exhaustive list.

At the first level of perspective I place aspects of sociocultural theories that attend to ontology and epistemology in seeing mathematics as a cultural historical discipline. Theorists such as Bishop (1988) and D’Ambrosio (1985) in the 1980s promoted a cultural metaphor in mathematics education that acknowledged the social dimension and the cultural nature of mathematical knowing. Such cultural learning theories relate to learners becoming mathematical by participating in a discourse (Gee, 1996) or in communities of practice (Wenger, 1998). At this level of perspective a social view of learning represents becoming a certain type of person in belonging to a cultural community. Knowing mathematics is knowing ways of talking, knowing how to talk about mathematics and mathematical objects, that is “knowing one’s way around the world” of mathematics (Hwang & Roth, 2011).

In the second level of perspective I place aspects of sociocultural theories that attend to how learning takes place in complex social environments, such as a classroom. In these environments learning is concerned with interrelationships within the discourse of mathematics and how this discourse relates to the norms of the mathematics classroom (Cobb & Bauersfeld, 1995a). Within this second level of perspective I also place aspects of theories that see learning as situated within a context (Lave, 1988). It could be said that the intervention aimed at this second level of perception as the introduction of exploratory talk situated the children in a particular context of learning. By encouraging exploratory talk, we were changing the classroom norms and the situation in which the children
were learning. The changing classroom norms would have been a valuable area of study but would not have met the aim to examine the learning of mathematics in the talk.

Aspects of sociocultural theories that I have placed at the first and second levels of perspective are important in recognising the cultural nature of mathematics and mathematical learning as well as the complex and situated contexts of learning. Knowledge is participatory and mathematisation is situated within the talk in a concrete setting (Sfard, 1998, 2012a) but, also within this participation model, learning relates to belonging to a community (Lave & Wenger, 1991). Whilst the participatory and situated views acknowledge that learning is something that individuals do, they do not provide a way of examining individual learning or individual cognition. In order to understand how an individual learns in a socially situated context, further interrogation was needed of how children were making sense of the mathematics whilst participating. Hence a different perspective was needed.

In the third level of perspective I place aspects of sociocultural theories that focus on the individual in relation to the structure of society; that is the community of practice or discourse of mathematics. These aspects of theories examine the relationship between the structure of society and an individual’s agency within this structure, where the structure is often seen as dominant. Ernest (1995) defined agency in relation to learning mathematics as “the central capacity all human beings have for initiating (and continuing) activities, including the possibility of inaction” (p.27) and acknowledged that learners understand in their own ways and bring “their own capacities for meaning making” (p.27). These capacities are historically formed and relate to a “sense of self”. This has introduced a way of knowing that is subjective, and relates to the notion of identity. Drawing on work by (Holland & Lachicotte, 2007) and (Bernstein, 2000), Lerman (2012) defined identity as a “sense of oneself as a participant in the social roles and positions defined by a specific, historically constituted set of social activities” (p.103). The role of agency and identity have been examined by theorists such as Boaler and Greeno (2000), in relation to discursive practices in mathematics classrooms, and by Wenger (1998) who has defined identity as becoming part of the community of mathematics; the way we define
ourselves and how others define us. Hence the notion of agency relates to subjectivity in examining the relationship between the individual and the structural organisation of the community of mathematics and educators.

In this doctoral study identity and agency are seen as intrinsic to sociocultural theories in positioning children within the discourse of mathematics, and agency could have been a valuable area of study. However the TC Project had not aimed to investigate agency and identity and it was felt that, without an initial focus, an examination of the data in this light would not be valid. For example no data had been collected that would have allowed for analysis of student voice. I later come to realise that agency may well have been a player in the development of pupil-pupil talk. I consider this potential focus on agency further in the conclusion chapter, but it was not a direct focus of the TC Project and hence not of the doctoral study. The other reason for not focusing on agency and identity was that, whilst this would have provided for a study of an individual within a socially situated context, the individual’s relationship with knowledge is subjective. Such theories would not seem to help in focusing on how the children were making meaning in the socially situated context.

In the fourth level of perspective I have placed sociocultural theories that attend to the emergence of concepts in relation to language and communication. Such emergent theories offer another sociocultural view of the individual within mathematics education. I refer in particular to Sfard (2008) (discursive theory), Radford (2006) (social and cultural semiotic mediation theory), and Seeger (2011) (emotional and relational theory). Whilst these three theorists have approached emergent theories differently, a basic tenet of emergent theories is that learning mathematics is not just about communication with mathematical objects but that mathematical objects are produced as referents through communication and mathematical practices.

The aim of the TC Project and the doctoral study was to examine the mathematical learning that took place in the talk. This aim required a focus on the individual cognition in relation to the talk but not from a traditional acquisition view of learning or container metaphor. This aim required an approach that would underpin an examination of how an individual made sense or meaning of cultural knowledge within a situation; how an individual acquires an
understanding, not as fixed or contained but as a sense of what is happening in the situation. Such an approach would recognise that participating in an activity involves mutual construction of cultural knowledge but that ultimately the understanding, or sense making, is individual. Further to this, and in relation to mathematising, an approach was required that helped to see how the sense making was becoming mathematical. An emergent theoretical perspective would seem to support this in examining how concepts are mediated socially and semiotically. However as the intervention had targeted the children’s use of talk there was still a need to look more closely at the language of the children, how this changed, and if this change then suggested a change in the way the children were making meaning of the mathematics they were working with.

There was a need to examine more closely the language in the learning and to focus on the use of language itself. Hence the approach would relate to the discipline of linguistics. The use of linguistics adopted for this doctoral study is not based on a Chomskyan view of language as an innate system (Chomsky, 2006) but from Halliday’s view of language as embedded in cultural acts and as a mode of behaviour (Halliday, 1978; Halliday & Matthiessen, 2004) and from Gee’s (1996) use of language in developing cohesion in a discourse. Halliday’s SFL and Gee’s discourse theories are about achieving cultural and social purposes through language, where language is seen as a meaning-making resource. Whilst the analysis of the study is on the use of children’s grammar it is not looking at grammar from a formal perspective but as a function of language, how language gets things done, and hence is an insight into how language works within a culture or discourse.

The use of SFL and the emergence of concepts suggested a focus on the functional use of the children’s language (both verbal and gestural) in relation to meaning making in learning mathematics. In further zooming into this focus the use of deixis in particular gave an insight into how the children were developing coherence, making meaning and relating to mathematics as social and cultural. Like the convergence of rays of light from different angles, these perspectives came together to shine on the children’s use of pupil-pupil talk to examine the sense they were making as they worked together.
In sum, the particular sociocultural view adopted for this doctoral study has been developed from a Vygotskyan notion of concept formation and integrates social semiotic mediation with sociocultural linguistic perspectives. As such it is distinct from other sociocultural theories. I have attempted to classify some aspects of sociocultural theories into different levels of perception in order to support my understanding of the differences between these aspects and how my view is distinct from these. The theoretical view of the doctoral study related to the fourth level of perspective as the social learning of an individual’s cognition, and to the functional use of language in meaning making. This view is not dichotomous as social or cognitive, but is a view that intertwines both social and cognitive and provides a possible way of looking at children’s learning in mathematics and the relationship with talk.

### 4.5 Mathematising and meaning

A key tenet of the TC Project had been that the children made sense of the mathematics that they were involved in and it was important not to lose sight of this in the doctoral study. As Seeger (2011) has stated:

> Teaching students to make sense of mathematics and helping them make sense of mathematics by themselves seem of overriding importance to mathematics education in theory, research and practice. (p. 215)

In order to engage children with mathematics, early calculation problems are presented in practical real world contexts. Young children may see these as very different problems and solve each one within the context set (Carpenter, Fennema, Franke, Levi, & Empson, 1999). Different problems may relate to different activities as far as say addition and subtraction are concerned. In order to solve these problems within each context, different actions are carried out.

Different problems provide different contexts so the child’s formation of a mathematical description is based on a specific context. The child may be able to use the mathematical descriptions to suit the different problems and use mathematical tools or objects to solve these problems but is not yet able to abstract a concept of addition or subtraction.

Cobb and Bauersfeld (1995a) in comparing classroom norms had considered how school mathematics could emphasise symbol manipulation acts that the
children could not use or relate to different contexts. Children learn to manipulate the signs, carry out procedures but with little *meaning* of what they are doing mathematically. Such a phenomenon has been recognised and theorised from a long-standing perspective and at least as far back as Skemp (1976) in defining the distinctions between relational and instrumental understanding and further with Hiebert, Carpenter, Fennema, Fuson, Wearne, and Murray (1997) and the notion of making sense as relational, that is connecting ideas in mathematics, seeing the relations between mathematical ideas.

However a lack of relational understanding or connectedness of ideas seems to be inherent in children’s work in different contexts. As stated above, the problems young children engage in are related to practical real world contexts or everyday knowledge. In seeing the mathematics within an everyday practical context the child transcends the everyday and discovers the mathematical tools to solve that particular problem. The child forms a mathematical description for that problem (van den Heuvel-Panhuizen, 2003). In solving a particular problem the child may have transcended the everyday but may not have abstracted a concept of addition or subtraction that transcends the context.

Treffers (Treffers, 1987) has defined these different levels of transcendence as two ways of mathematising. *Horizontal* mathematising is seen as moving from the world of life to the world of symbols. How a child discovers and uses the mathematical tools and symbols to solve a particular problem. *Vertical* mathematising is then seen as transcending the context, as moving within the world of mathematical symbols. This suggests a two-step process. The first step is from the real world to mathematical tools and symbols, and the second step is from the mathematical tools and symbols used within different contexts to abstractions or mathematical objects.

An understanding of formal arithmetic entails vertical mathematisation, that is the second step, and this comes from “generalising and formalising situation-specific problem-solving procedures and concepts about a variety of situations” (Gravemeijer, 1997, p. 329). Concepts such as addition or subtraction are generalised from a range of contexts. In order to arrive at the concepts the child is required to abstract the commonalities from the different contexts and to
reorganise mathematical objects, such as numbers and operations, into a coherent esoteric system. The generalisation transcends the different processes used in the context of the different problems to arrive at a concept that can be used in a general, abstract or formal way. The use of this concept becomes an object itself; it is *reified* or *objectified*. The abstract concept becomes concretised.

In the TC Project objectification had been related to the notion of a *conceptual shift* as a theoretical model based on the constructivist notion of a *procept*, the duality of process and object and the child’s inner organisation of this. With the move to a theoretical underpinning based on the social notion of learning in the doctoral study, the idea of a *conceptual shift* that had been theorised in the TC project would need reformulating. The TC notion of *conceptual shift* was seen as an individual, inner change where talk was part of the mechanism. In order to examine learning from a thoroughly social position objectification would need to be seen as social and cultural. In order to understand how sociocultural perspectives relate to objectification I refer to those theories that have been upheld for constructivist perspectives and then compare them with more recent theories related to sociocultural perspectives.

### 4.6 Objectification from a Piagetian perspective

From a Piagetian perspective a child would be seen to abstract the commonalities through reflective abstraction where a concept is derived not from the perceptual properties of objects but from the properties that were introduced by previous actions upon the objects (Piaget, 2001). Different word problems relate to different actions upon objects. Abstraction is through reflection upon the properties of the actions and a “gradual realisation that the physical properties of objects are unimportant to their function in logico-mathematical operations” (Walkerdine, p. 119). A problem such as $3 + 4 = 7$, that could be derived from different contexts comes to be seen as a formal $A + B = C$ statement.

A learner is seen to move through layers of reflective abstraction. An operation on a mental entity becomes in turn an object for reflection at the next level, allowing for further mental operations (Gray, Pinto, Pitta, & Tall, 1999). Hence
mathematical understanding is derived from interiorised actions where children’s experiences are re-represented at abstract levels. Thought is raised to a re-representational level from the coordination of actions. The role of talk and language has been seen as important in relation to abstraction and re-representation. Karmiloff-Smith’s (1992) notion of Representational Redescription explained how children learn to translate representations in one context to representations in other contexts, enabling the development of more generic schema. Verbalisation supports the redescription and re-representation at more abstract levels.

Key to the Piagetian perspective is the individual’s realisation of logico-mathematical operations to arrive at an understanding of a set of structures or ‘correct’ versions of mathematical ideas. In relation to Sfard’s (1998) ‘acquisition metaphor’ (AM) the notion of reflective abstraction suggests that a learner acquires information that is stored in the mind as representations or a schema. A schema is a personalised, individual version that can differ from the ‘correct’ version. Understanding is seen as the revision and modification (or assimilation and accommodation) of a personalised version (or schema) towards the acquisition of the ‘correct’ version.

Talk and communication within the classroom becomes important in revising and modifying schema. The teacher is seen to provide cues about the appropriateness of answers and to support children in developing their personal representations towards the ‘correct’ one. Classroom discourse and pupil-pupil talk may be seen to provide ‘cognitive conflict’, an opportunity to ‘test out’ ideas in relation to the correct version. As knowledge is acquired, communication is seen as a window to the inner mind (Lerman, 2001) to look at the information stored as representations, to examine the individual’s schema and to determine how well the individual is acquiring the ‘correct’ version.

In this perspective vertical mathematising is an inner cognitive process that relies on reflective abstraction. The child has an inner meaning of the mathematics. To abstract the concept of addition and subtraction the focus is on the logico-mathematical ideas that are presented within the actions. Language is seen to have a key role here; first through verbalisation in the translation of representations and second in ‘testing out’ ideas against the ‘correct’ versions.
or logico-mathematical structures. As such social aspects such as classroom norms become important in considering how well the representations are 'tested out' or examined but the social aspect is not a force in the notion of abstraction. There is at first an inner individual organisation before ideas are taken into the social sphere. Meanings may be negotiated socially but they are to test out abstractions that have occurred first in the individual.

4.7 Objectification from a Vygotskyan perspective

Horizontal and vertical mathematising within a social perspective happens at first in the social sphere. That is objectification and the arrival at formal arithmetic is essentially social and “communication drives conceptualisation” (Lerman, 1993, p. 23). Vygotsky’s social perspective is informed by his theory of the formation of concepts. This theory identifies scientific concepts as the pre-existing social, cultural or institutional knowledge associated with a discipline such as mathematics. Scientific concepts are higher order concepts and are differentiated from the lower order, spontaneous concepts that are grounded in everyday experience. In common with a Piagetian perspective, instantiation of scientific concepts requires higher level thinking and abstraction. However within a social perspective, scientific concepts are cultural, hence a child instantiates the knowledge of their culture and this happens through communication and language. A sign or word embodies a generalisation or a concept that relates to social or cultural knowledge. Words already have a meaning in the adult world. A child is seen to negotiate this meaning, to determine the sense or significance of a word, and to instantiate the concepts that are embodied within it, and so language leads learning.

*Knowledge isn't in the individual’s mind, nor 'out there' in objects or symbols. Knowledge is as people use it, in its context, as it carries individuals along in it and as it constructs those individuals. Knowledge is fully cultural and social, and so too is what constitutes human consciousness.* (Lerman, 1993, p. 23)

In this way individual cognition is social and conversational (Ernest, 1991, 1998). Spontaneous concepts are based on intuitive or embodied knowledge that can be gained through experience with the world. Such intuitive knowledge can be defined as tacit knowledge that is implicit, ‘personal’ knowledge
(Polanyi's (1962) definition); what we know but what is hard to explain using language. Scientific concepts relate to propositional knowledge; explicit knowledge that can be declared or expressed in a language. Cultural knowledge is knowledge that has been transmitted to another cognising being. In order to transmit knowledge it has to become explicit or propositional. Hence in the learning of formal arithmetic, tacit or personal experience of the world becomes mathematical when there is social or cultural transmission of (explicit) knowledge. Within their play children may be joining groups of objects or partitioning sets but they are not aware of the cultural meaning or significance of the processes that they are carrying out. These processes are not seen as addition or subtraction until cultural awareness is raised.

In raising cultural awareness within a practical experience the children access the meaning of the formal cultural knowledge. Gee's (1996) definition of a meaning as “a product of the bottom-up action and reflection with which the learner engages with the world and the top-down guidance of the cultural models or theories the learning is developing” (p.50) further relates to the Vygotskyan theory of concept formation and suggests that meaning can be seen as the product of bridging between the tacit, embodied knowledge of the experience and the propositional or conceptual knowledge that is transmitted within a learning experience. Gee also proposed that meanings are situated as they “don’t just reside in individual minds; very often they are negotiated between people in and through communicative social interaction” (author’s italics) (Gee, 1996, p. 52). Hence meaning is situated within the experience and within the transmission of knowledge. That is, it is situated within a context and within communication.

Therefore within the theoretical framework for this doctoral study an understanding of formal arithmetic is arrived at through abstractions of commonalities and reorganisation of mathematical objects and these are mediated socially, through language. In using the term language I refer to multiple meanings; spoken, gestures or symbols, and also refer to inner and public speech. Within this theoretical framework, mathematical knowledge and hence formal arithmetic is cultural. In order to access formal arithmetic the child
accesses the meaning, where meaning is seen as the product of the bridge between tacit embodied knowledge and cultural explicit knowledge.

In accessing a meaning, the child is determining what is significant or what is important to focus on. Within a Piagetian perspective this focus is based on logico-mathematical functions where these functions are seen as absolute, objectivised and detached from the knower and objectification happens first internally. Within a social Vygostkyan perspective this focus is based on mathematics as social, historical knowledge and the focus is made explicit as children engage in mathematical experiences. The use of language and signs (semiotics) in problem-solving situations direct the learner’s attention to what is important to focus on. Semiotic mediation, or mediation through language and signs, continues to modify a concept.

A concept emerges and takes shape in the course of a complex operation aimed at the solution of a problem... A concept is not an isolated, ossified, and changeless formation, but an active part of the intellectual process, constantly engaged in service communication, understanding and problem solving. (Vygotsky, 1986)

From this perspective horizontal mathematising (working within the context of the problem) and vertical mathematising (abstracting generalities across contexts) happens socially, through mediation of language, where language is seen as words, symbols and gestures. Ryan and Williams (2007) have regarded a Freudenthalian shift as a shift from the everyday problems to the children’s organisation and use of mathematical tools where this is mediated socially. A shift from the everyday world to the social cultural world of mathematics and the signs and concepts associated with organising and using mathematical tools. So a conceptual shift from a thoroughly social perspective could be presented as a Freudenthalian shift.

Meaning or making sense has been related to the idea of mathematising both horizontal and vertical and a social perspective is related to mathematisation as being mediated through language. I explore the social perspective of mathematisation further in the next section in relation to objectification and meaning making.
4.8 Meaning and objectification

“By virtue of participation in a culture, meaning is rendered *public and shared*’ (Bruner, 1990, p. 12) (author’s use of italics)

Gee’s (1996) theory of situated meaning suggested a cultural view of meaning as the product of ‘bottom-up action and reflection’ with the ‘top-down guidance of cultural models’. Gee (1996) proposed that the human mind is a pattern recogniser and builder. Sociocultural practices guide and norm the patterns. Learners may have their own agency from their own experiences but these patterns are normed within a discipline as patterns are recognised by others as important within that discipline. Meaning is “*situated* in specific social and cultural practices and is continually transformed in those practices” (p.63).

Mathematics is a specific social and cultural practice. If meaning making is seen as making sense of something within a social and cultural practice then the child needs to know, what is significant or important to focus on. The specific social and cultural practice of mathematics is the top-down guidance to indicate what is important within mathematics to norm these patterns. The cultural practice of teaching mathematics is where meaning is ‘rendered public and shared’.

Key to mathematisation is the use of mathematical objects at a horizontal level in the use of tools to solve a problem and at a vertical level in objectification. Font, Godino, & Gallardo (2013) have defined a mathematical object as “any entity which is involved in some way in mathematical practice or activity” (p.108). That is, anything that is used to solve a problem in a mathematical way.

Although a wide definition an object has to be something that can be individualised into such entities as properties, representations or processes. Within a social perspective these objects are seen as “socially shared cultural entities” (Godino, 1996, p. 419). In using a mathematical object with meaning then there is a reified view. In other words meaning is not the property (for example an odd number) or the process (such as addition) but the reified use of that property or that process that is seen as using an object with meaning.
From the theorisation above, reification is seen as social and cultural. Based on Gee’s theories, meaning is the product of top down cultural guidance, that is normed by a particular practice and happens through communication. In this case the practice is mathematics and key to mathematics are the processes, concepts, and so on, that are used to solve problems or to generalise within the world of mathematics. In abstracting generalities a child needs to know which commonalities to focus on. In seeing meaning as situated the focus is on what is significant both within a context and within the culture of mathematics and what is significant is mediated through language (including gestures and signs).

In this doctoral study the aim is to examine the children’s learning in the independent pupil-pupil talk from a social cultural perspective. In order to do this, I did not look at how a child’s representation compares with an absolute view of a mathematical representation. I looked at how the children communicated meaning to each other. A key consideration was how the meaning was mathematical. In other words how the meaning was normed by the cultural practices of mathematics. That is how children saw what was culturally significant in the mathematical objects and how they conveyed this significance in their talk.

In order to inform my examination of this I turned to emergent theories. Such theories have been recognised in relation to the role of language and communication in the understanding of mathematics and have become more established in the last decade or so. I refer in particular to Sfard (2000, 2008) (discursive theory), Radford (2006) (social and cultural semiotic mediation theory) and Seeger (2011) (emotional and relational theory). Whilst these three theorists have approached emergent theories from different perspectives, a basic tenet is that objectification is not just about communication with mathematical objects but that mathematical objects are produced as referents through communication and mathematical practices. Further to this the mathematical objects are cultural.

Sfard’s (2000) social perspective in relation to the “developmental priority or communicative public speech over inner private speech” (p.296) led to a re-examination of the process-object duality that had been part of the Piagetian tradition. In so doing Sfard (2008) related communication with the mechanisms
of human thinking and developed a complementary theory of mathematical thinking as communication or discourse. Mathematising is seen as communicating about mathematical objects (Einaï & Sfard, 2012), objectification is discursive, and so, from Sfard’s perspective, mathematical learning is seen as change in discourse.

Sfard (2012a) proposed two levels in objectification; an object level in exploring mathematical objects and an objectifying or reifying meta-level. These two levels seem consistent with the notions of horizontal and vertical mathematisation, however Sfard interprets these discursively. The meta-level constitutes reflection on existing discourse. New mathematical objects instigate this reflection on existing discourse, for example the introduction of negative integers, instigates a reflection on positive integers. Reflecting on an existing discourse involves a discursive change or vertical development. To this end, horizontal development combines existing but separate discourses and vertical development leads to higher discursive levels. Within Sfard’s theory objectification or reification is a discursive construct. Higher discourse levels require compression of the discourse, in other words saying more with less. For example multiplying 2 becomes both the operation and its result, that is, it is reified. As in Treffers’ (1987) notion of mathematising, learning in mathematics is a combination of vertical and horizontal developments, within Sfard’s theory this learning is discursive.

Sfard’s discursive theory has brought together the ideas of cognitive reflection and social communication that had previously been seen as distinct in Piagetian theories. Reflection is not seen as an internal construction of an object with an external existence. Reflection is seen as a change in discourse resulting in a compression or reification, hence reflection is social, it happens in communication.

Such a theory is not inconsistent with the theorisation that frames this theoretical study in that horizontal and vertical developments are viewed socially. However, whilst the emphasis is on discourse (Sfard acknowledges that discourse or communication is not just verbal but includes gestures and signs) the theory does not emphasise the notion of meaning as a product of tacit experience (the bottom-up action and reflection) with the explicit cultural
knowledge (the top-down cultural guidance). That is not to say Sfard’s theory does not include this notion of meaning, just that it does not emphasise it.

Sfard’s theories have acknowledged emergence of mathematical objects through the discursive processes that underlie mathematical problem solving. In doing so she has examined communication in relation to exchange of meaning (Sfard, 2000) and has pointed to a potential problem of seeing meanings as well-defined, object like entities that can be exchanged. Rather than looking at communication as exchange of meaning, Sfard used the notion of discursive focus. The clarity of discursive focus is related to how much the participants have a common focus or are referring to the same thing.

Sfard (2000) recognised that the idea of a common focus is problematic in that “focus is an interpretive concept and that it is up to an interpreter to decide what should count as a focus of a given utterance” (p.304). This nuance has provided a further consideration in how children share meaning. In making an utterance a speaker is indicating what is significant, that is they are giving an intention. The word intend comes from the Latin intendere which means to direct attention and so an intention can be defined as a product of attention. So if a child is listening to another child they are directing attention by interpreting a focus, that is, what was intended.

Seeger (2011) had related meaning making to the shared intentionality that happens within practice and stated that meaning “can be understood as the intentions that we want to convey” (p.40). As with other emergent theorists, Seeger saw social meaning as “the precursor to the conceptual, individual meaning” (p.209) but also related this to an ecological approach. Seeger posited that meaning making or shared intentionality is part of the common ground of communication and that shared intentionality relates to empathy, reciprocity, and cooperation as part of human development from birth. In relating to reciprocity Seeger noted turn-taking as a crucial feature of exchange both of verbal and non-verbal communication and how gestural and expressive interaction happens long before a child starts to learn to talk.

Within this emotional perspective of communication, what is intended by someone is a subjective construct and interpretation relies on a “perceptual
sensitivity to others” (Seeger, 2011, p. 208). If the idea of a discursive focus is in giving an intention, then this is a subjective construct and interpretations of a common focus or meaning can be seen in relation to personal, emotional and perceptual sensitivities.

Radford (2006) proposed that intentions can be seen as a two-sided coin. On one side is the subjective construct “the subjective content as intended by the individual’s intentions” and on the other side is the cultural construct where the intended object “has been endowed with cultural values and theoretical content” (p.53).

Within this two-sided perspective, the outcome of objectification is a personal object but in making meanings both subjective and cultural constructs are conveyed. Sharing intentions relates to directing attention to what is seen subjectively as significant by the speaker but meaning is related to attending to what is significant culturally. “It is in the realm of meaning that the essential union of person and culture, and of knowing and knowledge are realized” (Radford, 2006, p. 54). Whereas intentions are two-sided, meaning is ‘intrinsically cultural’ (p. 53).

As proposed earlier, mathematical objects are conceptual objects that are generated in activity. If mathematical objects are conceptual abstractions then they cannot be seen. Radford’s (2006) theory of the semiotic means of objectification, relates to the signs (symbols, words, images, and so on) that represent the conceptual objects. As mathematical objects are cultural, so the meanings of the signs are cultural. In giving meanings to conceptual objects we use language, signs and gestures as well as concrete and visual representations. Hence in objectification the child is attending to a culturally endowed meaning that is “reflected or refracted in the semiotic means to attend to it” (Radford, 2006, p. 53), where this meaning is mediated socially and semiotically.

4.9 Refocusing to define the research question

Refocusing the theoretical perspective for the doctoral study has provided an opportunity to ask different research questions. The second aim of the doctoral research was to examine the children’s learning and its relationship with the
independent pupil-pupil talk. That is to examine how meaning was communicated between the children as they talked together in solving a mathematical problem. In examining the relationship between learning and talk from a social perspective the focus became how children’s meaning making was mediated socially, culturally and semiotically.

Sfard’s notion of a discursive focus has provided an analytical model, focal analysis, for looking at the effectiveness of communication within a group of children by determining the clarity of the common focus. My interest in this doctoral study was in the children’s communication and the effectiveness of this would seem important, however the aim was to study the relationship between the learning and the talk and the mechanism that related the two.

An understanding of formal arithmetic within a sociocultural perspective is theorised as abstractions of commonalities and reorganisation of mathematical objects which are mediated socially, through language. Such objects are conceptual and meaning is seen to be endowed culturally. Meaning is seen as a product of tacit experience (the bottom-up action and reflection) and the explicit cultural knowledge (the top-down cultural guidance). In communicating meaning the speakers share intentions, that is they relate to what is significant. Sfard’s use of focal analysis was a way to determine the clarity of the focus that the speaker attends to or what the speaker sees as significant, and how it becomes the common focus. If the common focus is sufficiently clear to speakers and listeners then communication is effective. In determining the children’s learning in talk this notion of a sufficiently clear common focus would be important and is part of the doctoral study. However, Sfard’s discursive focus seems to miss out an element in the examination of the relationship between learning and talk, that is, how the children express their intentions within the talk.

Seeger (2011) and Radford (2006) have acknowledged the role of shared intentionality in meaning making. As suggested by Seeger intentions are subjective; empathy and reciprocity are a key part to human communication from a young age. Radford proposed that, whilst the intentions were both subjective and cultural meaning making is related to cultural constructs, and that the cultural meaning is mediated semiotically. Hence a study of the
children’s learning in talk would entail an investigation into how the children shared intentions, that is, how they directed each other to what they saw as significant. It would also entail an investigation into the how the children attended to what is significant culturally. This is what I intended to investigate in the doctoral study, that is how the children exchanged meaning.

As noted above, Sfard had indicated the potential problem of using the term ‘exchange’ with the word ‘meaning’. This problem has also been identified by Gee (2008) as the word ‘exchange’ suggests something (a fixed entity) being conveyed intact to another. Seeger had used the term ‘share’ with reference to sharing intentions but this would not seem appropriate to use with meaning. Sharing suggests that the children use each other’s intentions and whilst this is a useful analogy for intentions it is not so useful for meanings. Children cannot use each other’s meaning, meaning is a cultural construct. The term ‘negotiation’ also has problems. Meaning is not just social, it is also cultural. Negotiation suggests that meaning is arrived at through social consensus, however mathematical objects do not just have a consensual meaning within a group; they have a cultural meaning (Radford, 2006). With regard to these difficulties, I reverted to the use of the word ‘exchange’ in relation to meaning with the caveat that exchange is interpreted as giving and receiving and that meaning is not seen as a fixed entity but as a cultural construct.

Within these emergent theories children’s exchange of meaning is seen as a product of children’s intentions, what they saw as significant, and the cultural constructs that were represented by the mathematical objects within an activity. Meanings are situated within the context of the problem and as the children engaged in activities they used mathematical objects to solve the problems. These objects are conceptual and cultural and the meanings of these objects are mediated semiotically. So the focus of the doctoral study is on examining the children’s shared intentions and mediation of cultural meanings. Mediation happens through language (words, signs and gestures) and is situated within the task that the children are engaged with in the independent group work. So research questions would relate to the language (words, signs and gestures) that the children used in the talk to share intentions and to exchange meanings.
• How did the children use language to share intentionalities and exchange meanings?
• Did the intervention change the way the children used language to exchange meaning?

Seeger's (2011) ecological perspective has acknowledged the emotional and subjective elements of communication in meaning making. These are part of communication from birth and, whilst meaning making in mathematics is often seen as non-emotional, this aspect is considered as children communicate with each other. Sharing intentions requires children to be empathetic and perceptually sensitive to each other.

4.10 Discourse and language in mathematics

The theoretical perspective presented above has emphasised the role of language in children’s meaning making. As proposed by Font, Godino & Gallardo (2013) in regard to objectification or reification, language represents something; it has an intentional content. According to Gee’s definition of a Discourse, communication is socially situated within a social and cultural practice. Therefore, explorations between learning and talk need to concentrate on the interpretation of meanings within mathematics as a Discourse. I review research that has considered how language has been used to represent something in mathematics, in this case how does the language represent cultural mathematical objects.

Whilst much of the research in discourse and mathematics education has related to communication within the context of a setting such as a teacher-led classroom or group situation or in independent group work, research has also focused on the use of language. For example, Sfard and Lavie’s (2005) research, as referred to above in section 4.2, focused on young children’s use of words such as ‘more’ or ‘less’ when comparing which box had the most marbles.

Within the study of linguistics words specific to a context are termed content words and include nouns, verbs, adjectives, and adverbs. These are distinguished from function words such as articles, prepositions, conjunctions, pronouns and demonstratives (Halliday & Matthiessen, 2004). The study of
content words would indicate how children refer to mathematics objects such as numbers, properties, operations and so on. Sfard and Lavie (2005) studied the words ‘more’ and ‘less’ as content words to examine the children’s understanding of these mathematical concepts.

However the doctoral study focused on the children’s use of function words. The learning activities of the children in the TC Project, whilst focusing primarily on arithmetic, had been from a variety of mathematical contexts and contents. An aim was to determine if the use of language changed following the intervention. Examining the children’s learning across the different contents would not have provided information about any changes. Function words, however, are found in all sentences independent of the content. A further reason for investigating the children’s use of function words was based on the theory of systemic functional linguistics (SFL) (Halliday & Matthiessen, 2004) that purports the power of grammar and function words in making meaning; they are “the powerhouse where meanings are created” (p.21).

The tenet of SFL is that language has evolved because of its functions in making meaning out of a given environment. Words are used as part of a comprehensive system of language; “what is being said about one aspect also contributes to the whole picture” (Halliday & Matthiessen, 2004, p. 19). Within this system words become “patterns in what could go instead of what” (authors’ use of italics) (p.22). In order to make meaning we make systemic choices in which words to use, although this choice is not always conscious. That is, language is “a resource for making meaning, and meaning resides in systemic patterns of choice” (p.23). Or to put it another way, “the system is the underlying potential of a language, its potential as a meaning-making resource” (p.26). Therefore children choose words in order to make meaning. The choice of words is not necessarily conscious but the choice of the words is intentional. As the children are collaborating on a problem then it would seem that the word is used to share an intention. As such function words would be seen as powerful in expressing intentions and hence would be powerful in exchanging meaning.

As summarised by Eggins (2004), systemic functional linguistics views language as a strategic, meaning-making resource. Language use is functional
and the function is to make meanings. These meanings are influenced by social and cultural contexts. Hence the interest of the doctoral study in examining children’s meaning making is in the function of the language and not the content of the language. Content words were used in identifying the children’s talk in relation to mathematical objects such as numbers and operations but the children’s shared intentions and exchanges of meaning were examined primarily through their use of function words.

Research into the use of function words in mathematics education is not new. Interest in children’s use of pronouns dates back to at least the 1980s, for example with Pimm’s (1987) reflection on the authoritative use of the pronoun ‘we’. Since then Bills (2001, 2002) and Rowland (1992, 1999, 2000), have examined children’s use of words as indicators of how they were thinking.

Bills’ research was concerned with the use of language in relation to children’s thinking and reasoning. Bills’ studies examined how the use of “qualitatively different language is indicative of qualitatively different conceptualisations” (Bills, 2001, p. 152). Bills investigated the use of metaphors and linguistic pointers as indicators of children’s mental representations (2001) and the use of pronouns, causal connectives and tense for “ways in which explanations were given” (2002, p. 5). Bills’ research has given evidence of how language and thought are related. The children’s use of language was in giving explanations to an adult and not in independent group work. From a socio-constructivist perspective, the interest was on children’s internal representations or the use of language as a window to examine the ‘inner mind’. It did not examine how language is used to exchange meaning in problem solving from a sociocultural perspective.

Even so, Bills’ research indicated key function words related to children’s talk in mathematics and so is relevant to the investigations into the children’s use of language in this doctoral study. However from a sociocultural perspective and within the theory of semiotic mediation, rather than ascertaining an internal representation my interest was in how the children were directing attention to, what they saw as significant. A useful examination would be in how these words were used by children to share intentionality.
Rowland’s research within a socio-constructivist perspective had considered use of language “for the explicit communication of thought” (2000, p. 2) but not just as a window to the inner mind. Key to Rowland’s studies in use of language was the role of deixis. Deictic words are function words; their function in language is pointing out (from the Greek word ‘deixis’ meaning to point). The pointing out is specific to the speaker and the context (Halliday & Matthiessen, 2004). Interpretation of meaning depends on knowledge of the context in which the speech occurred. For example the personal pronouns ‘you’, ‘I’ and ‘we’ indicate the role of participants in the discourse (participant deixis). Also for specific deictics, such as the demonstrative determiners ‘this’ or ‘that’, the function identifies a subset of a particular thing that is being referred to and in relation to orientation by reference to the speaker. For example ‘this train (you know the one, the one by me) or that train (you know the one, the one over there)’ Halliday and Matthiessen (2004). Meaning is inaccessible without the context.

Rowland (2000) referred to a deictic principle as an indicator of cognitive states and also to the “use of language for the communication of thought, and as a code to express and point to concepts, meanings and attitudes” (p.2). Rowland referred to deixis as a “linguistic pointer to a shared idea” (1992, p. 47). In particular Rowland investigated the use of the pronoun ‘it’ as an indicator of something that was held in the mind; a mathematical referent that was understood but unnamed. Rowland’s (1999) study examined use of the word ‘you’ as used in an absolute sense, meaning ‘one’ can and suggested that this absolute use in mathematics referred to a generality, that is, something that anyone could do. ‘You’ was used to suggest a generalisable way of doing something, something that always happens and that anyone could do (Rowland, 2000). Rowland gives the example ‘you can square it’, where ‘you’ suggests that anyone could do this and ‘it’ suggests a variable. Rowland (2000) also suggested that the deictic use of the pronoun ‘it’ was used to refer to an idea that may or may not be physically present, an abstraction or something in mind but was not named or a conceptual variable where the something in mind could take any value.
Radford (2002) recognised the deictic use of words ‘this’ and ‘that’ as key elements in communicating where their “primary function is to point to something in the visual field of the speakers” (p.17). Such use is spatial and positional and Radford suggested that their use represents “the social processes of meaning production” (p.14). They are linguistic devices and signs to point to intentionality by an individual.

From Rowland’s perspective (2000) the general use of the pronouns was related to a kind of inductive reasoning. Rowland described this as going beyond or outside the evidence by discovering (generalising) additional knowledge from inside the mind. He described this kind of deductive reasoning as an insight or ‘trigger’ to see an “infinite kind of knowledge” from a “finite kind of information” (p.25).

On the other hand Radford’s (2003) focus on spatial deixis ‘that’ was seen as factual generalisation in that abstraction was on a concrete operational task according to the tasks needs. Factual generalisation is seen as fundamental to objectification. Mathematical objects are conceptual objects, they cannot be seen, and also they are in themselves not particulars but generals. For example the *fiveness of five* is beyond perception, it cannot be directly perceived. Knowledge of number is semiotic, that is through signs (Radford, 2002), and the way to reach the conceptual objects is through semiotic actions. Radford proposed that spatial deixis is the interface between the spoken and the seen (orality and perception) and is a “key element in mathematical discursive meaning production process”(Radford, 2002, p. 15). Radford termed this *objectifying deixis* “a process aimed at bringing something in front of someone’s attention of view” (p.15) or what to focus on. Hence spatial deixis is seen as a “central semiotic means of objectification in (a child’s) factual generalisation” (Radford, 2003, p. 50).

Rowland’s use of deixis (‘it’ and ‘you’) referred to their use as generalisations as a kind of inductive reasoning. Reasoning from a particular to the general by inferring general principles. Radford’s reference to spatial deixis and factual generalisation as abstraction according to the tasks needs, would seem more
akin to deductive reasoning, a heuristic or the application of rules based on logical consistency to a particular action.

Generalising is fundamental to mathematical thinking but can mean different things. For example Radford (2010) makes distinctions between generalisation, naive induction and algebraic thinking. However they are all forms of reflecting mathematically. Radford’s generalisation involved in semiotic means of objectification is not the generalisation of inductive reasoning or even algebraic reasoning but it is still a generalisation.

Generalisation (in its different forms) is a fundamental mathematical process, and so, within Font et al.’s (2013) definition, generalisation is a mathematical object and hence a cultural construct. Within Gee’s (1996) theory of a Discourse such processes are “socially accepted associations” (p.131), and generalising is seen as a quality of argument and logical coherence that is culturally valued (Forman, 1996). Whilst they may occur within practical activities both deductive and inductive reasoning require an abstraction or detachment from the practical activity. Within a theory of cultural semiotic means of objectification, generalising and situating knowledge are social and conceptual processes. They are not interiorised reflected actions of individuals related to logico-mathematical structures that are outside the knower. Whatever the generalisation, the logico-mathematical structures are social and cultural (Radford, 2006).

Koukkoufis and Williams (2005) have investigated the use of spatial deixis in integer operations with older children (year 5, 9-10 year olds) and identified the children’s use of factual generalisation as the children determined a compensation strategy with integers. The use of spatial deixis and factual generalisations has not been studied with younger children, neither has it been used to investigate changes in children meaning making following an intervention that focused on the quality of the children’s talk.

From the review of literature in this section a more specific research question related to the children’s use of functions words would seem relevant.

- Which words were used to support the children’s shared intentions and exchange of meaning?
• How did these relate to generalisations?

4.11 Summary

In this chapter I have reviewed literature and theoretical perspectives in relation to the two aims of the doctoral study. The first aim was to examine systematically the changes in the independent pupil-pupil talk and the second aim was to examine the children’s learning in mathematics and its relationship with the talk. The review of the literature has shown how the doctoral study builds on existing literature and theoretical perspectives in developing three sets of research questions.

From section 4.2

• Were there similarities or differences in the nature of talk, both social and academic, between different groups of children?
• Were there changes in the nature of talk, both social and academic, between the pre-intervention and the post intervention sessions?
• Was there evidence that these changes, both social and academic, supported the children in working collaboratively and productively on the mathematics tasks?

From section 4.9

• How did the children use language to share intentionalities and exchange meanings?
• Did the intervention change the way the children used language to exchange meaning?

From section 4.10

• Which words were used to support the children’s shared intentions and exchange of meaning?
• How did these relate to generalisations?

These are distilled into a key focus concerning children’s learning in mathematics in relation to independent pupil-pupil talk; to examine how the children exchanged meaning in mathematics within the independent pupil-pupil talk, and if the intervention changed the way the children exchanged meaning.
In using the phrase exchange meaning in mathematics, I refer to the children’s exchange of meaning of mathematical objects where mathematical objects are defined as an entity that is involved in a mathematical practice.

However the review of literature and theoretical positions suggested that there is much underpinning such a focus. It was seen that exchange of meaning whilst social, cultural and cognitive was related to subjective intentionalities and emotions (Seeger, 2011), but that meanings are intrinsically cultural (Radford, 2006). Also that meaning was situated and that language creates the context and situation for how meaning is situated within the discourse (Gee, 1999).

So an addition to the focus of the study would be what social (including emotional), cultural and cognitive aspects featured in the exchange of meaning in mathematics and whether the intervention changed the way these aspects featured in the exchange of meaning.

It was also seen that objectification was mediated semiotically, socially and culturally and that function words, in particular deixis, can be used to determine the meaning potential of language. This added a further dimension to the focus of the doctoral research in relation to the analysis of the function of language in young children’s exchange of meaning.

As such the doctoral study positioned its focus differently to the TC Project. In investigating the data in more depth and from a different perspective it was able to ask new questions. These new questions had the potential to examine children’s learning in talk in a novel way and to add to our existing knowledge of how young children learn in mathematics. This claim is further substantiated in relation to the key foci.

The doctoral study was based on the analysis of the function of language. Comprehensive functional analysis of primary school children’s talk has been carried out by Kumpulainen and Wray (1997) across the curriculum but this has not been carried out comprehensively in mathematics education. Corsaro (1986) had analysed the intentions of utterances of young children at play but this was not in relation to understanding in mathematics. Esmonde (2009) had examined the work practices as individualistic, collaborative and helpful in determining equity in cooperative group activities in mathematics with older
children. Cobb (1995) had analysed the sociological constructs such as obligations and expectations in small group interactions with primary school children. Whilst these studies have informed the analysis and coding in the doctoral research (this is outlined further in Chapter 6) the functional analysis of language in these studies has not been in relation to young children’s understanding in mathematics or has not been used to determine changes in an intervention.

The doctoral study also focused on the analysis of the social aspects as they featured in the children’s talk as well as the mathematics. Whilst examination of communication within classroom contexts related to mathematics talk is now well-researched, the examination of the talk that happens in small group work that is not about the mathematics is still a small field of research. As described above Wood and Kalinec (2012) had examined this relationship with older children. Thornborrow (2003) examined the off-task talk with primary aged children, however her interest had been in children’s building emergent social relationships and hierarchies with their peers and did not relate this to connection building or to the learning of mathematics.

Whilst Bills and Rowland have investigated the use of deixis in children’s learning in mathematics and Radford has developed a theory of objectifying deixis and factual generalisation these studies have not been carried out with young children and neither has this been used in relation to SFL and changes in functions of talk over an intervention. Rowland and Radford’s studies have shown differences in the use of deixis and generalisations and these have not been considered together in one study.

Whilst other studies have investigated communication in mathematics in small group settings they have not focused on the function of the children’s language as a way of determining change, neither have they examined the social aspect in relation to the children’s cooperation and talk in mathematics. Focus on the function of the children’s talk, both in the intentions of their utterances and in use of function words was used to help understand what had happened in the intervention of the TC Project. In particular functional analysis of words was used to determine if the intervention had changed the way children exchanged meaning. It was anticipated that this novel analysis of the function of young
children's language in independent pupil-pupil talk would shed some light onto our understanding of children's learning in mathematics.
CHAPTER 5 METHODOLOGY

5.1 Introduction

A theoretical and epistemological framework is necessary to guide research (Weidman & Jacob, 2011). Such a framework provides a philosophical orientation or ‘worldview’ that “underlies and informs methodology and research methods” (Corbin & Strauss, 2008, p. 1). It provides coherence in relating the four elements of epistemology, theoretical perspectives, methodology and methods (Carr, 2003; Crotty, 1998). Chapter 4 outlined the perspectives that underpinned the theoretical framework of the doctoral research in relation to learning in mathematics. The purpose of this chapter is to relate the theory further to epistemological perspectives and to methodologies that, in turn, support the coherence and purposes of the research and that informs the research methods.

The development of coherence requires an awareness of the researcher’s own beliefs and perspectives. These beliefs are reflected in the way the research is designed, what the research is investigating and how research questions and methods are determined. The beliefs also influence the conclusions that might be drawn from the study (Weidman & Jacob, 2011). In this chapter I set out to explain my beliefs and perspectives from an epistemological and ontological perspective.

As explained in Chapter 4, I had used the opportunity of using existing data from the TC Project to examine the data from a different theoretical perspective. That is from a thoroughly social or sociocultural position rather than from an approach that had integrated the social and constructivist positions. Language is seen to lead learning in a sociocultural position and this enabled me to ask different questions in relation to children’s meaning making in mathematics in talk and how they exchanged meaning.

In this chapter I explain how a sociocultural theoretical and epistemological position is related to a humanist interpretivist methodology. In the TC project the methodology had been related to Mercer’s (2004) sociocultural discourse analysis. Whilst there was an interest in the talk that supported productive problem solving, the emphasis had been on the educational outcome. In this
chapter a distinction is made in the study of learning that positions the doctoral study within a constructionist epistemological perspective where the interest in the intervention is as an event or phenomenon and that the phenomenon could be investigated in order to understand better what had happened. This in turn could further our knowledge of how children learn in mathematics.

5.2 Education and Social theory

If we see education as “development of the mind” or “promotion of personhood” (Carr, 2003, p.6), then research into education is a human inquiry, a social and psychological study, engaged in understanding the minds of other people. Hence research into education is positioned in the world of social theory. The chapter outlines key epistemological perspectives within this world. The aim is not to develop a synthesis of methodologies but to define the paradigmatic and epistemological perspectives that relate to the research questions and the research methods; to identify and select epistemological perspectives that meet the purpose of the research and to distinguish from other perspectives that do not.

The world of social theory has emerged as a multiparadigmatic, shifting theoretical landscape (Paulston & Liebman, 1993; Paulston & Liebman, 1994). In order to more fully understand the different paradigms it is helpful to know how the social theoretical landscape came about, how it is represented in the field of education and then more specifically in mathematics education.

Kuhn (1970) is accredited with the first use of the term paradigm in relation to the natural sciences, to mean “a way of looking at things: a set of shared assumptions, beliefs, dogmas, conventions, theories.” (Sardar, 2000, p.73). "To be located in a particular paradigm is to view the world in a particular way" (Burrell & Morgan, 1979, p.24). In this way a paradigm is seen to ‘guide action’ within disciplined inquiry (Guba, 1990), and so it is important to recognise the set of beliefs that ‘guide’ the action of this doctoral study.

Kuhn is further associated with the notion of a paradigm shift within the field of natural sciences and how this field is dominated by a single paradigm at a time. In the early half of the twentieth century sociology and psychology was mostly seen as a scientific enterprise, this orthodoxy was challenged in the 1960s and
1970s in relation to postmodern ideas (Rust & Kenderes, 2011). Such challenges were sceptical about human conception as an external reality and saw values as socioculturally constructed (Carr, 2003, p.255) and social theory became multiparadigmatic in nature.

Until the 1980s much of the research into education was also seen as a scientific enterprise and was informed by a psychology discipline. Theorists such as Popkewitz (1984) and Guba (1990) challenged this orthodoxy. Many educational paradigms have now emerged and educational theory is now seen to embrace the postmodern world of social theory from scientific psychological as well as sociocultural perspectives. This is not to say that one paradigm is right or another is wrong. A postmodern view gives an opportunity to enter a dialogue with different paradigms and to consider what they add to the information on education processes. Within a postmodern perspective there is no ‘one world view’. It is recognised that “different points of view can complement each other and fill in holes that a single point of view fails to fill” (Rust & Kenderes, 2011, p. 26).

Burrell and Morgan (1979) developed a two-dimensional matrix as a mechanism to map the multiparadigmatic landscape of social theory. This representation (figure 4.1) shows connections between different paradigms and the four quadrants each represent a social ‘metaparadigm’, ‘root paradigm’ or ‘world view’.

![Figure 4.1 Four paradigms for the analysis of social theory (Burrell & Morgan, 1979, p. 27)](image-url)

Figure 4.1 Four paradigms for the analysis of social theory (Burrell & Morgan, 1979, p. 27)
The idea of social cartography has been developed further (for example Paulston (1994), Paulston and Liebman (1994), and Weidman (2011)) created a social compass metaphor (figure 4.2), to ‘guide’ the researcher in building a theoretical framework.

![Figure 4.2: Theoretical compass (Weidman & Jacob, 2011, p. 14)](image)

A common feature of the mappings is the two dimensional matrix. Each dimension represents philosophical dichotomies. In one dimension the dichotomy relates to realist objectivism or to idealist subjectivism. The other dimension is concerned with regulation and equilibrium or to radical change and transformation. In presenting these dichotomies as dimensions the four metaparadigms are created: Functionalist, Interpretive or Humanist, Radical Humanist and Radical Structuralist. Burrell and Morgan’s matrix shows these metaparadigms as distinct quadrants. Weidman and Jacob’s theoretical compass is seen as a way to show possible directions.

Social cartography is of particular interest to comparative, international and development education (CIDE) where researchers work across a range of social sciences and heterogeneous orientations. However the mapping of paradigms can be used as a tool in investigating numerous educational problems and in helping to visualise the different perspectives that “conceptualise the phenomenon being investigated” (Tello & Gorostiaga, 2009, p. 159). The mapping can be used by researchers to “ground their work in a
theory or set of theories depending on the situation, circumstances, need, and context of their research” (Weidman & Jacob, 2011, p. 14). Within the focus of a topic such maps give flexibility in selecting theory to meet the need of the researcher and to build an appropriate framework (ibid.). Such mapping would seem to support research in mathematics education when seen from a postmodern perspective.

From the maps above the world of social theory is seen not only as dichotomous but also as macro and micro paradigms that can guide the direction in building the theoretical framework. The direction, and hence the framework, need to be appropriate to the context of the research and the focus. In reviewing the dichotomies the aim is to explain the epistemological and theoretical direction of the doctoral study. In order to rationalise the positioning, the nature of these dichotomies are defined. The dichotomies are then related to theories in mathematics education as indicated in the Piagetian and Vygoskyan perspectives considered in Chapter 4.

5.3 Epistemological considerations

Epistemology deals with the “nature of knowledge” (Hamlyn, 1995, p. 242) and “the conditions in which knowledge is produced” (Popkewitz, 1998, p. 61). Within a research study, the epistemology is inherent in the theoretical perspective, the methodology and the research methods (Crotty, 1998). There is a clear dichotomy between objectivism and subjectivism. Subjectivism is seen to provide a movement away from objective positivism and “what would seem to be problematic is any attempt to be at once objectivist and constructionist (or subjectivist)” (Crotty, 1998, p. 15).

“Objectivist epistemology holds that meaning, and therefore meaningful reality, exists as apart from the operation of any consciousness” (Crotty, 1998, p. 8) and objective realism holds that “human knowledge is description of an inherently ordered external reality” (Carr, 2003, p. 257). Facts are independent of human consciousness. This epistemological perspective is related to ontological views in mathematics, such as an absolutist Platonic view that claims knowledge is grounded in objective truth (Carr, 2003). Objective knowledge equates to certainty and mathematical truth. Take ‘2 + 2 = 4’ for
example. Within a Platonic perspective this statement is true necessarily, once and forever, anywhere in the universe (and as Carr pointed out even if there was not a universe it would still be true). Within this epistemology mathematical objectivity is connected to the logic of mathematical proof and reasoning which are seen as “true by virtue of their place in a system of mathematical rules and principles that are constitutive of their truth” (Carr, 2003, p. 121). An objectivist epistemology claims that such systems of rules or structures are “universal, historical and transcultural concepts ... of human thought” (Carr, 2003, p. 225).

In contrast to an objective perspective, subjectivism sees the nature of reality related to and dependent on consciousness. Knowledge is limited to experiences. From an idealist subjective epistemologically “one cannot be certain that anything exists beyond the confines of one’s own (private) mental experience” (Carr, 2003, p. 251). However, conceptual idealism sees this as incoherent. It views knowledge as social and interpersonal, not as an individual construction: “the mind that makes the world is a collective mind expressed in public or social traditions of received wisdom” (Carr, 2003, p. 124).

In Chapter 4 I examined the notion of mathematisation and mathematical objects from Piagetian and Vygoskyan perspectives. Ontologically and epistemologically the notion of objectification or reification is a mechanism that can work in both objective and subjective domains (Ernest, 1998). Objectivists saw that knowledge required “the imposition on sensory experience of rules and principles that are in some sense necessary and/or culturally invariant” (Carr, 2003, p. 121). Piagetian notions relate to mathematics as reasoning where “logico mathematical structures are the structures of rational thought” (Walkerdine, 1990, p. 6) and thinking is seen as a “set of universal, basic structures” (p.5) that is a structural notion.

Within a subjective domain, social construction of knowledge is related to how objects are generated culturally through language. However knowledge can still gain the appearance of objectivity and permanence (Ernest, 1991). Socially constructed reifications of more concrete conceptions and operations become cultural, abstract knowledge. The Discourse of mathematics is defined by socially construed rules and constraints that become reified into logical necessity (mathematics reasoning). For individuals these become personally
reconstructed as ‘real’ and ‘ever present’ (Ernest, 1991, p.220). “Since
objective knowledge and rules exist outside individuals (in the community or,
rather, in the realm of the social), they seem to have an object-like and
independent existence” (Ernest, 1998, p. 145). As such, reification is seen as
“treating perceived patterns as objective realities” (Carr & Kemmis, 1983, p. 84)
If knowledge is seen to be constructed through social processes then the
objective structuralist notion that there are universal, historical or transcultural
concepts is rejected (Carr, 2003). Within the social or cultural genesis of human
knowledge and understanding ‘truth’ is seen as “logical consistency” (Carr,
2003, p. 251), not a set of universal, basic structures.

In respect of the social compass metaphor a social or cultural view within
mathematics and mathematics education means a redirection away from the
positivist, objectivist epistemology towards notions of constructionism.
Knowledge is not seen as an objective value-free truth, it is seen as a social
construction. A constructionist epistemology suggests that all meaning is
socially constructed. Meaning is not inherent in objects; meaning emerges “only
when consciousness engages with them” (Crotty, 1998, p. 43) and when
consciousness is raised to a cultural level. As stated in Chapter 4 a child may
play with objects but the child will only become consciously aware of the objects
in relation to mathematics through cultural exchange mediated by language.

It is noted that the word constructionism in relation to Crotty’s definition of
meaning that is socially constructed had been used independently of Papert’s
(Harel & Papert, 1991) use of the word. Harel and Papert (1991) had expressed
constructionism as ‘learning-by-making’. Harel and Papert had also compared
their philosophy with Piaget’s constructivism. Both were concerned with
"building knowledge structures" but in Papert’s constructionism this building of
knowledge structures was seen to happen in a context where the learner is
“consciously engaged in constructing a public entity, whether it’s a sand castle
on the beach or a theory of the universe” (p.1). Whilst not theorised specifically
within a social and cultural perspective there are elements in Papert’s
philosophy that are not inconsistent with this study. For example he had
stressed the importance of tools and context. However a discussion about these
elements is beyond the scope of this doctoral research.
Historically, an objectivist epistemology and functionalist paradigm has dominated the field of mathematics education. However, theorists such as Bishop (1988) and D'Ambrosio (1985) in the 1980s, along with Lerman (1993) and Ernest (1998) in the 1990s, have promoted a cultural metaphor in mathematics education that acknowledges both the cultural nature of mathematical knowing and the social dimension affecting mathematics education research. These theorists have defined mathematics education from a constructionist perspective and so have positioned mathematics education on the socio-theoretical landscape.

Hence a constructionist epistemology has now become established as a possible paradigmatic perspective for mathematics education. However the objectivist epistemology is still seen to be prevalent (Appelbaum, 1995). Disciplines such as the arts are more readily seen as human and culturally influenced, mathematics is still seen to be an exception in being culturally independent. One reason put forward is that, in the arts, the cultural tools are still visible, whereas in mathematics the cultural tools are not so easily seen (Prediger, 2003). The reification of socially construed rules and constraints into what seems to be logical necessity means that, in learning mathematics, an individual is confronted with maths as the finished product presented as something unchangeable (Prediger, 2003); something that is only accessible objectively. This explains the contention held in Chapter 1 that current practices in classrooms may acknowledge the sociable process of learning but not the social notion of learning. In this doctoral study this is seen as a key epistemological viewpoint regarding children as active participants in learning mathematics.

In focussing on mathematics from a dialogic perspective rather than an absolutist monologic perspective it would seem that the epistemological coherence is achieved through constructionism (or conceptual idealism). That is knowledge is viewed as social and interpersonal, not as an individual construction of an objective reality, neither as an idealist subjectivism, but as social and interpersonal. This upholds a social view of mathematising as proposed in Chapter 4.
The focus of this doctoral study on children’s discourse reflects the importance of the social context. In establishing a coherent research, this study is positioned within a subjective, non-structuralist perspective and is consistent with the focus on mathematical knowledge as dialogic rather than absolute and monologic. The focus of the study relates to the construction of meaning within a social setting. In positioning the doctoral study away from a positivist structuralist position there is an opportunity to ask questions about discourse and culture and to examine the centrality of language to knowledge and thought.

It is recognised that there can be valuable research into children’s learning in mathematics from an objectivist, structuralist perspective. There are questions that have been appropriate to research within this paradigm which have provided useful insights into children’s learning. The point to make is not which of the paradigms is right or wrong but which one best meets the purpose of the research and the research questions.

5.4 Positioning the doctoral study in relation to an interpretivist methodology

A review of Crotty’s (1998) model of methodologies and the social mappings of Burrell and Morgan (1979), Paulston (1994), and Weidman and Jacob (2011) has indicated that a constructionist position reflected within an interpretivist humanist theoretical perspective establishes coherence, theoretically, epistemologically and ontologically. This also seems relevant methodologically in that the doctoral study had intended to explore human and social reality within one part of a classroom context; independent group work. When looking at the children in their group work there was an interest in their active engagement with learning within a social context.

Such a stance critiques the ‘passive spectator’ view of knowledge acquisition and the traditional transmission model of schooling and education that was suggested in Chapter 1. Interpretivist humanist theorists, such as Dewey, viewed knowledge as “active meaning making” and “active engagement with historically determined human problems” (Carr, 2003, p. 121). In aligning the doctoral study with this paradigm an epistemological coherence is established
in relation to a cultural view of mathematics and the social notion of learning mathematics.

Within the doctoral study’s methodological orientation the intervention that had been developed in the TC Project was seen from an interpretivist approach (Carr & Kemmis, 1983). This related to the practical or understanding view of knowledge and research that is not based on testing a hypothesis but is “expecting theory or understanding to follow” (p.29). Again this was an advantage in using existing research as there was the opportunity to use the data within a different methodological perspective.

Hence there was an opportunity to further review how epistemology and methodologies inform the research methods of the doctoral study. An interpretative notion is based on ‘understanding, meaning and action’ (Carr & Kemmis, 1983, p. 83) and not a technical or scientific approach based on explaining cause and effect (Stake, 2010). The emphasis of the doctoral study is on understanding and hence is coherent with a humanist interpretivist methodology. The epistemological orientation of the study is also constructionist.

5.5 Refining the focus of the doctoral study

As stated above an interpretative notion is based on understanding a phenomenon. But in the case of the doctoral study what is the phenomenon? Corbin and Strauss (2008) made a distinction between a phenomenon and a process where a phenomenon is a topic, an event or a happening and a process is a means of achieving that event. For example survival is a phenomenon. The process is then the means of surviving and the strategies by which surviving is managed. The TC project had presented an intervention, a means by which a practice is changed and so the interest had been in a process, how the teachers made it happen, the strategies they used, and the problems that arose. The doctoral study shifts the emphasis of the intervention from a process to a phenomenon. It was something that happened.

The TC Project was an interventionist study to develop effective pupil-pupil talk. Hence the project anticipated that there would be an improvement in learning through the development of the pupil-pupil talk. One could ask why else would
we have carried out the study. But advocacy can get in the way of being sceptical (Stake, 2010). In the TC project we were looking to find effectiveness as had already been defined in a type of talk. In the doctoral study the intention was to understand better what the learning was and whether the intervention had changed the learning; not just by looking at learning as a product of the intervention but looking at how the children were learning together in talk, how they were exchanging meaning and how this happened socially, semiotically and culturally.

The purpose of the research in the doctoral study was to better understand the situation created by the intervention of the TC Project and not the intervention itself. Stake (2010) stated that research is about understanding how ‘things’ work. Not just the ‘things’ themselves as particular instances but what they might tell us about commonalities or generalities. Within an interpretivist methodology generalisations are not made in a causal way but are made to better understand the commonalities or generalities.

In the doctoral study, the examination was not on the particulars of whether the talk was effective or not in particular situations but what the relationship between talk and mathemetising can tell us about children’s learning. How the children’s discourse in mathematics works.

Stake (2010) defined something as ‘workable’ as a “detailed story of human activity useful for refining a concept” (p.221). The story of the children’s episodes of talk that happened within the intervention of the TC Project are studied in detail in relation to definitions of discourse as language in use for making meaning (Wetherell et al., 2001) and a Discourse as a way of behaving and interacting ; a social product (Gee, 1996).

The episodes of talk are also related to the sociocultural notion of learning in mathematics, that is discursive, empathetic and reciprocative, and semiotic. Learning and meaning making were also seen as situated. So asking how the children’s mathematical discourse works implied asking how the children were exchanging meaning in social and cultural contexts.
5.6 Summary

The chapter has explained the methodology of the doctoral study and how it diverged from the methodologies of the TC Project. The methodology of the doctoral study related to constructionist epistemologies and to an interpretivist humanist paradigm. This has been examined in relation to non-absolutist views of mathematics and the theoretical paradigms that were presented in Chapter 4. In doing so it has made a distinction from methodology of the TC Project as an intervention study that was underpinned by an integrated theoretical perspective. It has also firmly established the doctoral study as interpretivist in seeing the intervention as a phenomenon and to focus on what happened, and in particular what happened to the learning.

There have been a range of research studies into discourse and language in mathematics that have recognised sociocultural perspectives (for example Heyd-Metzuyamin & Sfard, 2012; Sfard & Kieran, 2001; Sfard & Lavie, 2005; M. Wood & Kalinec, 2012). These studies saw the need of the child within the context of the classroom discourse and not from a pathologised structuralist perspective. Such a sociocultural perspective is in contrast to a technical view that the child has a problem to be overcome, and begins to consider the child’s positioning in the social context of learning (as discussed in Chapter 2).

The methodology sets out the conceptual framework and coherence of the doctoral study. It explains the main thing(s) to be studied and “the presumed relationships among them” (Miles & Huberman, 1994, p. 18). In doing so the research questions have been further refined:

- Has the emphasis on quality of talk been an agent for change in children’s mathematical discourse in the independent group work in these classes?

This in turn further determines which incidents to attend to and the choices to be made in selecting data samples, the contexts and the issues to be examined (Miles & Huberman, 1994). The use of research methods in relation to data collection and the use of methods for analysis are outlined in the next chapter.
CHAPTER 6 RESEARCH METHODS FOR ANALYSING THE DATA

6.1 Introduction

Whereas a methodology is seen as “a way of thinking about and studying a social phenomenon”, research methods are seen as “techniques and procedures for gathering and analysing data” (Corbin & Strauss, 2008, p. 1). The doctoral study is based on the investigation of existing video and transcript data. As stated in the introduction the use of primary or secondary data is not unusual practice in educational research (Cohen et al., 2011) and it has advantages in enabling the data to be looked at in depth and from a different perspective. However it does mean that the doctoral study did not involve one element of research methods as stated by Corbin and Strauss, and that was the gathering of the data. The data were collected as part of the TC Project and these data gathering methods were set out in Chapter 3. As these methods were not planned or executed entirely by me they are not included as data collection methods within the doctoral study.

However the research methods of the TC Project have provided a context for the data. As stated in Chapter 1, the research methods of the TC Project were based on both design experiment (Cobb et al., 2003) and sociocultural discourse analysis (Mercer, 2004). The reference to design experiment acknowledged a practical, non-technical research approach. Whilst investigating and developing an intervention there was awareness that social situations are complex and cannot be controlled in a technical way. Whilst the strategies for exploratory talk were seen as helpful in guiding the teachers it was seen to be important that decision on how changes were made in the classroom were decided by the practising teachers rather than implementation of a technique. That is the strategies may have been explicit but they were not prescribed.

Alongside this non-technical approach, Mercer’s (2010) notion of sociocultural discourse analysis had informed the data collection methods of the TC Project as set out in Chapter 3. As with Mercer’s sociocultural discourse studies, the TC Project was concerned with educational outcomes as part of the examination of the intervention. As such the Project had used mixed data
collection methods, both quantitative data from pre and post tests and qualitative data from the teacher interviews and video material.

Research within an interpretivist paradigm is not normally seen to change cultures but to explain consistent dimensions (Weidman & Jacob, 2011). The humanist interpretivist paradigm would normally relate to naturalist studies and research methods that looked at the current situation, regulating and interpreting what is there. Whilst there was an intention to examine the changes through the quantitative data I claim that the research methods of the TC Project did not contradict an interpretivist theoretical stance.

The intervention of the TC Project was intended to change practice and have an impact on learning and so it could be seen as highly interventionist and contrasted with naturalistic studies. Stake (2010) would suggest that most (my emphasis in italics here) qualitative interpretivist studies are non-interventionist in that they do not test a hypothesis. Carr and Kemmis (1983) proposed that there were degrees of intervention related to the emphases of the study. If the emphasis was on prescription and presentation of a technique, with a prediction that the correct use of this technique would raise attainment, then such an intervention would be seen as experimental. It would be testing an initial hypothesis and looking for the cause-effect relations. An intervention study within an interpretivist methodology would relate to a practical approach with an emphasis on understanding what happened. Although this approach also aims at an intervention that will change the situation, the research is not based on testing a hypothesis but is “expecting theory or understanding to follow” (Carr & Kemmis, 1983, p. 29).

In this respect the research methods of the TC Project were viewed within an interpretivist methodology. Where data were collected to examine the changes, including the educational outcomes, this was seen to inform an understanding of what had happened. The emphasis was not on testing a hypothesis to determine a generality but an examination of the intervention as the tracing of a unique phenomenon. There was an expectation that theory or understanding would follow. It is in this respect that the doctoral study has furthered the examination of the data in tracing the unique phenomenon.
As set out in Chapter 5, the methodology of the doctoral study related to constructionist epistemologies and to an interpretivist humanist paradigm and in this doctoral study the intervention was seen as a phenomenon. Hence the focus of the analysis was on understanding what happened, and in particular, what happened to the children’s talk and its relationship to learning following the intervention.

As had been shown in Chapter 3 evidence from the analysis for the TC Project had indicated that the strategies for developing exploratory talk had seemed helpful to the teachers in developing collaborative group work, but it was not evident that the children’s talk was characteristic of exploratory type talk. Evidence from the pre and post tests suggested the children overall made greater than expected progress in attainment and the teachers stated that the children were talking more and taking notice of each other’s ideas in mathematics.

Whilst this suggested that there may have been a difference in the nature of the children’s talk it was difficult to define it as a type of talk. Attempts at coding sections of the children’s talk in relation to disputational, cumulative and exploratory talk had not been possible (this is explained further in pp. 125-126). Unanswered questions remained regarding the nature of children’s talk and the nature of the change. The other unanswered question was related to the children’s learning and if this changed as the talk changed. From a theoretical and literature review in Chapter 4 learning was defined as exchange of meaning about mathematical objects. Hence in examining the children’s learning the focus of the doctoral study was on how the children exchanged meaning in mathematics, and if the way they exchanged meaning changed.

This chapter sets out the methods of analysis used in the doctoral study to investigate these questions. The data collected as part of the TC Project had been gathered from multiple cases. Hence it was possible to examine the idiosyncrasies within the different groups. It was intended that an examination of the idiosyncrasies would indicate where the intervention had appeared to support the children in becoming productive in their group work and where it may not have supported this. Within a sociocultural view of learning, there was awareness that the social situations were complex. The social aspects or
relationships within the groups would seem important and the study considered how these may have affected the children’s access to mathematical discourse.

The purpose of the analysis was to examine the children’s learning as they talked to each other about the mathematics within the task. Within a sociocultural view of mathematics education, learning could be seen as exchange of meanings in relation to mathematical objects, the exchange was social, cultural and semiotic. Meanings were seen to be intrinsically cultural and were mediated semiotically, that is through language, signs and gestures. Exchange of meaning in language was further underpinned by the theory of systemic functional linguistics (SFL), language was seen as functional and the function was to make meaning. A focus on the children’s exchange of meaning would be in their use of language (including signs and gestures). According to Gee’s theory of discourse the use of language in exchanging meaning was situated and adapted to a specific context. It was within these specific contexts that a multiple case analysis was carried out.

6.2 Qualitative data analysis within the doctoral study

Interpretive practice in research refers to a “constellation of procedures, conditions, and resources through which reality is apprehended, understood, organised, and conveyed in everyday life” (Gubrium & Holstein, 2003, p. 215). However one thing key to interpretive practices is the engagement with “both the hows and whats of social reality” (authors’ own italics) (p.215). That is “how things work in particular human situations” (Stake, 2010, p. 14). In the case of this doctoral study the engagement was in how the intervention worked, did it change the children’s learning in mathematics and, if so, what was this change. As this was a human activity there would be complex layers underlying the how and the what and so engagement with the activity would need to happen through a “practical understanding” (Miles & Huberman, 1994, p. 8) of the children’s talk and actions. Hence an engagement with the how and what of the intervention would rely on interpretations, or “primarily on human perception” (Stake, 2010, p. 11) and on practical understanding.

Interpretive reseach practices often involve qualitative data and analysis of such data has been said to provide a “rich description of personal action and complex
environment” (Stake, 2010, p. 31) that “provides abundant, interconnected details” (Stake, 2010, p. 49). So the analysis of the children’s talk looked at the shared intentions as subjective and social. The complexities of relationships and emotions and the exchange of what are intrinsically cultural meanings of mathematical objects. Miles and Huberman (1994) have also described qualitative data as being “vivid, nested in a real context” with “a ring of truth” (p.10). Hence the examination of the talk within the videos and the transcripts provide an examination with a context of the class situation and the task. It is hoped that in relating back to the context and examples of the talk that the ‘ring of truth’ is evident.

Although there is not an attempt to make general claims or to find covering laws, the purpose of interpretive practices within the use of qualitative data is to move from the particular to the general (Stake, 2010). As Stake indicated, the analysis of data involves looking at themes and patterns within the particulars and pulling out commonalities. Within this doctoral study I was not looking to the general in a causal way to explain the TC Project intervention as a process, but to understand the happenings and experiences of the TC Project intervention as a phenomenon. I was looking for features within the discourse that would seem to have a significance within the context of the children’s talk within the different groups, and then to relate what was seen as significant to a wider relevance (Taylor, 2001).

The doctoral research used video material from the ten transfer classrooms of the TC Project. These were seen as multiple cases. In working with qualitative data across multiple cases it was possible to take account of local idiosyncrasies (Miles & Huberman, 1994). The intention in the analysis was to move between the idiosyncrasies of each case in examining the different features of the children’s talk. In order to understand the idiosyncrasies the analysis made reference to the particular contexts of the pupil-pupil talk (Stake, 2010). In determining what was significant I was looking for patterns within the idiosyncracies of the different groups that would be seen as important to the way that the children were cooperating and exchanging meaning. From the patterns I then pulled out the commonalities where the features of the talk shared configurations. The intention was to understand these commonalities
and how they may have indicated a relationship between the learning and talk that had been happening in these cases. The aim was to understand the underlying meaning of these commonalities in relation to children’s exchange of meaning in mathematics. The aim was also to identify ‘deviant’ cases and to try to understand why they did not ‘fit the picture’ (Miles & Huberman, 1994, p. 208). These commonalities were then examined from a wider theoretical perspective in order to provide not just a *rich* but a *thick* description with “direct connection to cultural theory and scientific knowledge” (Stake, 2010, p. 49).

Hence I was not aiming to test a hypothesis regarding interventions based on exploratory talk with young children in mathematics. Instead I was aiming to look to any hypothesis that might emerge from the data. I was aiming to examine the relationship between learning and talk that happened in specific contexts and to consider if what happened here might relate to a wider perspective of children’s learning in mathematics.

Interpretive research methods study the meaning of the behaviour in human action (Carr & Kemmis, 1983). As they relate to studying meaning, interpretive research methods involve the researcher in a personal, subjective way. In this doctoral research, studying the children’s talk required an interpretation of the children’s talk and behaviour. Whilst this role was subjective, personal experience and understanding of the situation was used in making interpretations (Stake, 2010). This personal experience and understanding not only related to my involvement in the research project but came from my experience as a researcher in this field and also from my previous experience as a primary teacher of mathematics.

As such the analysis has offered “an interpretation or version which is inevitably partial” (Stake, 2010, p. 11). It does not capture the ‘truth’, but is my account of a social phenomenon or situation. These are my interpretations as an observer and as a researcher. I cannot know for certain what meaning the children intended within their talk, and it is possible that the children might not have known. Within an interpretive paradigm, knowledge is “partial, situated and relative” (Taylor, 2001, p. 12), hence the interpretations were specific to the situations within the group tasks and were relative to my viewpoint as the researcher. Links to theoretical perspectives and other research enabled these
interpretations to be examined from a wider perspective and these are referred to in Chapter 10. Hence it has been important to acknowledge my own understandings, convictions and conceptual orientations (Miles & Huberman, 1994). I hope that I have made these clear in my review of theoretical perspectives and epistemologies (Chapters 4 and 5).

In working with a large body of data over multiple cases some of the analysis involved quantising the qualitative data and used electronic sorting methods such as word counting and comparison of codes as organised in NVivo 9 research software. The use of quantised data within qualitative research is recognised as a valid research method. “The quantitative ideas of enumeration and recognition of differences in size have a place” (Stake, 2010, p. 19) and can provide a richer exploration of the data (Miles & Huberman, 1994). The mixed use of quantitative and qualitative data is not an epistemological issue; both are needed in interpretive methodology. However there are concerns that the use of quantising can remove the data from the context. This was considered with regard to the use of word counting. As it is a rudimentary method it was only used as a guide or indicator to inform a focus back onto the context of the talk.

The quantised data was from a small data base so it was not analysed within the formal standards for assessing and measuring aggregated data. Descriptive frequencies or proportions were used to support understanding of what was happening and not to explain generalities. Coding was arrived at from interpretations so other methods of statistical analysis were not appropriate and tests of significance would not have been meaningful.

6.3 Approaches to discourse analysis within the doctoral study

The data I selected to work with from the TC Project were the video materials and the transcripts from the ten transfer classes. In doing so the data consisted of spoken phrases and words, either directly from the video material or through the transcripts. Hence the data were primarily discursive and the analysis of these was carried out in relation to features within the connected items of speech. The intention was to provide a rich description of what was happening in this discourse. In Chapter 10 this was related to theory and research in order
to develop thick descriptions. These links to theory entailed a consideration of
the children’s exchange of meaning in mathematics as a Discourse.

Research related to discourse refers to a range of traditions (Wetherell et al.,
2001) including sociolinguistics, conversation analysis and discourse analysis,
amongst many. It is not the intention to examine these distinctions in this study
but to explain the purpose of the analysis methods. Key to the focus and
research questions of this study was the children’s use of language. This
seemed consistent with a view of discourse analysis as a “close study of
language in use” (Taylor, 2001, p. 5). That is as a view of language in
communication and as a vehicle for meaning. This view is not “restricted to the
descriptions of linguistic forms”, nor is it, “independent of the purposes or
functions which these forms are designed to serve in human affairs” (Brown &
Yule, 1987, p. 1). Instead the aim to examine an exchange in meaning would
seem to be situated in a particular social and cultural practice “where meanings
are created and changed” (Taylor, 2001, p. 6). In this regard the approach to
discourse analysis used in this study was to look at the ‘activity’ of language, its
use as a process in interacting and in the exchange of meaning.

This perspective of research in discourse was further based on Gee’s (1996,
1999; Gee & Green, 1998) work in sociolinguistics and how speakers signal and
interpret meaning. This would determine a contrast in the relevance of the
children’s use of language and an analysis of “the choices of words and actions
that members of a group use to engage with each other” and how the
consequent discourse shaped “both what is available to be learned and what is,
in fact, learned” (Gee & Green, 1998, p. 126).

Gee (1999) related discourse theory to building six things: semiotic building,
word building, activity building, identity and relationships building, political
building, and connection building. Whilst all of these would be interesting to
study, some of these are seen as more relevant for this study, such as:

a. Connection building: What sorts of connections happened both
within and across utterances? Do the connections help with
building coherence?
b. Word building: How are (some of) the words used to situate meanings? Which words and phrases seem important? How are they used in connection building?

c. Relationship building: What relationships are relevant to connection building?

In Chapter 4 I referred to Gee’s (1999) proposition that meaning was situated and that language created the context and situation for how meaning was situated within the discourse. It had been acknowledged that exchange of meaning in mathematics was social, cultural and cognitive and this related to shared intentionalities. Hence the notion of building connections would seem important in creating the situation for sharing intentionalities. In order to determine how intentions were shared and meanings were exchanged, analysis of the functions of utterances was carried out, and in particular a search for patterns that suggested connection building and cohesion, both in cooperating socially and in exchange of meaning in mathematics.

Within the field of interactional sociolinguistics an interest is in the use of words and phrases. According to Gee (1999), language is made up of grammatical cues or clues that help negotiation and collaboration in an interaction. This meant a closer examination of the linguistic features and analysis across and between words and phrases. As stated by Halliday (1978), “In order to understand the nature of language, it is necessary to start from consideration of its use” (p.52).

Interpreting the social context of phrases required examination of the functions or the pragmatic intentions of utterances. An utterance was defined as a short sequence of dialogue or as an individual sentence or phrase. The interest was in the children’s use of language to do something (Finegan, 2011), in other words in the children’s speech acts. For example speech acts could be directives in issuing a command or directing someone to carry out an activity; they could be asking a question or giving an explanation. Such speech acts were seen as important in examining the children’s shared intentionality about mathematical ideas. Speech acts were also seen important in examining the
children’s social communication and in how they were acting as a member of a social group, how the children were building connections.

Functional grammar creates the cohesion within language; how sentences or phrases are linked together. Evidence of cohesion is in linguistic devices such as conjunctions, pronouns, demonstratives amongst others as has been considered in relation to SFL. As reviewed in Chapter 4, function words had been seen as indicative of shared intentionality and exchange of meaning. For example the studies by Rowland (1992, 1999, 2000) and Radford (2002, 2003) had identified deixis in particular as evidence of generalisation and in objectifying. Within this doctoral study, content words were identified as mathematical objects in order to categorise talk about mathematics, but the analysis of the exchange of meaning focused on the children’s use of function words. These fulfilled the examination of the children’s learning in two ways, first as a meaning potential and second as a comparison across the intervention. As has been noted in Chapter 4, content words are specific to a situation so would not be an indicator of change.

The analytical approach of the thesis was based on Gee’s (1999) model of connection building and word building and was tied to the children’s use of speech acts and grammatical devices. The use of speech acts and functional grammar was of interest in examining the meaning potential of the children’s talk. It was also realised that the exchange of meaning happened within a social context of independent group work so there was also a consideration of the relationship building that was happening.

The analysis was carried out by coding speech acts and by frequency counts of function word use within the independent pupil-pupil talk. These data were organised and interrogated using NVivo 9 research software. The children’s use of speech acts and word use was examined further in selected short episodes of talk based on both the transcripts and the video material. As such the analytical approach of the thesis was multi-perspective in that the focus was on different types of language processes. In addition these different perspectives were examined at different levels of specificity; hence the approach was also multi-level.
These levels of specificity were developed from an initial situational analysis of the lessons and the group work within it, to the examination of the speech acts within the independent pupil-pupil talk and to the analysis at word level in relation to functional grammar. These different levels were based on the multi-level approach of exploratory talk studies such as Rojas-Drummond et al. (2003). They are set out below in Section 6.5 and shown diagrammatically in Figure 6.1. In the next section I set out key points in the journey that was taken towards developing this structure.

6.4 Developing the structure of analysis for the doctoral study

As has been indicated the doctoral study used existing data from the TC Project. Initial attempts at the analysis for the doctoral study had been based on Mercer et al.’s sociocultural discourse analysis and the multi-level process presented by Rojas-Drummond et al. (2003).

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>An analysis of the interaction. All the video data and transcriptions were analysed in detail. The researchers used this to gain initial interpretations of the interactions within the group work and of how productive the problem solving was.</td>
</tr>
<tr>
<td>II</td>
<td>Level II was subdivided into Level IIA and IIB. In Level IIA analysis was of the types of talk that predominated, that is how well the talk most resembled exploratory talk, cumulative talk and disputational talk. In Level IIA analysis of the children’s use of the ground rules for exploratory talk were also carried out. In Level IIB features of the speech acts such as argument were analysed.</td>
</tr>
<tr>
<td>III</td>
<td>Level III was of the problem-solving behaviour. This combined quantitative analysis of performance on a standard task and also qualitative analysis of how the problem was solved in particular examples of pupil talk.</td>
</tr>
</tbody>
</table>

*Table 6.1: Multi-level approach to sociocultural discourse analysis after Rojas-Drummond et al. (2003)*

As there had been insufficient time to analyse all the video data in detail for the TC Project, I initially attempted a fuller analysis in the doctoral study and to code the mathematics talk according to the characteristics of the types of talk (exploratory talk, cumulative talk or disputational talk) in the independent pupil-pupil talk. Problems were encountered in using Mercer et al.’s analytical
approach related to the difficulty in defining a dominant type of talk. This had been realised to some extent in the TC Project as the children did not appear to follow the ground rules for exploratory talk explicitly and argument and reasoning were rarely evident.

I found that it was not possible to typify much of the talk or to arrive at a determination of which type of talk was most dominant. As it had been difficult to identify types of talk with any confidence, attempts to determine change in the talk were not possible. Further to this it was acknowledged that much of the talk was not directly related to the mathematics. This category of non-mathematics talk seemed important in examining the social aspects of the children’s communication but such talk had not been considered to any extent in Mercer et al.s’ studies. It seemed that a further approach was needed to supplement the analysis of type of talk.

Cobb’s (1995) work on small-group interaction had looked at differences in types of interactions. These examined the attempts of children to explain their thinking and, where there were conflicts among interpretations, how the children resolved these. Cobb’s analysis had distinguished between interactions where the interpretations seemed to be shared or where one child dominated. Hence the analysis of speech was related to mathematical or social authority in dominating the talk. Analysis was also related to direct collaboration or to indirect collaboration to indicate where it was felt that the sharing of interpretations or conflict resolution was happening or where the talk was from one child’s perspective. As it seemed that the children’s talk within the independent pupil-pupil talk of the TC Project had involved dispute and domination of a task, it was thought that this framework might be suitable for analysing talk that was not identifiable as exploratory, cumulative or disputational or to talk that related to managing the task. Hence a first attempt for analysis was based on types of talk from Mercer (2010), Rojas-Drummond et al. (2008) and Cobb’s (1995) approaches. A screen shot showing the first attempt at coding the talk is given in Appendix 4.

Within this first attempt the multi-level approach had been effective in examining the data from multiple perspectives. It enabled an examination of the context of the different classrooms as well as a more detailed examination of the talk.
However the coding of the children’s speech acts did not focus sufficiently on the functions of the talk. They were fulfilling a wider purpose in looking at a type of talk or a social status of the children. Hence a more inductive process was used to interpret the functions of the children’s talk and to code utterances as *speech acts*. This was informed loosely on research into young children’s peer talk such as Corsaro (1986) and so became a combination of inductive and deductive processes. Key to this had been Corsaro’s identification of speech acts in children directing each other in what to do (this was more specific than the idea of dominance), being helpful or controlling and also in children declaring or describing what they were doing. This was particularly significant in identifying speech acts in the mathematics talk that could not be considered as explanations but were related to the children talking about their mathematics or telling another child. This focus on the functions of the children’s talk would also include disagreement and agreement within the specific utterances, rather than determining if a section of the discourse was disputational or involved conflict.

Hence a structure of analysis was developed that was an adaptation of the multi-level discourse analysis of Mercer (2010) and as presented by Rojas-Drummond et al. (2003). Whilst the initial level of analysis according to the context and situation of the group work was maintained, the analysis of the talk in the next levels focused on the functions of the children’s utterances and on the children’s use of function words. It was also felt that this would support interpretations of the connection building and relationship building within the group sessions.

Mercer’s examination at the third level had been of the children’s problem-solving behaviour. In shifting the theoretical perspective in this doctoral study to a sociocultural perspective of learning in relation to objectification then the interest shifted from the problem solving as a process to the children’s shared intentions or exchange of meaning within the problem solving. So whilst it was still seen as important that the talk was productive in supporting problem solving, the interest was in how this became supportive within the functions of the words used. That is how the children mediated their learning socially and semiotically. Such an analysis of discourse would also be consistent with Gee’s
discourse theory and Halliday’s functional use of language in examining cohesive devices and in building connections and relationships.

6.5 Structure of analysis

Hence an adaptation of the multi-level discourse analysis, as carried out by Rojas-Drummond et al (2003; 2008), was developed. Whilst Level 1 was similar to the level of Rojas-Drummond et al, Level 2 focused on analysis of the children’s speech acts and Level 3 focused on the children’s learning by examining use of function words in meaning making. The three levels are summarised below and are also set out in Figure 6.1.

Level 1: Situational analysis.

The intention of the analysis at this level was to set the context of the pre and post intervention sessions for the ten transfer classes. This was consistent with interpretive analysis methods (Stake, 2010). Whilst the context was not the focus of the analysis, it situated what happened and acknowledged the idiosyncracies of the groups.

In carrying out the analysis at Level 1, the video material and transcripts from two lessons (one pre-intervention and one post-intervention) from each of the ten transfer classes were observed in detail. Independent pupil-pupil talk was identified and distinguished from talk that was directed by the teacher. Notes were made alongside the transcript to present a narrative of what was happening as the children were talking. This was used to refer back to when coding the transcripts. Initial aspects were identified in relation to the management of the lesson, the group session and the nature of the task. Notes were made to summarise impressions of the ways the children worked and talk together. Initial quantised analysis of the transcript data was carried out to determine if there was a change in the amount of pupil-pupil talk, what the children’s talk had been about (mathematics or managing the task) and if there had been a change in what the talk was about.

An example of the notes from this level of analysis is presented in Appendix 5.
**Level 2: Analysis of speech acts.**

The intention of the analysis at this level was to interpret the children’s speech acts, which are the functions of their utterances. At this level, analysis of the speech acts were coded to ‘direct’, ‘explain’, ‘agree’ or ‘disagree’ and so on. The transcripts for the pupil-pupil independent talk were coded and organised using NVivo 9. The coding structure is set out in Section 6.7 below.

Only independent pupil-pupil talk was analysed at Level 2, that is talk directed from one pupil to another or others, not talk directed to the teacher. The teacher may have been present, for example observing the group but the teacher was not involved in the talk. If the teacher became involved in the talk then the section of transcript related to the teacher pupil talk was not included. If a pupil talked to another pupil outside the group work this was coded as ‘off-task’. Coding was carried out with talk about the mathematics and talk about managing the task. Interrogation of the codes was carried out using NVivo 9 to determine the proportional frequencies of the speech acts. This enabled a search for any patterns. These patterns were examined in context by relating back to the transcripts, with support from the video material. Key points or commonalities were pulled out for consideration within a wider perspective.

**Level 3: Analysis of use of words.**

The intention of the analysis at this Level 3 was to identify children’s word use within the mathematics talk. Independent pupil-pupil talk in mathematics only was analysed at this level. The analysis was related to a study of the functional use of words and Halliday’s theory of SFL. Text searches in NVivo 9 were carried out to determine the frequency of words that would normally be associated with exploratory talk, such as agree and disagree, because and why. Word frequency counts were carried in NVivo 9 to identify function words that were used more frequently and to determine if this frequency changed over the intervention.

As stated earlier, word counting is fairly rudimentary and so analysis was carried out regarding the use of these words as the children engaged in problem solving in mathematics, with the intention to understand how the
children were using these words to exchange meaning in mathematics. Hence the meaning potential of the function words were examined within examples of dialogue. These were examined across the groups. Examples of dialogue from pre intervention and post intervention sessions were studied to determine any changes in use across these situations. In relation to the literature on children’s use of function words (Bills, 2001; Radford, 2002, 2003; Rowland, 1992, 1999, 2000) a focus was on use of causal connectives and the deictic use of pronouns and demonstratives. A further use of modal verbs also became apparent in the children's talk, but this has not been referred to in the literature.

Word frequency queries and text searches were carried out in NVivo 9 to determine the children’s use of function words and also to determine any changes in use over the intervention.

![Diagram showing multi-level analysis]

**Figure 6.1: Multi-level analysis of the doctoral study**
6.6. The data set: selection and reduction

The doctoral study was based on a subset of the original data set of the TC Project. Video material was selected from the ten transfer schools A, B, C, D, E, F, H, I, J, and K. Schools G and L were the development schools and the pattern of videoing was not carried out in the same way and so they were not used for this study. Three lessons from nine of these schools were transcribed and two lessons from school C (a video of the third lesson was not possible due to access to the school). Contextual information for each of the schools is presented in Table 3.1 in Chapter 3.

Figure 6.2: Data selection for the doctoral study

From these ten transfer schools video material and transcripts from the pre-intervention and one post-intervention lesson were examined. The elapsed time between these two lessons was at least two months. The pre intervention
session was videoed before the ground rules for exploratory talk had been introduced and the second lesson was videoed between six weeks and two months after the introduction of the ground rules. The children had been engaging in mathematics group sessions based on the ground rules twice a week over this period. In the Level 1 analysis it was found that in School H there was no independent pupil-pupil talk in either the pre intervention or the post intervention session, so this school was not used further in the analysis. It was also found that in Schools C, D and J there had been no evidence of pupil-pupil independent talk in the pre intervention session, although there was evidence of independent pupil-pupil talk in the post intervention session. It was also noted that in some schools it had not been possible to record the group session of the same children, due to factors at the schools. However all the children who were included in the video material had worked with the ground rules for exploratory talk during the intervention. The process of data selection and reduction is shown diagrammatically in Figure 6.2.

<table>
<thead>
<tr>
<th>School</th>
<th>Sessions used in analysis</th>
<th>Year Group</th>
<th>Group sessions used in analysis with pseudonyms of children</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A1 &amp; A2</td>
<td>Y2</td>
<td>Diane, Emma, Olwen</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Diane, Emma, Olwen</td>
</tr>
<tr>
<td>B</td>
<td>B1 &amp; B2</td>
<td>Y2</td>
<td>Lucy, Jane, Ann</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mary, Jane, Ann</td>
</tr>
<tr>
<td>C</td>
<td>C2</td>
<td>Y1</td>
<td>Alan, Brenda, Eve</td>
</tr>
<tr>
<td>D</td>
<td>D2</td>
<td>Y1</td>
<td>Harry, Joe, Vera</td>
</tr>
<tr>
<td>E</td>
<td>E1 &amp; E2</td>
<td>Y1</td>
<td>Alex, Mandy, Ellie, Lara</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Chas, Mandy, Lara</td>
</tr>
<tr>
<td>F</td>
<td>F1 &amp; F2</td>
<td>Y1</td>
<td>Avril, Libby</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Avril, Libby, Colin</td>
</tr>
<tr>
<td>I</td>
<td>I1 &amp; I2</td>
<td>Y1</td>
<td>Harvey, Jack, Martin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Harvey, Jack, Martin</td>
</tr>
<tr>
<td>J</td>
<td>J2</td>
<td>Y1</td>
<td>Cleo, Tanya, Yvette</td>
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<td>K</td>
<td>K1 &amp; K2</td>
<td>Y2</td>
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<td></td>
<td></td>
<td>Fran, Iris, Pierce</td>
</tr>
</tbody>
</table>

Table 6.2: Summary of the group sessions from the 15 lessons

The resulting data set for the Level 2 analysis were from 15 lessons and are set out as follows. They are also summarised in Table 6.2 with the children involved (pseudonyms are used).

- Two group sessions from schools A (A1 and A2), B (B1 and B2), E (E1 and E2), F (F1 and F2), I(I1 and I2), K (K1 and K2) (where 1 stands for the pre-intervention lesson and 2 stands for the intervention lesson).
• One group session from the post-intervention lesson from schools C (C2), D (D2), J (J2). There was little or no independent pupil-pupil talk in the pre-intervention lesson in these schools.

• The groups of children from schools C, D, E, F, I, J were younger Year 1 children (aged six years old) and the children from Schools A, B, K were older Year 2 children (aged seven years old).

Selection and reduction of the data to use for the doctoral study is recognised as part of analysis. As the researcher I had decided which data to work with. As Miles and Huberman (1994) stated, such data reduction “sharpens, sorts, focuses, discards and organises data” (p.10). The use of transcripts is also a method of data selection and reduction as they provide only the verbal interaction that has been understood by the transcriber. I had also reduced the data further by selecting the independent pupil-pupil talk within these lessons for the main levels of analysis. I had defined independent pupil-pupil talk as the talk that is directed by one pupil to another or others. In doing this I was “constructing a certain version” of the talk to be analysed (Taylor, 2001, p. 38). I had selected what to include and what not to include.

![Figure 6.3. Further data selection in the multi-level analysis](image-url)

138
The data was further selected according to the interest of the analysis in both the speech level and word level analysis. Whilst the whole of the lessons had been observed in Level 1 analysis, the speech level analysis (Level 2) had focused on the independent pupil-pupil talk and the word level analysis (Level 3) had focused on the talk about the mathematics. See Figure 6.3.

6.7 Analytical tools

The video data from the TC Project provided a visual record of the social situation where the interactions could be observed as sequential events. Although there are techniques for structured microanalysis of video material, the body of video data was too large for such examination and much of the analysis was from the transcripts of the mathematics talk. The video material was used to check the accuracy of the transcripts and to help interpret the functions of utterances as children worked on the tasks. In the Level 3 word analysis a small selection of the mathematics talk was revisited in relation to the video material as the interest was in the children’s use of language as words, signs and gesture.

Electronic methods were used for sorting and organising the transcript. Comparisons of coding using NVivo 9 that were employed as tools for analysis were matrix queries, word frequency queries and text searches. Codes were given to utterances as “tags or labels for assigning units of meaning” (Miles & Huberman, 1994). As stated on p. 122, an utterance was defined as a short sequence of dialogue or as an individual sentence or phrase and the meaning of an utterance related to its function as interpreted within the context of the transcript. These codes defined the utterances as speech acts. The codes for the speech acts had been developed both inductively and deductively as explained in section 6.4. The final version of the coding as used in NVivo 9 is set out in figures 6.4 – 6.6 below and brief descriptions are given of the features of the talk that were looked for in interpreting the functions of the utterances.
**Coding for ‘what the talk was about’**

**Children:** Coded by school letter and pseudonym (A Diane; B Lucy; C Eve) to enable other codes to be linked to individual children so that each child’s participation within the group could be analysed.

**Off Task:** Talk that was not related to managing the task, the mathematics or to cooperating with each other. For example talk was about other children, dinner/play time, hobbies and interests that were not related to the task.

*Examples:* Look you’re on camera; Oh I’m hungry; We’re on green table; What do you like, Transformers?; I’m going to get my water bottle

**Maths:** Talk that was about mathematical objects (numbers, counting, operations) suggesting or describing processes, giving solutions, stating if something is correct or not, reading out problems

*Examples:* Five multiplied by five equals ten; Yes, exactly, going to have to count it to work it out; Seven, now this one, there are three left look; So it’s seven isn’t it?; There was ten worms; It is right though!; Yea, so that’s one isn’t it?

**Managing:** Talk that indicated how the children were organising the completion of a task. What to do? How to do it? Which steps to take in completing the task? How to use resources? How to carry out written recording? This may include talk that involves numbers but relates to how the resources are managed rather than the mathematics
Examples: Just rub that out; Shall we have another go; We have to draw the real thing now; Oh spread them around a bit then; We need to make the word problem; Just let me write the answer down somewhere; How can we add the box there; Put them over here

**Cooperation:** Talk that indicated how the children were cooperating as a group. Who is doing it? Whose turn it is, who uses resources and who records the work.

Examples: Let me have a go, I haven’t, I need my go; Then you can pass it on; Why are you copying mine?; Which turn do you want?; I’m doing it; You’ve already got it; That one’s yours; I’m going to put one; Do you mind? You put them in a group; No let me...; Who wrote this? Is this yours? There you go

**Talk about talk:** ‘Meta talk’, talking about the talk. How the pupils were using the rules for good talk such as the explicit use of ‘agree’. This can overlap with **Maths** talk, for example the children explicitly state ‘do you agree’ in relation to a solution of a problem

Examples: Why are you talking to me?; She says so; I’m not speaking anymore; Shush, shush; So do we all agree? I disagree;

**Subjective comment:** Talk that suggested emotion and/or identity.

Examples: Nice and easy; It’s like I’m the master; Oh yea, Emma’s good at that; Because I can’t do it, you can do it; This is a good game; Well we’re going to have to help you; I don’t know; I don’t know how; This is hard

‘Off task’, ‘maths’, ‘managing’ and ‘cooperation’ were coded discretely but ‘talk about talk’ and ‘subjective comment’ could be coded with ‘maths’ or ‘managing’ or ‘cooperation’. ‘Management’ and ‘cooperation’ were used collectively as ‘non-maths’ talk and so ‘talk about talk’ and ‘subjective comment’ were included in ‘non-maths’ talk.
Coding for ‘non-maths’ speech acts

Figure 6.5: Speech acts coding for ‘non-maths’ and talk

**Agree** Children were agreed or reached an agreement in cooperation (how the group interacts, how to take turns, who uses resources, who carries out the recording) or in managing the task (what to do, how to record). This was often determined through the sense of a piece of narrative and included terms such as:

*Examples:* Yes that’s what I was thinking; That’s what I said; Ok; Yeah, Yea, we’re only doing one thing; I think so

**Disagree** Disagreement in how the group cooperated (whose turn is it, who should use resources and who is talking) or in the management of the task (what to do). This was often determined through the sense of a piece of narrative but often included terms such as:

*Examples:* I’m not; No you don’t; I’m doing it; Don’t, stop it!; No you can’t, No we’re not; We don’t need that
**Directing** One or more children were telling the other children what to do or who does what, such as what turns to take. This was further coded as:

**Facilitating** Directions that were intended to give further suggestions or help to resolve a dispute. Supportive in organising the way the children cooperated or in managing what needed to be done. This could be coded with ‘agree’.

*Examples:* Well we could; Well let’s have a look; So how do we work it out? I know, carry on from the lines; Put them back shall we... So can you try doing bigger circles; It’s ok, you can do it however you want; Then you can go first then

**Control** Controlling the way the group worked together (cooperation) or in what needed to be done (managing). Pupils could be controlling the ideas or initiating directions. This could be coded with ‘disagree’.

*Examples:* Have to put these back then; Just rub that out; Just do...; I’m going to read this and we have to figure out if that’s right; We start again; Miss said we don’t need that; We’ve all got to do it; I’ll tell...; Write it; No we’re not, we need to sort it out; Wait...; You put what you think; Come on it’s my go now isn’t it?; It’s all of us; Just because she did, it doesn’t mean everybody has to take in what she says, ‘cos..

**Question** Direction given as a question, this may be controlling or facilitating

*Examples:* Yes, shall we do a dot? What do you think? Ok, what do we do?

**No Collaboration** Speech acts coding for ‘managing’ if talk is related to child(ren) managing the task individually. This is determined from viewing the video but can be evident in the talk

*Examples:* But I’m going to carry on; I’ve just finished

Speech acts coding for ‘non-maths’ talk were not mutually exclusive, apart from ‘disagree’ and ‘agree’ as utterances cannot be both. For example a piece of narrative could have multiple codes such as Direct/Control/Dispute or Direct/Question/Agree
Coding for ‘maths’ speech acts

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<th>Nodes</th>
<th>Sources</th>
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<td>Managing</td>
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<tr>
<td>Responding</td>
<td>15</td>
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</tr>
</tbody>
</table>

Figure 6.6: Speech acts codes for ‘maths’ talk register

**Directing** One or more children were telling other(s) how to do the maths, giving the mathematical ideas.

 Examples: No two do, five, two, five, two, five divided by two; You start with the biggest number, We’ve got to put eight, seven; Two times eight, come on, two times eight; I told you that there was nine in that one and ten in that one; So you have to make a line; And then you write 24; We’ve got to count; So we match them up now

**Calling attention** Talk that drew the other children’s attention to a number or idea.

 Examples: Look...it is; There are three left look; Look, 15 flies were on a cake; So sixty take away two; 10p. There’s 10p; This equals 6; That equals 12; That one’s the one
**Describing** Talk related what the child(ren) was doing or thinking (e.g. counting), relating the mathematical tasks set (reading out the questions), giving an account of recording or thinking aloud.

Examples: Two, share between two; Double seven; Two four six; One, two three four five six seven, one two three four five six seven; Take away four; Mm, that leaves 1 2 3 4 5 6; How many were there altogether? Right, I think how many numbers are left? I get 23; I'll count how many. 1, 2, 3, 4, 5, 6, 7, 8. I've got eight; I think it’s going to be 2001

**Explaining** Talk goes beyond description and gives an exact meaning of a mathematical idea

Examples: No there has to be like a line between them because the four of them have been taken away; So you can take away like three then take away a two; Then you’d have 1 2 3 4 5 6; So there’s just one left then you add 3 sweets at the end; So we have 3 boxes and then two eggs in another box; No cause it's multiply.

**Questioning** Asking a question about a mathematical idea or checking if a solution is correct. Questions could be to another child but not always, some are individual as the child is thinking aloud.

Examples: Ok, so six, what is the multiplication? So it’s seven isn’t it?; Why do you have those dots? How many were there? Do you think it’s that one? Do you get 25? Have we got two the same? Does that make 10?

**Agree** Talk that indicated children were agreeing with each other’s ideas in mathematics. This was often determined through the sense of a piece of narrative but often included terms such as:

Examples: Yeah, that’s what I think; 20 add 5, yes, great. 1, 2, 3, 4, 5; Yea, yea; That one equals.... so are we all happy with that? Now look she’s right; Do you agree it’s 5p?

**Disagree** Talk that indicates children are not in agreement or in dispute about their ideas in mathematics. Comes from the sense of a section of narrative but often includes:
Examples: No there has to be...; We don’t need...; Yes we do; No, I mean about that; This isn’t right; But there are 20 eggs; I’m not doing 25, I get 23; No it’s seventy; No, there’s two more 10ps; This one’s wrong

Responding This coding was for extracts of dialogue when children were responding to each other over a sequence of utterances. This made a distinction between sections of dialogue where children were working together on a task but giving individual descriptions, questions or directions, that is not responding to each other and sections of dialogue were the children were interacting:

Examples: Ok, you said two; You mean six divided by two equals three; Seven, you put seven in each; Where? Where? I can’t see eleven on it; I know but you can take away like a three then take away one; I do know what you’re saying, that’s it altogether; Is it that one?... Yes, it’s definitely that one; You get it?... Yeah.... 3, 6 make 18; Now look she’s right

No collaboration Talk suggested the children were not working on the task together. This is often determined from viewing the video but can be evident in the talk.

Example: You could have done it like me; I’ve just done it up to 23; m I’m going to do it my way.

6.8 Validity

Whilst interpretive research methods involve the researcher in a subjective way, personal experience and understanding of the situation are used in making interpretations (Stake, 2010). In analysing the children’s talk I could not know for certain what the function of the children’s speech acts were, for example I could not know for certain if an utterance had been a question or a direction. However strands were employed in the analysis to increase confidence in making the interpretations. One strand was the integrity of thinking and my struggle with deciding on the children’s intentions and meanings behind the speech acts (Stake, 2010). The analysis of the children’s talk was an account of a social phenomenon within a particular situation and so “inevitably reflected the
observer/researcher’s partial understanding and special interest” (Taylor, 2001, p. 12).

Whilst it is recognised that neutrality was not possible there was a need to be self-aware and to imagine stepping back to “observe oneself as an actor within a particular context” (Taylor, 2001, p. 17). In stepping back and attempting some sort of objective stance, theory and other findings from research literature were used to inform the interpretations of the children’s intentions. Taylor stated that, whilst discourse analysis is not a neutral, technical form of processing, it “always involves theoretical backgrounding and decision making” (p.24). This suggested a level of agreement in developing the research methods and the tools for analysis in relation to theory of discourse analysis. A level of agreement was also reached in discussing the findings in relation to other theorists and researchers in the field of functional language in mathematics education.

A second strand to increase confidence involved elements of triangulation through the use of both qualitative and quantised data. Gee and Green (1998) proposed validity was further based on convergence and coverage. Within convergence the intention was to analyse the data in different ways; the coding of phrases, word counts and the analysis of episodes of talk. This supported a level of triangulation (Miles & Huberman, 1994). Various perceptions were seen to be compatible and to support a common conclusion. Coverage was intended through the relation of the data to the situation and the contexts of the talk in the classroom. Data could have been further validated by seeing if interpretations were commensurate with the children’s own interpretations but this had not been possible here.

Interobserver reliability of the coding of phrases was also carried out by Dr Fisher, my lead supervisor, with the transcripts of independent pupil-pupil talk for group B’s pre-intervention and post-intervention group sessions. Inter-observation reliability measure was determined by Agreements/(Agreements + Disagreements) x 100. This was measured at 80% for coding for ‘what the talk was about’. The main disagreements in these codes were with the use of ‘subjective comment’ and in distinguishing between ‘cooperation’ and ‘managing’. However there was general agreement between ‘maths’ and ‘non-
maths’ talk, so when carrying out quantitative comparative analysis ‘management’ and ‘cooperation’ were used together as ‘non-maths’ and became seen as social talk. Both of these related to completion of the task rather than talk about mathematical objects or processes. It was felt that the coding for ‘directing’, ‘control’, ‘dispute’ and ‘agree’ were more critical in looking at affordances and constraints and there was more agreement in the coding of these. Utterances coded as ‘subjective comment’ were not used frequently by the children and were not used quantitatively for comparison purposes.

The reliability measure for speech acts coded within the ‘maths’ talk utterances was 80% for the pre-intervention group session B1 and 70% for post-intervention group session B2. The disagreements in coding led me to further rationalise my decision making so that I was more confident that I was being consistent. For example, there was disagreement in coding utterances where children read aloud given mathematics questions and whether this should be coded as ‘describing’ or ‘directing’. Within this thesis I rationalised this as ‘describing’. Other disagreements were with coding for ‘responding’ and whether these were with individual utterances or over a sequence of dialogue. Within this thesis I used ‘responding’ over a sequence of dialogue where the utterances suggested interaction. Other differences were with ‘description’ or ‘explanation’ and it was rationalised that the use of conjunctions or modal verbs suggest an ‘explanation’ rather than a ‘description’. Whilst these distinctions for the differences in coding have been rationalised within my interpretation, they need to be taken into account when drawing patterns from quantised and comparative use of the data.

Within discourse analysis, validity is not constituted by “arguing that analysis ‘reflects reality’”... “The analysis interprets its data in a certain way, and those data, so interpreted render the analysis meaningful in certain ways and not others” (Gee & Green, 1998, p. 159). Hence it is recognised that the data are related to particular situations and to my interpretations.

6.9 Ethical issues

In planning the TC Project advice was sought from the University of Exeter, School of Education and Lifelong Learning Ethics Officer and ethical approval
was obtained from the School Ethics Committee confirming that the proposed research met the ethical guidelines set out by BERA. Ethical considerations for the TC Project are set out in Chapter 3 and a copy of the ethical approval form can be found in Appendix 2. This had taken into account the main issues of care for the participants and the danger of violation of privacy. Consent had been obtained from parents and teachers (copy of the consent letter is in Appendix 3) and the teachers took care in selecting children where consent had been obtained for the use of video recording.

However in carrying out the doctoral study I was aware of how these issues may have been played out in the research. The research project had been intended as part of the classroom practice of that teacher. This meant that teachers’ professional decisions had to be taken account of in making research decisions. The impact on the doctoral research was that in some cases the children were not the same in both the pre-intervention and the post-intervention sessions. The teachers had also made decisions regarding the mathematics task and some seemed more conducive to problem solving than others. The teachers had also made decisions in how to use exploratory talk and how much independent pupil-pupil talk they should manage in their classrooms. For example in School H the teacher had not used exploratory talk within group work independent of the teacher, hence there was no evidence of independent pupil-pupil talk in the post-intervention session.

As this was part of the teachers’ practice it was not felt that the children were involved in anything that was beyond the normal scope of the classroom. However this in itself has implications ethically. Consent was obtained from the children orally but it was recognised that within a classroom context the adult is traditionally seen in authority. This was particularly the case with the classroom teacher. As a researcher it was possible not to reinforce this authority position so strongly but this may not have been the case with the teacher. Even so it always seemed that the children were eager to take part and there were no cues verbal or non-verbal that suggested otherwise.

As an intervention there had been ethical issues in the selection of pupils. It is assumed that the intervention was to improve the educational process in some way so why should some children benefit from this and not others. The teachers
had selected children that they felt needed this support so in some sense there was an attempt to be equitable in helping these children access mathematics. In many cases the teachers used the strategies for exploratory talk with the whole class, even though the focus was on the six children, or if not they intended to take the practice to the whole class once they felt confident with the management of independent group work. Hence it was often the case that these strategies were not used exclusively with the children in these groups.

A further consideration was in the analysis of the children’s talk in the doctoral study. Care had to be taken with qualitative data more so than with quantitative data due to the “intrusiveness of the personalistic methods of qualitative research” (Stake, 2010, p. 203). Whilst the data was managed anonymously and pseudonyms have been used throughout, the talk corresponds to individual children. Hence an issue of concern was in interpreting the children’s intentions with a respectful judgement. I needed to keep in mind the potential multiplicity of the meanings of the children’s talk. I needed to be aware that these were my interpretations of what the participants meant in their discourse or their actions and that my interpretations were those valued by me within a theoretical framework. This was particularly the case as I was using existing data and was not able to collect further data or to refer to the participants for further clarification of meaning.

6.10 Summary

In this chapter I have rationalised the research methods that were used for the TC Project and set out the analysis methods for the doctoral study. I have explained how they built on a constructionist methodology and an interpretivist paradigm and how they were based on theories of discourse analysis. I have also set out the multi-level process of analysis that has been adapted from work by that of Mercer (2010) and Rojas Drummond et al. (2003; 2008). In using a multi-level approach the data was further selected and reduced by looking in more detail at the children’s talk. In my adaptation of this multi-level approach codes were developed inductively but also deductively in referring to Corsaro’s (1986) identification of speech acts of young children. I also referred to the theories of Gee’s interactional sociolinguistics (Gee, 1999) and Halliday’s SFL
(Halliday & Matthiessen, 2004). These have been further linked to children’s functional use of language in learning mathematics.

As such the analysis of the functions of the children’s language has been used to examine the cohesive devices in the children’s exchange of meaning in mathematics in relation to the research foci:

- how the children exchanged meaning in mathematics within the independent pupil-pupil talk, and if the intervention changed the way the children exchanged meaning.
- the social (including emotional), cultural and cognitive aspects featured in the exchange of meaning and how the intervention changed the way these aspects featured in the exchange of meaning.
- the function of language in young children’s exchange of meaning
- if the intervention changed the function of the language and if so how this changed the social, cultural and cognitive aspects featured in the exchange of meaning.

And from the research questions that had been developed from the review of the literature and theoretical perspectives, as presented in Chapter 4.

- Were there similarities or differences in the nature of talk, both social and academic, between different groups of children?
- Were there changes in the nature of talk, both social and academic, between the pre-intervention and the post intervention sessions?
- Was there evidence that these changes, both social and academic, supported the children in working collaboratively and productively on the mathematics tasks?
- How did the children use language to share intentionalities and exchange meanings?
- Did the intervention change the way the children used language to exchange meaning?
- Which words were used to support the children’s shared intentions and exchange of meaning?
- How did these relate to generalisations?
<table>
<thead>
<tr>
<th>Level</th>
<th>Purpose in relation to research questions</th>
<th>Data and analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Situational</td>
<td>Initial interpretations from observations of video data and transcripts</td>
<td>• All video data and transcripts from ten transfer classes</td>
</tr>
<tr>
<td>analysis</td>
<td>• Similarities or differences in the nature of talk across the groups</td>
<td>• Low level analysis with large corpus of data</td>
</tr>
<tr>
<td></td>
<td>• Changes in the nature of talk between the pre-intervention and the post intervention sessions</td>
<td>• Qualitative analysis of initial impressions</td>
</tr>
<tr>
<td></td>
<td>• Evidence that the changes supported collaboration and productive problem solving</td>
<td>• Quantitative analysis of amount of talk and proportions of talk in mathematics and non-mathematics.</td>
</tr>
<tr>
<td>2: Speech level</td>
<td>Systematic interrogation of speech codes:</td>
<td>• Transcripts of the independent pupil-pupil talk of the nine classes (15 group sessions)</td>
</tr>
<tr>
<td></td>
<td>• Similarities or differences in the nature of talk across the groups</td>
<td>• NVivo 9 organisation of codes</td>
</tr>
<tr>
<td></td>
<td>• Changes in the nature of talk between the pre-intervention and the post intervention sessions</td>
<td>• Low level quantitative analysis to determine frequencies of speech acts in all 15 group sessions</td>
</tr>
<tr>
<td></td>
<td>• Evidence that the changes supported collaboration and productive problem solving</td>
<td>• High level qualitative analysis of samples of dialogue to examine the collaboration and mathematical talk</td>
</tr>
<tr>
<td></td>
<td>• Use of language to exchange meanings within the nature of the talk</td>
<td></td>
</tr>
<tr>
<td>3: Word level</td>
<td>Systematic interrogation of use of function words:</td>
<td>• Utterances coded as mathematics talk</td>
</tr>
<tr>
<td></td>
<td>• Word use to support shared intentions and exchange of meaning</td>
<td>• Low level analysis in counting words</td>
</tr>
<tr>
<td></td>
<td>• Word use related to generalisations</td>
<td>• High level analysis of small samples of dialogue to examine word use in generalisations</td>
</tr>
<tr>
<td></td>
<td>• Changes in word use</td>
<td></td>
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<tr>
<td></td>
<td>• Evidence that changes in word use changed the way children exchange meaning</td>
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</tbody>
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Table 6.3: The research questions in relation to the multi-level analysis
7.1 Introduction

In this chapter I present the findings from the Level 1 situational analysis. In working across multiple cases the aim was not to lose the idiosyncrasies of each case. Within this doctoral study idiosyncracies were acknowledged by looking at the different classroom situations, the teacher management strategies and the nature of the tasks in relation to the intervention within each group session. These were not focused on as the content of the data. The thesis did not intend to investigate these as factors but to situate the children’s discourse to better understand what was happening (Stake, 2010).

Throughout the analysis the pre-intervention group sessions were indicated by the class letter and the number 1, as in A1, and the post-intervention group sessions were indicated by the class letter and the number 2, as in A2. The year groups Year One (Y1) and Year Two (Y2) are also noted.

The transcripts were reviewed along with the video data to check for accuracy (but again this would be my understanding of what was said) and notes were given alongside the transcript as a narrative of non-verbal actions and events. Again this was a selection and reduction of data as I noted what I saw as important. I also summarised my impressions from the lessons, an example is presented in Appendix 6. These were used for contextual and situational
information in order to understand the circumstances and the situational background to the talk within the group. As such the context of each class and situational experiences of the group are given in the analysis and results Chapter 7. The content data, that is the transcripts and videos of the independent pupil-pupil talk, are further analysed according to the methods indicated in Chapter 7.

In this doctoral study the first level situational analysis identified:

- Key aspects related to different situations within the fifteen group sessions. These were taken from notes whilst observing the video material of the whole lesson.
- Initial analysis of changes in the talk:
  - Determining changes in the amount of talk by counting number of utterances.
  - Analyses of the codes in NVivo 9 for ‘what the talk was about’; ‘maths’, ‘non-maths’ and ‘off-task talk’

### 7.2. Key aspects related to the different situations

In the analysis of the TC Project the different classroom situations had not been outlined in a systematic way. In this doctoral research I present them under the following aspects:

- Time and management of the lesson: balance between amount of whole class teacher input, teacher involvement within the group and independent group work.
- Time and management of the group work: amount of teacher involvement.
- The nature and content of the task: the key mathematical ideas and the nature of the task
- Initial observations related to the talk and collaboration.

A table showing key points taken from video observations are given in Appendix 5 and a summary is outlined below.
**Time and management of the lesson**

In the videoed sessions observed for this doctoral study each lesson had a period of whole class teacher input, apart from two of the classes (E2 and K1). Sessions E2 and K1 were *stand alone* group sessions and were not part of a mathematics lesson. The mathematics lessons lasted from 30 minutes to one hour and most were 40 to 50 minutes long. This would be typical of a *Numeracy* lesson as directed by the National Numeracy Strategy (NNS) (DfEE, 1999) and the Primary National Strategy (PNS) (DfES, 2006). Where there was a whole class teacher input this was between 5 minutes and 35 minutes with most being approximately 20 minutes.

**Time and management of the group work**

The group sessions lasted between 20 minutes to 30 minutes. In some cases there was very little teacher involvement in the group sessions, for example in the sessions for classes B and F this was only the odd minute or so. In other group sessions the teacher was involved in the group work more frequently, for example in the sessions for class K the teacher often questioned the children but then sat back to observe and listen to the children. In some of the pre-intervention sessions the teacher directed the group work. In classes C, D, and J the teacher direction meant there was no independent pupil-pupil talk. All the talk was between the teacher and the pupil. In classes E and I the teacher directed most of the task and the talk but left the group for short periods and there was some independent talk. In classes A, B and F teacher involvement and direction was short. In class H there had been no evidence of independent pupil-pupil talk in either the pre-intervention of the post-intervention session so this school was not used further in the analysis of this doctoral study.

**The nature and content of the tasks**

As has been stated the TC Project was based on a practical rather than technical methodology and there were no prescribed tasks for the teachers. The teachers had guidance in developing tasks but they adopted and adapted ideas that they thought were suitable for the children in the focus groups. The content of the tasks varied according to the class and school’s curriculum requirements.
These were based on the NNS and PNS. The nature of the tasks were categorised according to how open or closed they were as follows:

- **Closed** - one predetermined solution and a strategy has been directed
- **Directed strategy, > 1 solution** – there are multiple predetermined solutions, strategies have been directed
- **Open strategy, 1 solution** – there is one predetermined solution, strategies have not been directed
- **Open strategy, > 1 solution** – there are multiple predetermined solutions, strategies have not been directed
- **Open ended** – no predetermined solutions or directed strategies

<table>
<thead>
<tr>
<th>Closed</th>
<th>Directed strategy &gt; 1 solution</th>
<th>Open strategy 1 solution</th>
<th>Open strategy &gt; 1 solution</th>
<th>Open Ended</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 (Y2) Solving word problems for division</td>
<td>C2 (Y1) Finding number bonds to 10 with dominoes</td>
<td>B2 (Y2) Grid puzzle for counting in multiples</td>
<td>A1 (Y2) Representing doubling and halving</td>
<td>A2 (Y2) Representing word problems for addition and subtraction</td>
</tr>
<tr>
<td>I1 (Y1) Counting sets of cubes in tens</td>
<td>K1 (Y2) Representing multiples with materials</td>
<td>E2 (Y1) Ordering and positioning on a 3 x 3 grid</td>
<td>E1 (Y1) Place value represented on 100 square</td>
<td>D2 (Y2) Partitioning sets of counters up to 12</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>I2 (Y1) Matching values of sets of coins</td>
<td>F1 (Y1) Place value represented on 100 square</td>
<td></td>
<td></td>
<td>K2 (Y2) Finding solutions to equalities</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J2 (Y1) Estimating length</td>
<td>F2 (Y1) Partitioning numbers up to 16</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 7.1: Nature and content of the mathematics tasks*

The mathematics tasks from each of the group sessions were allocated to one of these categories. These are presented in Table 7.1 along with a brief description of the mathematical content of the task. Further details about the content of the tasks are presented in the table of key aspects in Appendix 5. According to the interpretations of the nature of the tasks it seemed that closed tasks were used in the pre-intervention sessions whilst the open-ended tasks were used in the post-intervention sessions. However there is no hierarchical sense in the categories with one being better than the other and this doctoral study does not aim to hypothesise any relationship between the children’s talk
and the different nature of the tasks. These were intended as presenting the context. The interest of the doctoral study was in the mathematical processes that the children were involved in rather than the specific content of the mathematics. However the tasks were viewed as part of the situational context and aspects of the tasks are considered in the discussion on children’s learning in Chapter 10.

**Initial observations related to the talk and collaboration**

Talk in both the pre-intervention and post-intervention independent group sessions was not always about mathematics. Other talk was on sharing resources and turn taking. Individual children appeared to dominate the management of the task and turn taking and there were arguments related to this in some groups. In most groups it appeared the children were collaborating rather than working individually and this did seem more apparent in the post-intervention group sessions, apart from group session B2 and in class H where there was no independent pupil talk in the post-intervention session.

It was difficult to identify the characteristics of the talk as exploratory or cumulative. Disputes or ‘squabbling’ often occurred but this was related to the management of the task and turn taking. Dispute about the mathematics was not so evident. The children were talking about their mathematics as they were carrying out the tasks and they were checking solutions for problems with each other. This seemed to be more evident in the post-intervention sessions. It appeared that there was some indication of children giving explanations in the pre-intervention sessions which do not occur in the post-intervention sessions. There were occasional moments when it was felt that the children had gained some insight in working together but these seemed infrequent and it was difficult to determine the learning that was happening. Examples of the children’s explanations and insights in working together were examined in more detail and are presented in the next two Chapters in relation to speech acts and word use.

From observations of the video material for this doctoral study key points related to the different situations were:
• In the three Y2 classes (A, B and K) the children had experienced independent pupil-pupil talk prior to the intervention. Only one Y1 class (school F) had this experience.

• In classes E and I there had been some independent pupil-pupil talk prior to the intervention but the children had been reliant on the teacher’s direction with only short episodes of pupil-pupil talk.

• In classes C, D and J there had been no independent pupil-pupil talk in the pre-intervention lessons. Analysis for these groups only examines the post-intervention group session.

• In classes A and B there had been little change in the structure of the lesson. In classes C, D and J there had been little or no independent talk so there was a substantial change in the way the groups were expected to work.

• In class H there was no independent pupil-pupil talk in either of the lessons. This class was not used further in the analysis.

• There were more extensive periods of independent pupil-pupil talk in most of the post-intervention group sessions.

• Talk in the group sessions was not always about mathematics. Other talk was on sharing resources and turn taking. Individual children appeared to dominate the management of the task and turn taking and talk about managing the task was disputational at times. This was more evident in some groups.

• It was difficult to identify the characteristics of the mathematics talk as exploratory, cumulative or disputational.

• There was some indication of explanations given in the pre-intervention sessions which do not occur in the intervention sessions.

• It seemed that children were talking about the solutions for problems with each other more in the post-intervention sessions.

In reviewing the video material and the transcripts from the TC Project, there seemed little evidence that the intervention had developed exploratory talk but
these were general impressions. There was still the impression that something had changed but it was not clear what.

This analysis of the key aspects from the different classroom situations has furthered the analysis of the TC Project. It has presented a systematic overview of the management of the lessons and the length of time the children were engaged in independent pupil-pupil talk. It has also presented a way of analysing the nature of the mathematics tasks. The findings from this analysis could be said to confirm the impressions that we had as a research team, but did not take the understanding of what had happened further. As such the analysis is presented to inform the context of the doctoral study.

7.3 Initial analysis of changes in the talk

7.3.1. Changes in the amount of talk

Situational analysis of the video material showed that there was an increase in the length of time that the children engaged in independent pupil-pupil talk in nine of the ten transfer classes. In class H there had been no independent pupil-pupil talk in either of the pre or post intervention sessions. In some cases this increase was from none or very little to a substantial amount. To determine if the children were talking more together the transcripts were examined using NVivo 9 to count the frequency of turns taken within the independent pupil-pupil talk. Table 7.2 shows the frequency of turns taken within the pupil-pupil group talk for each of the nine classes and the proportional changes from the pre-intervention to the post-intervention session.

<table>
<thead>
<tr>
<th>School</th>
<th>A (Y2)</th>
<th>B (Y2)</th>
<th>C (Y1)</th>
<th>D (Y1)</th>
<th>E (Y1)</th>
<th>F (Y1)</th>
<th>I (Y1)</th>
<th>J (Y1)</th>
<th>K* (Y2)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Inter</td>
<td>130</td>
<td>57</td>
<td>N</td>
<td>N</td>
<td>9</td>
<td>21</td>
<td>37</td>
<td>N</td>
<td>9*</td>
<td>263</td>
</tr>
<tr>
<td>Inter</td>
<td>220</td>
<td>84</td>
<td>64</td>
<td>250</td>
<td>25</td>
<td>126</td>
<td>201</td>
<td>106</td>
<td>166</td>
<td>1242</td>
</tr>
</tbody>
</table>

Proportional change

<table>
<thead>
<tr>
<th>School</th>
<th>A (Y2)</th>
<th>B (Y2)</th>
<th>C (Y1)</th>
<th>D (Y1)</th>
<th>E (Y1)</th>
<th>F (Y1)</th>
<th>I (Y1)</th>
<th>J (Y1)</th>
<th>K* (Y2)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportional change</td>
<td>169%</td>
<td>147%</td>
<td>N/A</td>
<td>N/A</td>
<td>278%</td>
<td>600%</td>
<td>567%</td>
<td>N/A</td>
<td>1800%</td>
<td>472%</td>
</tr>
</tbody>
</table>

N = not counted
School K* transcript of first group session was not able to record all of the independent talk as it happened between several pairs of children.

Table 7.2: Frequency of turns in independent pupil-pupil talk and proportional changes
As suggested from the observations of the video material there had been a substantial increase in several groups. A proportional increase might suggest more interaction within the groups (Stacey & Gooding, 1998) but this is a rudimentary indicator as we do not know if all turn taking was related to talk about the mathematics. Turn taking does not necessarily suggest that the children were exchanging meaning.

**7.3.2 Analysis of ‘what the talk was about’**

Initial observations, both in the TC Project and confirmed by the situational analysis of the doctoral study, had indicated that as well as talking about the mathematics the children often talked about managing the task or turn taking. Sequences of the independent pupil-pupil talk were coded as ‘maths’ talk or ‘non-maths’ talk. Talk that was not related to the mathematics or the task was termed ‘off-task’ talk.

*‘Maths’ talk:* Talk that was about mathematical objects (numbers, counting, operations, suggesting) or mathematical processes. This included children reading out problems, giving solutions, recounting process and stating if something is correct or not.

*‘Non-maths’ talk:* Talk that was about managing the task (what to do or how to do it) and talk that was about cooperating as a group (who is doing it, whose turn it is)

*Off Task:* Talk that was not related to the mathematics, managing the task or to cooperating.

Table 7.3 shows the frequency of codes for ‘maths’ talk, ‘non-maths’ talk and ‘off-task’ talk within the independent pupil-pupil talk for both the pre-intervention and the post-intervention sessions for the six groups (A, B, E, F, I, K) collectively. These were the groups where there had been independent pupil-pupil talk in the pre-intervention session and so allowed comparison. Although there was an increase in the frequency of the codes, when taken as a proportion there was negligible change between the pre-intervention (55%) and the post-intervention (56%) sessions.
The percentage frequency of references to talk that was ‘off task’ was 2% in both the pre-intervention and the post-intervention sessions. This would suggest the children were mostly engaged on the task, either on managing the task or on the mathematics itself. The interest of the doctoral study was in the learning that happened as the children engaged with the task so the category of ‘off-task’ talk was not investigated further.

### Table 7.3: Frequency of codes for ‘maths’, ‘non-maths’ and ‘off task’ talk and proportion of maths talk (from groups A, B, E, F, I, K)

<table>
<thead>
<tr>
<th>Group session</th>
<th>Number of codes for ‘maths’ talk</th>
<th>Number of codes for ‘non-maths’ talk</th>
<th>Number of codes for ‘off-task’ talk</th>
<th>Total</th>
<th>Proportion of maths talk out of all independent pupil-pupil talk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-intervention</td>
<td>315</td>
<td>243</td>
<td>10</td>
<td>568</td>
<td>55%</td>
</tr>
<tr>
<td>Post-intervention</td>
<td>698</td>
<td>540</td>
<td>19</td>
<td>1257</td>
<td>56%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group session</th>
<th>Percentage of ‘Maths’ talk</th>
<th>Percentage of ‘Non-maths’ talk</th>
<th>Proportional change in ‘Maths’ talk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y2 A1</td>
<td>34%</td>
<td>66%</td>
<td>1.3</td>
</tr>
<tr>
<td>Y2 A2</td>
<td>45%</td>
<td>55%</td>
<td></td>
</tr>
<tr>
<td>Y2 B1</td>
<td>74%</td>
<td>26%</td>
<td>0.9</td>
</tr>
<tr>
<td>Y2 B2</td>
<td>63%</td>
<td>37%</td>
<td></td>
</tr>
<tr>
<td>Y1 E1</td>
<td>79%</td>
<td>21%</td>
<td>0.8</td>
</tr>
<tr>
<td>Y1 E2</td>
<td>67%</td>
<td>33%</td>
<td></td>
</tr>
<tr>
<td>Y1 F1</td>
<td>52%</td>
<td>48%</td>
<td>1.1</td>
</tr>
<tr>
<td>Y1 F2</td>
<td>58%</td>
<td>42%</td>
<td></td>
</tr>
<tr>
<td>Y1 I1</td>
<td>73%</td>
<td>27%</td>
<td>0.5</td>
</tr>
<tr>
<td>Y1 I2</td>
<td>37%</td>
<td>63%</td>
<td></td>
</tr>
<tr>
<td>Y2 K1</td>
<td>91%</td>
<td>9%</td>
<td>0.9</td>
</tr>
<tr>
<td>Y1 C2</td>
<td>76%</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td>Y1 D2</td>
<td>69%</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td>Y1 J2</td>
<td>38%</td>
<td>62%</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.4: Proportion of ‘maths’ and ‘non-maths’ talk for each group session. Group sessions with approximately half or more than 60% ‘non-maths’ talk are highlighted
Although there was no change in the proportion of ‘maths’ and ‘non-maths’ talk overall when the groups were examined collectively (Table 3), when the groups were examined separately (Table 4) there were variations.

The data in Table 7.4 show the changes from the pre-intervention to the post-intervention sessions for each group. The proportions of ‘maths’ talk to ‘non-maths’ talk are also presented for the groups C, D and J. These three groups had no evidence of independent pupil-pupil talk in the pre-intervention session, so these data are not used comparatively but to indicate the proportion of mathematics and non-mathematics talk in the post-intervention session only.

In Table 7.4 the group sessions where more than 60% of the talk did not relate to mathematics are highlighted. These group sessions were the pre-intervention session A1 and the post-intervention sessions, I2 and J2. Group J was from a Year 1 class where there had been no evidence of independent pupil-pupil talk pre-intervention. The other two Year 1 groups C and D also had no evidence of independent pupil-pupil talk pre-intervention but had approximately 70% of talk about the mathematics. Group A was from a Year 2 class where there was evidence that independent group work was the norm in the pre-intervention session but the proportion of ‘non-maths’ talk was over half in both the sessions examined. This is contrasted with Group K, another Year 2 class where independent group work seemed to have been the norm. In both the pre-intervention and the post-intervention sessions for Group K over 80% of the talk related to the mathematics. In this case the proportion of ‘maths’ talk to ‘non-maths’ talk did not seem to depend on the year group or whether independent pupil-pupil talk had been the norm in the class before the intervention.

Table 7.4 shows that for Group A there was some increase in the proportion of ‘maths’ talk in the post-intervention session (A2) but the ‘maths’ talk still amounted to less than half of the independent talk. For Group I there had been a large decrease in ‘maths’ talk from the pre-intervention session (I1) to the post-intervention session (I2), suggesting that the intervention had not supported the children in focusing on talk about the mathematics in this post-intervention session. For the other groups there was little or no change in the proportions of ‘maths’ talk to ‘non-maths’ talk.
7.4. Summary

To summarise there were some variations in the proportion of maths talk and non-maths talk across the groups. Group A had more than half of the talk about ‘non-maths’ for both of the sessions but there was an increase in the proportion of ‘maths’ talk following the intervention. In Group I almost three quarters of the talk was about mathematics in the pre-intervention session but this decreased to less than half following the intervention. The variations did not seem to depend on the year group or the amount of independent pupil-pupil talk prior to the intervention in these cases.

On their own, the data shown in Tables 7.2, 7.3 and 7.4 cannot be used to hypothesise but they do indicate that, although the intervention encouraged more independent pupil-pupil talk, it did not increase the proportion of mathematics talk, apart for Group A. For most groups the proportion remained fairly similar and in one group, Group I, the proportion of mathematics talk reduced considerably. As the children were working independently it would not seem unreasonable that they should talk about managing the task and how to cooperate. Such talk would not seem unimportant. However it would seem desirable for the children to talk more about the mathematics than managing the task. This analysis has raised the question why there should be a variation in the proportion of talk and why for one group the proportion of ‘non-maths’ talk increased considerably. This had not been the intention of the intervention in the TC Project.

There could be several factors that influenced these variations. The tasks themselves could have influenced how well the children accessed the mathematics within the tasks. There is not enough space to examine this in any depth within the doctoral study where the focus is on the nature of the talk, not the task, but the tasks are acknowledged as part of the situational context of the talk.

The classroom norms and expectations of the children in working within groups could also have influenced the variations. Initial observations from the TC Project and the situational analysis for this doctoral study suggested that in classes such as Group I, it was often the norm for the children to wait for
instructions to be given by the teacher. This had not been the case for other groups such as Group A, B, F and K who appeared to be more autonomous in working as a group. Although Group A had appeared autonomous the majority of the talk was not about the mathematics. This is contrasted with Group K where over 80% of the talk was about the mathematics in both of the sessions. Again, there is not enough space in this doctoral study to examine the different classroom norms and teacher involvement in the group work. This would be another story.

In this doctoral study the focus is on the nature of the children’s learning through their talk and how the intervention impacted on this. In order to determine how the intervention had impacted on the learning through the talk the analysis was first carried out to determine changes in the nature of the talk by interpreting the functions of the utterances in the Level 2 analysis. The findings of the Level 2 analysis are presented in the next chapter, Chapter 8.
Level 2: Analysis of talk
speech acts

intentions of utterances

Figure 8.1: Levels of analysis, focus on Level 2: Analysis of speech acts

8.1 Introduction

Analysis at Level 2 was to investigate the nature of the children’s talk and any changes in the nature of the talk. Analysis of the nature of the talk was carried out over both of categories, ‘maths’ talk and ‘non-maths’ talk. If the intervention were to be effective then it would encourage the children to exchange meaning in relation to the mathematics but the social aspect of the children’s talk was also seen as important in their exchange of meaning in mathematics.

Analysis was carried out to investigate the independent pupil-pupil talk by coding utterances according to interpretations of their function, that is, they were coded as speech acts. These codes were then used to investigate patterns, first to investigate patterns in each category by comparing differences in the speech acts between the groups and second, to examine changes in the nature of the talk by comparing patterns of speech acts between the pre-intervention group sessions and the post-intervention group sessions.

The results of the analysis for each of the two categories are presented in the sections below. Section 8.2 presents the results for ‘non-maths’ talk and section 8.3 presents the results for ‘maths’ talk. The key points from these results are summarised in section 8.4.
The coding of the utterances was managed using NVivo 9 software as outlined in Chapter 7. The software was used to carry out matrix queries for quantitative examination in looking at percentage frequencies. These were low-level analyses carried out with the transcripts of independent pupil-pupil talk. The data came from the nine classes. However, the data were analysed comparatively to examine any changes across the intervention with the six groups that had prior evidence of independent pupil-pupil talk were used. Data from the other three groups are also presented but were not used to examine any changes across the intervention.

- Six groups used for comparison across the intervention (pre-intervention and post-intervention sessions): A, B, E, F, I, K.
- Additional data for the three groups not used for comparison across the intervention (post-intervention sessions only): C, D, J.

The quantised analyses were used to direct high-level qualitative analyses of a smaller sample of transcript excerpts. NVivo 9 was used to support the identification of these transcript excerpts by highlighting items and code striping.

These two approaches, low-level and high-level, were used to determine any changes in the patterns of speech acts and so help to understand the nature of the children’s talk. The approaches helped to understand how the talk may have changed over the intervention (six groups) and how the changes may have differed between groups (nine groups).

Where possible, the patterns of speech acts were related to types of talk, disputational, cumulative or exploratory, but in this doctoral study it was considered that the nuances in relating to these types were an important aspect in determining the nature of the children’s talk in relation to their learning.

8.2. Analysis of the ‘non-maths’ speech acts

As indicated in the data in the previous chapter (Chapter 7), approximately half the talk was about managing the task and cooperating as a group. In three of the groups, Group A, Group I and Group J, the children had talked more about managing the task and cooperating as a group than they had talked about the mathematics in at least one of the sessions.
The ‘non-maths’ speech acts were analysed to investigate how the intervention had impacted on the way that the children managed the task and cooperated, and how the ‘non-maths’ talk may have supported or hindered the children’s opportunities to exchange meanings in their talk about the mathematics. If the children were unable to collaborate in managing the task and working as a group it would seem unlikely that they would be able to exchange meaning about the mathematics.

Codes were developed inductively and deductively and the codes for the ‘non-maths’ speech acts are set out in Chapter 6. They are set out again below.

**Agree** Agreement in how to take turns, use resources or manage the task

**Disagree** Disagreement in how the group cooperated (who should do what) or in the management of the task (what to do).

**Direct** One or more children telling the other children what to do, who does what or whose turn it is.

The speech acts for ‘directing’ were coded further according to ‘facilitate’ and ‘control’.

**Facilitate** Directions that were intended to give further suggestions in managing the task or help to resolve a dispute.

**Control** Controlling the way the group worked with an intention to dominate rather than to facilitate.

**Question** Direction given as a question, this may be controlling or facilitating

As with any qualitative research these are interpretations of what the children intended, we cannot know for sure what the functions of the utterances were.

Investigations were carried out to determine variations and commonalities across the groups and also to determine if there had been any changes in the nature of the ‘non-maths’ talk following the intervention. Quantised data for all groups collectively are presented in Table 8.1 to show overall changes in speech acts. Quantised data for each group are presented in Tables 8.2 and 8.3. The data in Table 8.2 show the percentage frequencies of the different
speech acts for ‘non-maths’ talk for the different group sessions (pre-and post-intervention). The data in Table 8.3 show the proportional changes for the different speech acts for ‘non-maths’ talk for the six groups, A, B, E, F, I, and K, where there had been evidence of independent pupil-pupil talk prior to the intervention. Shading was used to highlight the variations and commonalities across the different group sessions. There was no intention to generalise from these but to indicate the groups and the sessions where higher-level analysis of the speech acts could be carried out. In the higher-level analysis the speech acts were analysed qualitatively. Examples are presented to exemplify key points related to the children’s talk in managing the task and how this is seen to relate to the children’s collaboration.

8.2.1. Overall changes in ‘non-maths’ speech acts

The data for the six groups (A, B, E, F, I, K), where there had been evidence of independent pupil-pupil talk before the intervention, are presented collectively for each speech act in ‘non-maths’ talk in Table 8.1. Data for the three groups where there had not been evidence of pupil-pupil talk (C, D, J) are also presented but these were not for comparison of changes across the intervention.

Initial impressions, both in the TC Project and in the Level 1 analysis for this doctoral study, had been that the children were arguing more about managing the tasks. These data suggest that ‘disagree’ speech acts did not dominate the talk about managing the tasks but that speech acts related to one or more children controlling the management of the task dominated. There did not appear to be any change in the percentage frequency of ‘control’ speech acts overall, hence there was no suggestion that this changed as children were managing the task together in the post-intervention sessions.

These data also suggest that overall there had been no change in the proportion of ‘disagree’ speech acts in ‘non-maths’ talk. As there was more independent talk then the impression may have been that there was more argument and dispute, and the frequency of utterances coded as ‘disagree’ did seem to increase from 28 to 55, but as a proportion of all the ‘non-maths’ talk there appeared to be no change.
Table 8.1: Percentage frequencies of ‘non-math’ speech acts and proportional changes

There appeared to be a proportional increase in the percentage frequencies for ‘agree’ and ‘facilitate’ so, if there were any indication of change, it was that the children agreed more and facilitated more in managing the tasks or cooperating as a group. However the percentage frequency of ‘agree’, in particular, is small and it would not seem possible to generalise from these quantitative data alone.

8.2.2. Variations in ‘non-maths’ talk for each group

The data in Table 8.2 indicate that the percentage frequencies for the different speech acts varied across the different group sessions and that ‘control’ was the speech act with the greatest percentage frequency in all groups apart from one group session, E1.

The level of disagreement for each group varied considerably. It appears that those group sessions with the greatest frequency percentages for ‘disagree’ (E1, F2, J2) were with the younger Year 1 groups. Although with another Year 1 group session, D2, the level of disagreement was not so prominent. The level of disagreement did not seem to relate to whether the children had experienced
independent pupil-pupil talk before as Group F children had experienced pupil-
pupil talk before whereas Group D had not. In group session E1 it appeared that
all talk about managing the task was related to disagreement, suggesting a high
level of dispute. This group session is given as a qualitative example below in
examining the relationship between controlling and disagreement.

<table>
<thead>
<tr>
<th>Year</th>
<th>Group session</th>
<th>Agree</th>
<th>Directing</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>Facilitate</td>
</tr>
<tr>
<td>Y2</td>
<td>A1</td>
<td>10%</td>
<td>42%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>9%</td>
<td>39%</td>
<td>23%</td>
</tr>
<tr>
<td>Y2</td>
<td>B1</td>
<td>2%</td>
<td>33%</td>
<td>18%</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>2%</td>
<td>58%</td>
<td>13%</td>
</tr>
<tr>
<td>Y1</td>
<td>E1</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>E2</td>
<td>1%</td>
<td>56%</td>
<td>13%</td>
</tr>
<tr>
<td>Y1</td>
<td>F1</td>
<td>2%</td>
<td>70%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>3%</td>
<td>43%</td>
<td>11%</td>
</tr>
<tr>
<td>Y1</td>
<td>I1</td>
<td>3%</td>
<td>35%</td>
<td>53%</td>
</tr>
<tr>
<td></td>
<td>I2</td>
<td>10%</td>
<td>32%</td>
<td>32%</td>
</tr>
<tr>
<td>Y2</td>
<td>K1</td>
<td>0%</td>
<td>56%</td>
<td>0%</td>
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<tr>
<td></td>
<td>K2</td>
<td>23%</td>
<td>40%</td>
<td>11%</td>
</tr>
<tr>
<td>Y1</td>
<td>C2</td>
<td>5%</td>
<td>64%</td>
<td>0%</td>
</tr>
<tr>
<td>Y1</td>
<td>D2</td>
<td>11%</td>
<td>56%</td>
<td>8%</td>
</tr>
<tr>
<td>Y1</td>
<td>J2</td>
<td>7%</td>
<td>51%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Shading key:

- % ≤ 9
- 10 ≤ % ≤ 19
- 20 ≤ % ≤ 29
- % ≥ 30

*Table 8.2: Percentage frequencies of 'non-math' speech acts for each of the fifteen group sessions.*

It would seem that if the children were collaborating then a level of argument
would be part of this and would indicate the groups were working together.
However a high level of disagreement would suggest disputational talk and this would not seem to be conducive to children’s opportunity to talk about the mathematics.

The two speech acts, ‘control’ and ‘disagree’ were investigated qualitatively to understand further the nature of the children’s talk and what role these speech acts had in the children’s talk both prior to and after the intervention. A matrix query was carried out in NVivo 9 by referencing to the speech codes ‘control’ and ‘disagree’ The examples given below illustrate key points that arose from this analysis related to social positioning and competition for resources that begin to help understand the children’s interactions in working together.

**‘Control’ and ‘disagree’ speech acts:**

Control of the task or the group work was often dominated by one child. This was apparent in group sessions A1 and C2. In the pre-intervention group session A1 Emma saw herself in authority in the group:


Emma: It’s like I’m the master

In post-intervention group session C2 this was the case with Brenda:

*Dialogue 8.C2.1*

1. Brenda: I’m the captain of it
2. Eve: No you’re not
3. Brenda: Yes I am, I’m the captain

These comments suggested that Emma and Brenda may have seen themselves in an authority position in managing the task in each of their groups.

The social authority positioning of one child was also noticeable in the group session F1. 70% of the speech acts were referenced to the ‘control’ code and qualitative analysis showed how Avril, then working with Libby, took charge of the task from the start

*Dialogue 8. F1.1*

Avril: A pen each one and one for you, right, so which one shall we look for? You have to write it down there, which one do you want?
Avril continued to dominate the management of the task and also the turn taking.

Dialogue 8.F1.2

1. Avril: I’ve done mine, yours Libby? Or did you do that one?
2. Libby: I did that one
3. Avril: My go

In this pre-intervention session there had been little evidence of agreement or disagreement. Libby did not challenge Avril’s authority. The two children were taking turns in ‘having a go’, but they did not challenge each other.

In the post-intervention session for this group, F2, the element of control in the group appeared to relate to disagreement with 40% of the speech acts referenced to the ‘disagree’ code, along with 43% to the ‘control’ code. This is illustrated in the post-intervention session when Avril and Libby were joined by Colin. Avril and Libby started the task together and again Avril took control from the start.

Dialogue 8.F2.1

Avril: How much do we need to make Libby? Libby, how much do you want to make, Libby? How much do you want to make?

The dialogue in 8.F2.1 suggested that the discourse started in the same way as the pre-intervention session with Avril controlling the task. When Colin joined the group this seemed to change.

Dialogue 8.F2.2

1. Avril: I’m telling
2. Colin: What?
3. Avril: You just made me lose...(count)
4. Libby: 1,2,3,4,5...
5. Avril: Stop it Libby I’m trying to count! I’m telling.

As this was a post-intervention session it was expected that the intervention and introduction of ground rules would have helped the children in collaborating, but this seemed to have caused a dispute instead. Whilst the intention was not to
have children arguing or ‘squabbling’ in managing a task together, the development of argument might indicate that the other children were taking a role in managing the task. It may be that encouraging the children to talk together had caused conflict in managing the task. Where one child had dominated, in this case Avril, the encouragement to question and argue may have undermined Avril’s authority. In so doing Avril may have reverted to the teacher as an authority figure to support her with the statement ‘I’m telling’ (F2.2.1 & F2.2.5). This caused a great deal of disagreement in the group, so much so that later Libby announces;

**Dialogue 8.F2.3**

Libby: I’m not going to speak in this group now. Thank you Avril.

This level of disagreement was of concern to the teacher and the group was disbanded following this post-intervention session. It seemed this was an example where the TC Project intervention had not been effective and this may have been due to the introduction of the third child Colin. However there was a difference in the talk behaviour of Libby from the pre-intervention session. Libby had done exactly what she was told by Avril in the pre-intervention session. In this post-intervention session Libby did give her point of view which resulted with a defiant ‘I’m not going to speak in this group now’ (8.F2.3). I come back to this group and Libby’s developing talk authority in looking at the talk in mathematics in section 8.3.2. below.

The relationship between control and disagreement is illustrated by another group, Group E. In the pre-intervention group session, E1, there had been no explicit evidence of direction or control of the task as no child appeared to be telling the others what to do but there was evidence of disagreement. In the extract of dialogue from pre-intervention group session E1 the children had a disagreement related to copying.
Dialogue 8.E1.1

1. Alex: (to Mandy) You're copying me. I'm doing 68, you're copying me
2. Mandy: Are you doing 68?
3. Alex: Will you stop copying me

Arguably there is a sense that Alex was taking an authority position as she was challenging Mandy, but she was not directly controlling the task or the group work, she was not telling them what to do. The concern with copying would also suggest the children were working as individuals and not collaborating.

In the analysis of the speech acts in the post-intervention session, E2, the frequency of speech acts related to ‘control’ increased and the frequency of speech acts related to ‘disagree’ decreased. So it would seem that that one or more children were controlling the task but that there were fewer disputes. It is suggested that this could mean there was greater interaction by the children and that they were no longer working individually.

In the post-intervention session, E2, Chas was working with Lara and Mandy and he seemed to take control as he shared out the coloured bears that they were to use in the task.

Dialogue 8.E2.1

1. Chas: Put those in the middle. Put two to me, and you have the others. So what colour? So blue will go to Lara.
2. Chas: Blue goes to Lara
3. Chas: There like that one goes... *(Chas is playing with the bears and has one bear jumping over another)*

Later the other two children challenge Chas in managing the resources.

Dialogue 8.E2.2

1. Chas: I'm the blue bears
2. Lara: I was the blue bears

And also in the turn taking.
Dialogue 8.E2.3

1. Chas: Now it's my turn now

2. Mandy: My turn...... No, it's my turn

3. Chas: No, no, no, no ... yeah it's your turn now

Although the group session E2, had a greater percentage frequency in 'disagree' than some of the other groups and the talk about the task did appear to be disputational at times, this is contrasted with the disagreement about copying in the pre-intervention session, E1. The dispute in the post-intervention session was related to one child telling the others what to do, possibly with the intention of telling or directing in order to complete the task. The challenge to this again may have suggested that the other children were also taking control.

I return to the children in these two groups in class E in examining their mathematics talk in section 8.3.2. below.

I have used these extracts of dialogues for group sessions F1, F2, E1 & E2, above, to illustrate a key point that disagreement along with control can be indicative of the children working together, whereas disagreement or control on its own may not. In the example above with Avril and Libby in group session F1 (Dialogues 8.F1.1 & 8.F1.2), the greater percentage frequency of 'control' in the pre-intervention session was seen as Avril telling Libby what to do but the small percentage frequency of 'disagree' suggested Libby did as she was told. In the example with Mandy and Alex in the group session E1 (E1.1), the children appeared to be working individually as the disagreement related to copying, there was little evidence of any child taking control of managing the task. However in the post-intervention session, E2, the increased frequency of 'disagree' in Group F and 'control' in Group E (E2.2 & E2.3) showed that there may have been interaction, albeit not in a constructive way.

Although I am suggesting that some level of disagreement may have been consistent with the children collaborating there were occasions when this was at such a disputational level that it may have disrupted and detracted from the talk about the mathematics and this is considered in section 8.3. The reason that there was such a level of dispute appeared to be that one child was taking an authority position. Why the children in these groups may have done this is
discussed later in relation to children’s discourse and social interaction in Chapter 11.

**8.2.3. Group changes in ‘non-maths’ speech acts**

Table 8.3 shows the proportional changes for the different speech acts for ‘non-maths’ talk for the six groups A, B, E, F, I, and K, where there had been evidence of independent pupil-pupil talk prior to the intervention. Although the proportional changes varied across the different groups they reflected the changes in Table 8.1, where the groups were examined collectively, in that the increases appeared to be mostly in relation to the speech acts ‘agree’ and ‘facilitate’.

<table>
<thead>
<tr>
<th>Year</th>
<th>Group</th>
<th>Agree</th>
<th>Directing</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>Facilitate</td>
</tr>
<tr>
<td>Y2</td>
<td>A</td>
<td>0.9</td>
<td>0.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Y2</td>
<td>B</td>
<td>1.0</td>
<td>1.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Y1</td>
<td>E</td>
<td>0%→1%</td>
<td>0%→56%</td>
<td>0%→13%</td>
</tr>
<tr>
<td>Y1</td>
<td>F</td>
<td>1.5</td>
<td>0.6</td>
<td>0%→11%</td>
</tr>
<tr>
<td>Y1</td>
<td>I</td>
<td>3.3</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Y2</td>
<td>K</td>
<td>0%→23%</td>
<td>0.7</td>
<td>0%→11%</td>
</tr>
</tbody>
</table>

**Shading key:**

- Small proportional change or ≤ 5% in both cells
- Proportional change with decrease ≤ 0.6
- Proportional change with increase ≥ 1.4 or change from 0% to at least 5%

**Table 8.3: Proportional change of percentage frequencies of the ‘non-maths’ speech acts for the six groups A, B, E, F, I, K**

The analysis of the changes focused on the two groups, Group A and Group I, that had shown an increase and decrease in the proportion of ‘maths’ talk (Tables 7.3 and 7.4 in Chapter 7) and on Group K which had the greatest proportion of ‘maths’ talk in the pre-and post-intervention sessions.
In the first example, Group A, the proportion of ‘maths’ talk had increased between the two sessions. In Group A references to the speech act ‘disagree’ appeared to halve between the two sessions. Did this suggest that a decrease in dispute and argument about managing the task had enabled them to talk more about the mathematics? This is contrasted with the second example, Group I, where the proportion of ‘maths’ talk had decreased between the two sessions. The data presented in Table 8.3 suggested that, for Group I, references to the speech act ‘facilitate’ decreased proportionally, whereas references to the speech act ‘disagree’ increased proportionally, and to a large extent. The speech act ‘agree’ also increased proportionally but not to the same extent as ‘disagree’.

The third example, Group K, appeared to have the greatest proportion of mathematics talk in both the pre-intervention and the post-intervention session. The group also appeared to have a smaller percentage frequency of ‘disagree’ speech acts in the ‘non-maths’ talk. The greatest change in the speech acts for the ‘non-maths’ talk for Group K was an increase in agreement.

The non-maths talk for Group A, Group I and Group K were investigated qualitatively by referencing to the speech codes for ‘non-maths’ in NVivo 9. Again the interest was in ‘control’ and ‘disagree’ but now also with ‘agree’ so these codes were highlighted. Extracts of dialogue that include these speech acts are given below and are used to present changes in the way that these children cooperated on the tasks. These are used to illustrate key points related to these children’s views of the tasks.

**Group A: change in ‘non-maths’ talk**

As suggested by the Level 1 analysis (Chapter 7) independent pupil-pupil talk prior to the intervention had appeared to be the norm for Group A’s classroom. But the Level 1 analysis had suggested the children were often arguing about taking turns both in the pre-intervention session and the post-intervention session. In Group A, there had been an increase in the proportion of speech acts referenced to ‘agree’ in the post-intervention session. The data in Table 8.3 suggest that the frequency of ‘control’ utterances increased along with the frequency of ‘facilitate’ which also increased.
Early on in the A1 pre-intervention session the children referred to the task as a game.

*Dialogue 8.A1.2*

1. Emma: This is a good game
2. Olwen: It’s not exactly a game, well it is a game

From the analysis of the ‘control’ speech acts presented earlier (Dialogue 8.A1.1) Emma had stated she was ‘the master’, so it seemed that Emma was positioning herself in authority in the group. Turn-taking seemed to be important to the children, possibly as part of the game, and in the pre-intervention session the children were in dispute about this.

*Dialogue 8.A1.3*

1. Olwen: Diane, I haven’t had a go first
2. Emma: You’ve had a go to be first
3. Diane: I’ve only had one go

The dispute continued.

*Dialogue 8.A1.4*

1. Emma: My turn
2. Olwen: I’m not speaking any more

The level of dispute about turn-taking in this pre-intervention session suggested that the children’s collaboration was not constructive. Emma had associated with a positioning of authority and it seemed that the Olwen and Diane were challenging this.

In contrast the examples of dialogue from the post-intervention session, A2, suggested a different discourse. Although still in relation to turn-taking, the children appeared to be negotiating.

*Dialogue 8.A2.1*

1. Olwen: Yes. Does anyone else want to have a go?
2. Emma: Can I because then it’s fair
3. Emma: It’s you then it’s you then it’s me
4. Olwen: But I haven’t done it yet, so it’s not fair really.
The children’s talk was less disputational, they were referring to the idea of fairness to help them ‘play the game’ more constructively and negotiate turn taking rather than disputing it. It had the sense that the children were ‘playing nicely’.

A key point that arose from the analysis of this group was that the children saw the task as a game and that within a game you take turns. The changes in the talk for this group suggested that the intervention may have been effective in supporting these children to cooperate within the ‘maths game’ and to take turns in a more negotiable way, or to ‘play nicely’ together.

The proportion of mathematics talk for Group A appeared to increase over the TC Project intervention. An initial hypothesis is that the decrease in disputational talk over the turn-taking may have supported this. I come back to the changes in this group regarding the speech acts for the mathematics talk in section 8.3.3 and an examination of a relationship between change in collaboration of the task and the change in the talk about the mathematics.

**Group I: change in ‘non-maths’ talk**

The proportion of mathematics talk appeared to halve over the intervention for Group I. The initial analysis from Level 1 (Chapter 7) had shown that the children in Group I had experienced some independent talk in their mathematics group work before the intervention but there had been frequent directions given by the teacher. In the post-intervention group session the children were working independently for most of the time and so this was a change in a classroom norm for these children. With this increased independence it did not seem unreasonable for the children to talk about managing the task together further as they did not have so much direction from the teacher. However Table 8.3 suggests that whereas there had been little dispute before the intervention this became more evident after the intervention.

In the pre-intervention ‘non-maths’ talk the utterances suggested the children’s focus was on the use of resources, in this case the resources were cubes that they were given to count.

*Dialogue 8. II.1*

1. Harvey: *(to Jack)* No you can’t just take them *(the cubes)* like that
2. Martin: No don’t take them all we’ve only got nine

In the post-intervention session the ‘non-maths’ talk still related to the use of resources but seemed to extend to the completion of the task as well. In this session the children were sticking cards with values of coins in matching pairs onto a sheet of sugar paper.

*Dialogue 8.12.1*

1. Martin: no, you’re not; you’re just putting them all together like ...
   we’re not allowed to
2. Jack: Well you do
3. Martin: You don’t put in the pile.
4. Martin: No we’re not ready to stick them
5. Jack: We are
6. Martin: No we’re not, we need to sort it out

This continued.

*Dialogue 8.12.2*

1. Jack: I think we need some more sugar paper
2. Martin: No we don’t. That’s why you didn’t stick it right
3. Jack: I did
4. Martin: No you need to stick that to that and that to that and that one there
5. Jack: I need the glue, I need the glue
6. Martin: I need the glue
7. Jack: I think Martin stuck one on the other side
8. Martin: I didn’t!

These examples indicate how a disputational level of talk about the resources continued into the post-intervention session. The children were focused on the completion of the task; whether and how they should complete the recording of the task and the use of resources. This concern with the task seemed to increase with increased independence. It is possible that this was due to more autonomy in managing the task but may also have been indicative in how they
viewed the mathematics task as a ‘job to be done’.

A key point that arose from the analysis of this group was that these children were focused on the management of the task itself, rather than the mathematics. The children were concerned with how the resources should be used, and by whom, and how they were expected to complete the task. In Dialogue 8.I2.1 utterance 1 Martin stated that they ‘we’re not allowed to...’ indicating a sense of permission from the teacher in what they were doing. This did not come from the mathematics but from supposed rules in how to complete the task. This aspect is considered in the section 8.3.2 when examining the mathematics talk for this group.

**Group K: changes in ‘non-maths’ talk**

In Group K there seemed to be no evidence of agreement or disagreement in the pre-intervention session but these became apparent in the post-intervention session. This was particularly in the case with ‘agree’ speech acts where an increase from 0% to 23% was indicated. There had also been an increase in ‘disagree’ speech acts from 0% to 9%.

In the pre-intervention session, K1, the children were directing whose turn it was.

*Dialogue 8.K1.1*

1. Ben: (to Pierce) You pick one

   (After Pierce has completed his task he then asks Ben)

2. Pierce: (to Ben) Now it’s your go

The children were taking turns with no evidence of argument. Although the act of complying with taking the next turn would suggest agreement, this was not stated explicitly.

In the post-intervention session, K2, Pierce worked with Fran and Iris. First the talk was about taking turns.

*Dialogue 8.K2.1*

1. Pierce: Which one, ok, it’s your turn now. It goes me, Fran, you
2. Iris: I'll do these ones,
3. Fran: Me and Iris will do these ones
4. Iris: And you do this one
5. Pierce: Yea, I will

The children were negotiating how the turn taking could operate, suggesting they were working together on the task. The nature of this talk has some similarities in the way that the children in group session A2 were negotiating turns. Pierce, Iris and Fran were less explicit about the turn taking being fair but this could have underlined the negotiation.

Later the children negotiate how the task can be completed (the children are writing numbers for the inequality > 50 on a piece of paper with a square grid).

*Dialogue 8.K2.2*

1. Fran: What are you doing?
2. Pierce: What am I doing?
3. Fran: You could have filled all of the squares in
4. Pierce: Yea we could of

In utterance 3 Fran’s suggested that ‘You could have filled all the squares in’. Unlike utterance 1 in *Dialogue 8.I2.1.*, in group session I2, Fran’s utterance did not seem related to permission from the teacher. One interpretation of Fran’s suggestion was for Pierce to use the squares in recording his numbers. This was not to do with how the teacher had told them to record the numbers; it was a suggestion in how they could have managed it as a group. Another interpretation is related to the mathematics itself and that in recording numbers greater than 50 they could fill all the squares on the sheet. From either interpretation the talk in this group in managing the task was different to the talk that was illustrated by Group I where the children were referring to the teacher’s permission in being ‘allowed to.’

Whilst in the pre-intervention session it appeared that the children in Group K were working without any dispute, the increase in argument (agree and disagree) in the post-intervention session suggests that the children were
collaborating further, not just taking turns to do their piece of mathematics but sharing the management of the task. The relationship between this talk and the children’s talk in the mathematics for this group is investigated in section 8.3.3.

**8.2.4. Summary of the analysis of non-maths talk speech acts**

From the quantitative analysis of the ‘non-maths’ speech acts, the speech acts related to control seemed to dominate the talk. Even though there was more independent talk following the intervention there seemed to be little proportional change in most of the groups. Where there appeared to be an increase in group E, this may have indicated more collaboration. The greater percentage frequency of ‘control’ speech acts may have suggested that in some groups this was associated with children’s social authority positioning.

The percentage frequency of speech acts related to argument (agreement and disagreement) seemed to change in most of the groups. Changes in level of dispute seemed to vary across the groups (both increases and decreases) but there appeared to be an increase in agreement in most of the groups. This also related to an increase in facilitating in several of the groups and was illustrated by Group A where the cooperation in turn-taking became less disputational.

It was possible to surmise that the children from the younger Year 1 classes were more likely to be involved in dispute in both the pre-intervention and the post-intervention session. The data in the tables 8.1 and 8.2 suggest that group experience of independent pupil-pupil talk before the intervention may not have been a factor influencing the level of dispute. However qualitative investigation of the children’s talk for Group I suggested that the experience of independent talk prior to the intervention could have been a factor.

Key points that arose from the qualitative analysis of the speech acts were that:

- Where control was associated with argument (disagree and agree) there was more evidence of the group collaborating on the task;
- Social authority positioning by some children dominated the management of the task and in some cases caused dispute;
- Some children saw the task as a game and this was associated with turn-taking;
- Some children’s focus was on the task itself (a ‘job to be done’) and the
use of resources.

The intervention of the TC Project had intended to help children become actively engaged in mathematics by collaborating and working independently from the teacher. Key to children’s collaboration in learning mathematics is the ability to cooperate with each other and to manage the task (mostly) autonomously. Where there was evidence of control associated with argument this suggested that the children were working together. However where the argument became disputational, as in Group F, or the talk focused on the task and not the mathematics as in Group I this was not seen as effective collaboration.

It seemed that there may have been a connection with the changes in the levels of dispute as shown in Tables 8.2 and 8.3, and changes in the proportion of talk about mathematics (Tables 7.3 and 7.4 in Chapter 7) as illustrated by Groups A and I. However Group F had the greatest increase in disagreement but the proportion of mathematics talk did not decrease. Deeper analysis of the speech acts has suggested a few factors that may have been involved in children’s management of the task. It is realised that these are only a few of the many possible factors that could be involved.

The key points related to control, turn taking and focus in the task management raised above are discussed further in relation to young children’s discourse and enculturation into mathematics discourse in the discussion. These points are related to social and emotional aspects of the children’s discourse in sharing intentions and exchanging meaning.

8.3. Analysis of ‘maths’ speech acts

Initial impressions from the TC project (chapter 4) and from the Level 1 situational analysis in this doctoral study (Chapter 7) had suggested that the characteristics of exploratory talk were not evident within the mathematics talk in the post-intervention sessions. This was further confirmed by an initial attempt to characterise the post-intervention mathematics talk as exploratory, cumulative or disputational (see development of the analysis structure in Chapter 6). Whilst some aspects of disputational talk did seem evident, analysis according to types of talk did not seem effective in determining the nature of the
children’s talk in either the pre-intervention sessions or the post-intervention sessions. In order to define systematically any changes in the children’s talk over the intervention it seemed necessary to analyse the nature of the children’s talk prior to the intervention as well as following the intervention and again the use of the characteristics for the types of talk did not seem to support this. Rather than characterising according to type, the intentions of the children’s utterances were interpreted and coded as speech acts. Use of NVivo 9 then enabled the identification of patterns of speech acts. Where possible these patterns were used to make links to the types of talk.

The patterns of speech acts were determined within the mathematics talk in both the pre-intervention and the post-intervention sessions. The intention was to determine similarities or differences in the mathematics talk between groups and to determine if there were any changes across the intervention. This was carried out not only to define any changes but also to examine the way that the children talked to each other about their mathematics. It was anticipated that this analysis would support a better understanding of the nature of the children’s talk about mathematics.

In this doctoral study the analysis of the children’s mathematical talk focused on the intentions of the children’s utterances as they referred to mathematical objects and processes. The codes were developed both inductively and deductively as outlined in Chapter 6 and the codes for these are set out in more detail in section 6.7 and are set out again briefly below:

- **Directing** One or more children tell other(s) how to do the maths
- **Calling attention** Talk that draws the other children’s attention to a number or idea.
- **Describing** Talk relates what the child(ren) is doing or thinking (eg counting), relating the mathematical task (reading out the questions) or giving an account of recording.
- **Explaining** Talk that gives an exact meaning of a piece of mathematics.
- **Questioning** Asking a question about a mathematical idea or checking if a solution is correct.
**Agree** Talk that indicates children are agreeing to another child’s idea or answer in mathematics.

**Disagree** Talk that indicates children are not in agreement or in dispute about their ideas or an answer in mathematics.

**Responding** Sequences of utterances that show interaction in the speech acts.

The speech acts were managed using NVivo 9 and were interrogated quantitatively using NVivo 9 matrix coding queries to determine similarities and differences across the groups and to determine changes across the TC Project intervention. The data for all groups collectively are presented in Table 8.4 and show overall changes in the mathematics speech acts. The data for each group are presented in Tables 8.5 and 8.6. The data in Table 8.5 show the percentage frequencies of the different speech acts for the mathematics talk for the different group sessions (pre-and post-intervention). The data in Table 8.6 show the proportional changes for the different speech acts for the mathematics talk for the six groups A, B, E, F, I, and K, where there had been evidence of independent pupil-pupil talk prior to the intervention. Shading is used to highlight the similarities and differences across the different group sessions.

The quantitative data was used to highlight key aspects that could be further investigated qualitatively. Queries were used in NVivo 9 to track back to the context of the speech utterances. Interrogation of the transcripts was also carried out by highlighting selected items and by coding strips. Examples of extracts from the transcripts are presented to exemplify key points related to the children’s talk in sharing mathematical ideas.

### 8.3.1. Overall changes in ‘maths’ speech acts

The data for each speech act in the mathematics talk for the six groups, where independent pupil-pupil talk had been evident in the pre-intervention sessions, are presented collectively in Table 8.4. The data for the three groups that did not have evidence of independent pupil-pupil talk in the pre-intervention session are also given for the post-intervention sessions only. These data show that the speech act with the greatest percentage frequency both in the pre-intervention
and the post-intervention session was ‘describe’, with at least one third of the speech acts related to this.

Six groups: A, B, E, F, I, K

<table>
<thead>
<tr>
<th></th>
<th>Agree</th>
<th>Call</th>
<th>Describe</th>
<th>Direct</th>
<th>Disagree</th>
<th>Explain</th>
<th>Question</th>
<th>Respond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-intervention</td>
<td>3%</td>
<td>3%</td>
<td>33%</td>
<td>18%</td>
<td>3%</td>
<td>8%</td>
<td>9%</td>
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<tr>
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<td>38%</td>
<td>13%</td>
<td>8%</td>
<td>4%</td>
<td>8%</td>
<td>18%</td>
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Three groups C, D, J

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<tr>
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<th>Call</th>
<th>Describe</th>
<th>Direct</th>
<th>Disagree</th>
<th>Explain</th>
<th>Question</th>
<th>Respond</th>
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</thead>
<tbody>
<tr>
<td>Post-intervention</td>
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<td>3%</td>
<td>34%</td>
<td>21%</td>
<td>10%</td>
<td>3%</td>
<td>11%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Table 8.4: Percentage frequencies of ‘maths’ speech acts and proportional changes

Whilst the percentage frequencies for the speech acts ‘describe’, as well as ‘direct’ and ‘respond’, accounted for almost 70% of the mathematics talk, the proportional changes were relatively small. So a first impression was that little had changed over the intervention. This could explain why we had found it so difficult to determine the changes that had happened when initially working on the TC Project.

However, the proportional increase for two speech acts ‘agree’ and ‘disagree’ appeared to at least double. It is noted that the percentage frequencies for these two speech acts were small in both the pre-intervention and the post-intervention sessions, but this does give an indication that the introduction of the ground rule related to agreeing and disagreeing may have changed the nature of the talk in a small way. This is examined qualitatively in section 8.3.2. below.

The greatest proportional decrease shown in Table 8.4 was for the speech act ‘explain’. This appeared to halve across the intervention. Again it is noted that the percentage frequency for this speech act was small in the pre-intervention
and the post-intervention sessions. However any decrease in the speech act ‘explain’ would not seem indicative of a development of exploratory talk.

### 8.3.2. Variations in ‘maths’ speech acts for each group

<table>
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<tr>
<th>Year</th>
<th>Group</th>
<th>Agree</th>
<th>Call attention</th>
<th>Describe</th>
<th>Direct</th>
<th>Disagree</th>
<th>Explain</th>
<th>Question</th>
<th>Respond</th>
</tr>
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<td>1</td>
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<td>5%</td>
<td>2%</td>
<td>24%</td>
<td>15%</td>
<td>9%</td>
<td>2%</td>
<td>7%</td>
<td>35%</td>
</tr>
<tr>
<td>1</td>
<td>J2</td>
<td>1%</td>
<td>0%</td>
<td>38%</td>
<td>22%</td>
<td>2%</td>
<td>7%</td>
<td>13%</td>
<td>17%</td>
</tr>
</tbody>
</table>

**Shading key:**

- % ≤ 9
- 10 ≤ % ≤ 19
- 20 ≤ % ≤ 29
- % ≥ 30

**Table 8.5: Percentage frequencies of ‘maths’ talk speech acts for each of the fifteen group sessions.**

The data in Table 8.5 indicate differences in the use of the speech acts for the mathematics talk between each group. Consistent with Table 8.4, the speech act that had the greatest frequency appeared to be ‘describe’ in most of the groups. The data in Table 8.5 do not suggest that there are any relationships between the speech acts and year group. The percentage frequency for the
‘describe’ speech act is greater in both year groups for example group session B2 (Year 2 group) and session I2 (Year 1 group).

The pre-intervention session B1 was one exception in the use of the ‘describe’ speech act. In this session the ‘explain’ speech act had a greater percentage frequency than ‘describe’. However following the intervention in the session B2, the use of explanation appeared to decrease and the use of describing to increase. The pre-intervention session E1 also had a greater percentage frequency of ‘explain’ speech acts and this decreased following the intervention. In the post-intervention session D2, the speech act ‘respond’ had a greater percentage frequency than ‘describe’. There is no comparative independent pupil-pupil talk data for Group D.

Although the percentage frequency for speech acts ‘agree’ and ‘disagree’ were small over all the groups, the post-intervention group sessions F2 and E2 had greater percentage frequencies of ‘disagree’ compared with the other groups. For the group session F2 the percentage frequency for ‘disagree’ was 12%. It is noted that this is in comparison to 40% percentage frequency for ‘disagree’ in the ‘non-maths’ talk.

The quantised data in table 8.5 have highlighted speech acts ‘agree’ and ‘disagree’ as possible elements in determining the change along with the speech act ‘explain’. Where the speech act ‘explain’ decreased, the speech act ‘describe’ appeared to increase. Qualitative analysis of the utterances were carried out for the speech acts ‘agree’ and ‘disagree’, ‘describe’ and ‘explain’. These codes were searched by highlighting the transcripts in NVivo 9 for each of the group sessions. Examples of these examinations are given below.

‘Explain’ and ‘describe’ speech acts for ‘maths’ talk:

In the pre-intervention group session B1 there seemed to be a greater percentage frequency of speech acts related to explaining. This pre-intervention session is presented as an example of the children’s explanations where the children appeared to be responding and engaging with the mathematics.
In the pre-intervention session, B1, the three children were solving the word problem, ‘There are twenty eggs; a box holds six eggs. How many boxes would you need to hold all the eggs?’

**Dialogue 8.B1.1**

1. Lucy: 19, 20... So we have three boxes and then two eggs in another box.

2. Ann: There are 20 eggs and you’ve got, right so 20 eggs, so you put all of those 20 eggs in a box and there are six eggs to go in a box each. 1, 2, 3, 4, 5, 6.

3. Lucy: So we have three boxes,

4. Ann: Yea, yea

5. Lucy: And we have two eggs in the fourth box, yea? You get it?

Ann and Lucy’s utterances had been coded as explanations. Lucy initially gave a solution in utterance 1. Ann then gave an explanation 'so you put all those 20 eggs...' (utterance 2). Lucy then replied with the same solution 'so we have three boxes’ (utterance 3) and Ann agreed. Lucy then qualified the use of a fourth box for the two remaining eggs. These speech acts were coded as ‘explain’ as there seemed to be an intention to give an exact meaning of the solution and the process. These utterances were also coded as ‘respond’ and ‘agree’ as the children appeared to relate to each other’s utterances. Ann’s ability to explain her mathematics may have been aided by the context, as she stated;

**Dialogue 8.B1.2**

Ann: This is rather a bit easy for me because I’ve got chickens

This could be described as an example of exploratory talk as the children were reasoning together in finding the solution. It is noted that this possible example of exploratory talk can from a pre-intervention session.

In contrast utterances related to ‘explain’ were not evident in the post-intervention session B2. In this group session Mary replaced Lucy. The children were solving a puzzle arranged on a grid that required them to count in
multiples of four. The puzzle had four squares on the grid that had been blanked out and each square had a value of four. The children were finding the value of all four blanked squares (4 x 4) and they attempted to solve this by counting in ones.

Dialogue 8.B2.1

1. Mary: We’ve got to count
2. Mary: 1, 2, 3, 4, 5, ... I ended up with 16
3. Ann: I ended up with 21. *(to Jane)* What did you end up with?
4. Ann: 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
5. Mary: 14 she ended up
6. Mary: So this is hard, cos Jane ended up with 14, I ended up with 16; you *(to Ann)* ended up with 21.

In this extract from the post-intervention session B2, the children were talking aloud as they counted in ones and then told each other what they had found as the total. They were describing their mathematics, thinking aloud and then relating this to each other. The children arrived at different answers. It seemed that they were trying to comply with the ground rule that they all had to agree but as the talk progressed they were unable to determine which answer was correct. The children did not seem to be able to explain why they each had a different answer or to decide which one was correct. There was no intention to give an exact meaning of the mathematics but they did give an account of the mathematics that they were using as they talked aloud. For example Ann recounted in utterance 4. Later Jane appeared to use a different strategy (maybe counting in multiples) but she worked on this independently and did not share it with the other children.

This example of talk from the group session B2 is given to illustrate talk coded as ‘describe’. In this example the children do not appear to be engaging with each other, other than to tell each other the solution they had arrived at. They were not responding to each other in solving the problem together. The children may not have been be in dispute as they were not arguing, but they seemed unable to work together to find a solution.
In relation to the TC Project, it seemed the intervention had not been effective in developing the mathematics for Group B. This happened in a class where the teacher frequently reinforced the talk rules. However the children seemed unable to explain their mathematics to each other as they had done in the pre-intervention session. This could have been because of the change in the children in the group or it could have related to the context of the task. In the pre-intervention session the context seemed to have helped the children in giving an explanation. This did not seem to be the case here.

'Disagree' in the 'maths' talk related to the 'non-maths' talk:

The indication of an increase in speech acts related to disagreement might suggest that the talk had become disputational. However challenging a decision would entail disagreement and this could be constructive rather than leading to a non-productive dispute. This would be anticipated if the children were developing exploratory talk. In the analysis of the 'non-maths' talk the 'disagree' speech act had suggested confrontational and disputational talk in some groups as one or more children had dominated the management of the task and turn taking. This had been particularly so in Group F where there was domination from one child, Group I where the children had focused on the task rather than the mathematics and Group A where the children had focused on turn taking. Group F and Group I are referred to in this section as examples of changes in ‘disagree’ speech acts for the ‘maths’ talk. I refer to Group A later as an example of a group with a range of different changes in the talk.

Group F had shown a large increase in disagreement in managing the task and this was thought to relate to one child’s dominance and social positioning within the group. The group is considered here in relation to disagreement in the talk about the mathematics. In the pre-intervention session, F1, Avril had dominated the management of the task (Dialogue 8.F1.1 & 8.F1.2) but there had been little dispute over this. In the post-intervention session, F2, the dispute in managing the task increased (Dialogue 8.F2.2 & 8.F2.3). There also appeared to be an increase in the percentage frequency for the ‘disagree’ speech act in the mathematics talk for this group from 1% to 12%. This percentage frequency of 12% for ‘disagree’ in the group session F2 seemed to be greater than many of
the other groups in the mathematics talk. However it was less than the percentage frequency for ‘disagree’ in the ‘non-maths’ talk; this had been 40%.

In the pre-intervention session F1, Libby had not challenged Avril in the management of the task and she also appeared not to challenge Avril in the mathematics that they were doing. Libby barely spoke as Avril asked her what she wanted to do and directed her to each step in finding the numbers. In this extract of the session the children were colouring in all the 5 digits on a hundred square. The learning intention was that they would see the pattern of the tens digit 5 and the unit digit 5.

Dialogue 8.F1.3

1. Avril: Right you have to look for all the fives, I can see some fives, one there, one there, if you want to cross that one out, or which one do you want Libby? (Libby points to a number where 5 is a digit)
2. Avril: Right you did 5 did you?
3. Avril: Right, ok?
4. Avril: I’ve done mine, yours Libby? Or did you do that one?
5. Avril: 35, which one do you want? Ooooh
6. Avril: What’s that number?
7. Libby: 55
8. Avril: Right, good girl. I had 45, right which one do you want?

This extract of talk could be described as cumulative as Libby followed the mathematics that Avril was doing.

This is contrasted by the talk in the post-intervention session, F2. In the post-intervention session the children were finding ways of partitioning the spots on a ladybird’s wings by placing counters on pictures of ladybirds. The children had placed all the counters that they were given onto the two wings and were trying to determine how many there were altogether by counting. Avril asked Libby if they agreed on the number of counters.
Dialogue 8.F2.4

1. Avril: Do you agree? Do you agree Libby?
2. Libby: No

Avril was asking for agreement, as she had been encouraged to do by the ground rules introduced to the class, but in this case there was disagreement with a firm 'No' from Libby and this disagreement continued.

Dialogue 8.F2.5

1. Avril: How much is that?
2. Libby: 23
3. Avril: No that’s not!
4. Libby: 24?
5. Avril: 37, ‘cos I just counted. Do you want to count if it’s 37?

Later the children have been told to use 14 of the counters and to find how many ways to partition the 14 counters across the two wings. Colin had also joined the pair of children.

Dialogue 8.F2.6

1. Libby: Let me try
2. Avril: Yea, but we might not think, agree with that.
3. Colin: I know
4. Avril: No, we don’t agree with that
5. Libby: Please can I try
6. Colin: I don’t think it's that

Again the children were attempting to use the ground rule for agree and disagree but it seemed to be causing confrontational talk rather than being used constructively. Later, the children had placed the 14 counters across the two wings and they were counting how many there were altogether.
Dialogue 8.F2.7

1. Libby: 6, 7, 8, 9, 10, 11, 12, 13, 14, 14
2. Avril: No it isn't, I'll tell you...
3. Libby: There’s 14, I counted in ones
4. Avril: 2, 4, 6 ...
5. Libby: You’re counting in twos, I counted in ones

If characterising this as a type of talk then it would be seen as an example of disputational talk. I have included it here because it shows a change from the pre-intervention talk in the way the children were engaging in the mathematics. Even though the children were unable to arrive at a solution the children were talking to each other about the mathematics. There was also a sense of logic (albeit misconceived) in the last extract as Libby (utterance 5) tried to rationalise why they had found different totals. It is not clear if she really believed that counting in ones and counting in twos would give a different total. If so this would show that her concept of conservation in number or cardinality was not sound but at least there was an attempt at giving a reason for the different totals that they had arrived at.

Even so, the extracts of talk from the group session F2 are included in this doctoral study as an example of mathematics talk that did not develop the way we had anticipated in the TC Project. This happened in a class where the teacher reinforced the talk rules. The other children worked in groups of three in the class and the talk in these groups was often seen as constructive. It seemed that Avril was adopting the ground rules that had been introduced by the teacher, so why did the children react this way? This again raises questions regarding the propensity of individual children in working collaboratively. The notion that introduction and adoption of the ground rules by the children will result in exploratory talk is not without its nuances and the confrontation that resulted from the social positioning that was evident in the management of the task and cooperation was also evident in the mathematics talk. This point is discussed further in the discussion Chapter 10.
Group I’s apparent increase in the use of ‘disagree’ speech acts in the ‘maths’ talk was not as substantial as Group F’s and suggested that there was still a relatively small percentage frequency with 7% of speech acts as ‘disagree’. The analysis of the post-intervention session related to the ‘non-maths’ talk suggested the children had seemed concerned with how to complete the task rather than in the mathematical ideas of the task. It is noted that Group I was the group that had a substantial decrease in the proportion of mathematics talk in the post-intervention session.

In the post-intervention session, I2, the children were given cards which displayed different sets of coins. The task was to match cards where the coins had the same total value. In this extract Jack was holding up a card with coins that he thought had a value of 6p and he showed this to Martin and Harvey. There was some consideration between the children whether they agreed or not, suggesting that the children were using the ground rules.

Dialogue 8.l2.3

1. Jack: This equals 6
2. Martin: Let’s have a look, 1, 2, 3, 4, 5, 6. 6p, there’s no 6p
3. Harvey: No for 6p, you need...
4. Jack: 1 2 3, 1 2 3 4 5 6
5. Martin: I disagree
6. Harvey: I agree, No, I don’t agree

The extract above indicates that the talk in the mathematics was related to the need to agree so it seems that the children were adopting the ground rule. There was little evidence of any exact meaning of what they were doing in matching the cards and the children’s utterances mostly related to counting out the values of the coins. It is noted that Harvey started a statement regarding a need (3) suggesting use of a modal verb. This is examined further in Level 3 analysis of use of words, but at this point it is seen as indicating an attempt to relate to the mathematics. Although there is disagreement this does not seem to be disputational in the same way as Group F. However the children seemed unable to determine which answer was correct. The children did not seem to be able to explain why they each had a different answer or to decide which one.
was correct. This seemed similar to the inability to agree on the solution that had been apparent in group session B2.

Group E, also had a greater percentage frequency of ‘disagree’ in the post-intervention session. For Group E analysis of the ‘non-maths’ talk had suggested there had been a decrease in the level of disagreement, but in the mathematics talk there was an increase from almost nothing to 15% (Table 8.5). In this post-intervention session it seemed that ‘direct’ was the most frequent speech act and not ‘describe’ or ‘respond’ as with the other groups. A matrix query was carried out in NVivo 9 to identify speech acts for both ‘direct’ and ‘disagree’ within the transcript. These extracts of talk were initially considered as another example of disputational talk but as the talk developed it seemed that something else was happening.

In the post-intervention session E2, the children were given 9 houses (3 red, 3 blue, 3 yellow) and 9 bears (3 red, 3 blue, 3 yellow). The task was to place each coloured bear on a different coloured house, that is the children were finding the different combinations.

Dialogue 8.E2.4
1. Chas: Blue, blue, Lara, blue there, no not there.
2. Chas: No put yellow there now, I’ll show you where. No.
3. Chas: That bit’s wrong, blue’s wrong, blue’s wrong.

In this extract Chas was directing the placement of the bears following the rules of the combinations as presented in the task. There was little response from the other two children. His speech acts seemed confrontational in the way he responded to Lara and Mandy in the positioning of the bears. This type of talk continued but there was some response from Mandy.

Dialogue 8.E2.5
1. Mandy: But then what about..... We’ve only got...
2. Chas: No, it’s supposed to be...
3. Mandy: No... because look
4. Chas: Leave it! It’s supposed to be there.
Mandy was challenging Chas and they argued over the position of the bear. Again this seemed to be disputational. It is noted that Chas stated ‘it’s supposed to be...’ (utterances 2 & 4). This suggests a use of a modal verb and is considered further in Level 3 analysis of use of words but it is noted that this seemed to be an attempt to refer to the mathematics.

Later all three children become involved in sorting the position of the bears.

Dialogue 8.E2.6

1. Mandy: They’re all different.
2. Chas: Ah, he fell off! *(one of the bears falls over)*
3. Lara: So that’s red, red, red
4. Chas: No, they’re not allowed to be... Ohhh red red

Mandy (utterance 1) had stated that there were different coloured bears on the houses, as was needed for the solution, but Lara pointed out that a red bear was sitting on a red house (utterance 3.). Chas then stated ‘they’re not allowed to be’ (utterance 4). Again, Chas was seemed concerned that their solution met the rules for the mathematics of the task and he used a modal verb to suggest this. I come back Chas’ used of modal verbs in Chapter 10. These utterances were not explanations, in that none of the children gave an exact meaning to what they were doing, but there was a sense that the children were working out a solution together following the rules of the mathematics in the task and that they were directing each in positioning the bears.

Later Chas noticed another incorrect arrangement with a yellow bear on a yellow house.

Dialogue 8.E2.7

Chas: Look it’s yellow yellow. You can’t have yellow yellow, you can’t have yellow yellow, remember? You can’t have yellow yellows, so you may need a blue, separate them. Put a red, blue, Lara, and a yellow there.

Again Chas referred to the rules by saying ‘you can’t have ...’ and was suggesting that ‘you may need ...’ in order to find a solution. Although Chas is telling the other two children what ‘should be’, what ‘you can’t have’ and what ‘is
needed’ the utterances do not given an explanation, they do not give an exact meaning of why they should move the bears. However the children were following the rules in finding a solution. Chas was directing this but with Lara and Mandy giving their opinions and showing these by pointing.

Although the tone seemed confrontational at points, they could be seen to help each other solve the problem. In directing and disagreeing the children were pointing out to each other to show where they should reposition the bears. It is worth noting that this group did solve the problem. They then went on to arrange the different combinations of bears and houses onto a 3 x 3 blank grid so that each row and column had a different arrangement. The pattern of talk was similar but the children did work together to solve the problem.

From the examples of dialogue given in the extracts above, it seemed that speech acts related to ‘explain’ were not evident in the post-intervention sessions. However the speech acts related to ‘disagree’ were more evident. In some groups this became disputational (for example Group F) and in others the children were sharing solutions but were unable to resolve them and reach an agreement (for example Group B and Group I). Whilst the talk could still appear disputational it was used alongside direction to realise a solution to a problem, as in Group E.

‘Responding’ speech acts for ‘maths’ talk

Utterances that suggested a child had related to another child were coded as responding. These utterances would have been coded along with another speech act such as describe, explain, question, direct, agree or disagree. If we were looking for talk where the children were exchanging ideas then it would seem that they should be responding to each other. Apart from agree or disagree, where it would seem evident that this was a response, not all the other speech acts were given as a response to another child. A child may have asked a question or given a direction but this was not always responded to. It is noted that not all responses would have been given verbally. There could have been gestures such as nodding or shaking of the head or the act of carrying out a direction, so in coding from the transcript it is possible that not all of the interaction was identified.
The data in 8.5 suggested that for the post-intervention group session, D2, the percentage frequency of speech acts referenced to ‘respond’ was 35%. This group session appeared to have the greatest percentage frequency for ‘respond’ speech acts when compared to the other groups. Group D were from a Year 1 class that had no evidence of pupil-pupil talk in the pre-intervention session. The extract presented below is from a sequence of utterances that suggested the children’s comments related to each other continuously.

In this post-intervention session the children were finding arrangements for the numbers 7, 8, 9, 10, 11 and 12 so that they did not have to count each individual counter. This was related to the idea of the arrangement of dots on the face of a die. The children did not have to count these, they could see how many there were from the arrangement. As such this activity related to subitising in that the children could see a set without counting. However, unlike natural subitising with numbers over 6, the recognition of quantity relied on the children’s use of partitioning of numbers.

The children had positioned 7 counters in a diagonal line. The teacher asked if they could recognise this as 7 and then left them to decide between themselves.

*Dialogue 8.D2.1*

1. Joe: Yea, that’s 7, 1 2 3 4 5
2. Harry: But you’re not allowed to count
3. Joe: Yes
4. Harry: You’re not allowed to count
5. Joe: Why not?
6. Harry: You’ve got to recognise it
7. Joe: You could do it like that
8. Vera: But that would be just the same as counting like that
9. Harry: But can you recognise that? Just going down there? No you can’t, I’ve got to count like 22, 24
10. Vera: I can recognise it, sort of
11. Harry: Mm, that’s given me an idea, how about if you put one in each corner, like a 4
12. Vera: That’s a good idea
13. Harry: Because... and then you put one there, yea one there
14. Vera: And one in the middle
15. Harry: You can’t really recognise that
16. Harry: Oh yes you can, no you can’t
17. Vera: How about if we do the 6 and then put the last one in the middle
18. Harry: What’s six then?
19. Vera: Look, 6
20. Harry: Aha, 3 add 3 equals 7
21. Vera: 3 add 3 add 1
22. Harry: Equals 7
23. Vera: That’s one done
24. Joe: But I can’t recognise it!
25. Vera: I can
26. Joe: That’s still seven

I have presented Dialogue 8.D2.1 to show a sequence of utterances that were coded as ‘respond’. Each utterance was seen to respond to another utterance. Alongside the respond coding the utterances would have been coded against other speech acts. Whilst there was a range of these codes such as describe, direct, disagree and agree, there was no evidence of explanation, in that the children did not give an exact meaning for their directions or disagreements. There was evidence of the children relating to the rule of the task, they should be able to recognise how many there were without counting, but there is never any explanation of why they did or did not need to count. Harry and Vera seemed to have understood the purpose of this rule but it is not so clear that Joe did.

So far in the analysis examples of talk have been found that suggest children were exchanging ideas about the mathematics. This seemed to be as they were describing what they were doing and directing each other in how to complete the mathematics of the task. Ideas were challenged, directions and ideas were given. Some rudimentary explanations were given, for example in Dialogue 8.D2.1 utterances 17-22, Vera and Harry gave some indication of explaining
what they meant as they positioned the counters to make two lots of three with one in the middle. What is noticeable is that the children were referring to specific examples as they gave their rudimentary explanations.

8.3.3. Group changes in ‘maths’ talk speech acts

Changes across the groups were considered to determine, in particular, if there was evidence of changes across several of the speech acts, hence indicating that the talk may have changed in several ways. The speech acts ‘agree’, ‘call attention’, ‘direct’, ‘disagree’, ‘explain’, ‘question’, and ‘respond’, would all be seen as potential indicators of talk that was more cohesive, in that there may have been more exchange of ideas. The only speech act that might not suggest this was ‘describe’ as this could refer to a child talking aloud their mathematical thinking. This speech act would only be seen as conducive to cohesion if it was associated with references to the other speech acts.

Table 8.6 shows the changes across the six groups where comparison was possible (A, B, E, F, I, K). Interesting the only speech act that increased

<table>
<thead>
<tr>
<th>Year</th>
<th>Group</th>
<th>Agree</th>
<th>Call attention</th>
<th>Describe</th>
<th>Direct</th>
<th>Disagree</th>
<th>Explain</th>
<th>Question</th>
<th>Respond</th>
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<td>2.7</td>
<td>0.7</td>
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<tr>
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<td>0.8</td>
<td>0%–42%</td>
<td>0%–15%</td>
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<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>1</td>
<td>F</td>
<td>0%–1%</td>
<td>2.0</td>
<td>1.0</td>
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<td>12.0</td>
<td>0%–0%</td>
<td>0.7</td>
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<td>0%–3%</td>
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<tr>
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<td>0%–2%</td>
<td>0.1</td>
<td>1.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Small change or ≤ 5% in both cells
Proportional change, decrease ≤ 0.6
Proportional change, increase ≥ 1.4 or change from 0% to at least 5%

Table 8.6: Proportional change of percentage frequencies of the ‘maths’ talk speech acts for the six groups A, B, E, F, I, K
consistently across all the groups was the ‘disagree’ speech act. However as
was seen above in the qualitative analysis, an increase in disagreement did not
necessarily indicate disputational talk.

Two groups that showed an increase in four of the speech acts suggesting
further cohesion were Group A and Group K. For Group A these speech acts
were ‘disagree’, ‘agree’, ‘explain’, and ‘question’. For Group K these speech
acts were ‘call attention’, ‘direct’, question’, and ‘respond’. Quantitative
examination indicated that, for some of these speech acts, the percentage
frequencies were small so these are not claimed as general rules for changes in
talk. However they may indicate that there were changes in these two groups
that were worth investigating qualitatively.

**Group A: changes in ‘maths’ talk**

By examining the transcripts for the two sessions for Group A, sections of the
dialogue that include speech acts for ‘disagree’, ‘agree’, ‘explain’, and ‘question’
were selected from NVivo 9 coding and examined further. Extracts from these
sections of dialogue are presented as examples of changes in the children’s talk
in the pre-intervention and the post-intervention sessions for Group A.

In the pre-intervention session the three children were given a large card with
an image of two baskets, smaller cards with functions such as ‘double ten’ and
small images of eggs. The task was to show the function by placing the images
of the eggs onto the images of the baskets. First the children were deciding how
to show the function ‘divide by two’ with twenty four eggs.
Dialogue 8. A1.5

1. Olwen: Twenty four divided by twelve equals two
2. Diane: I thought twenty four...
3. Olwen: You start with the biggest number
4. Olwen: Look...it is – I think the two should go there
5. Diane: Yeah, that’s what I think
6. Emma: Ok, you said two
7. Olwen: That’s alright, if you don’t want two, what’s twelve and twelve?
8. Olwen: Well you think that, Emma don’t! You put what you think and then I’ll put what you think, then Diane puts what she thinks

In this extract of talk from the pre-intervention session, the children stated what they thought. So in that respect they were giving opinions. There was an attempt by Olwen in utterance 7 to check by adding twelve and twelve but within this utterance is also the statement ‘that’s alright, if you don’t want two…’ Whilst the mathematical sense of this is not clear there is an indication that it is alright for them to have different solutions to the problem. In fact Olwen clearly stated in utterance 8 that she did not have to think the same as Emma, and that they could individually have their own ideas. At this point the talk resorted to arguments about turn-taking as was seen in the ‘non-maths’ talk for these children in Dialogue 8.A1.3 and 8.A1.4 above.

The next the function that the three children looked at was ‘double’ with the seven eggs.

Dialogue 8.A1.6

1. Diane: Double seven,
2. Emma: Double seven, you start with double seven
3. Diane: I know what that one is
4. Diane: No, we need to know what it equals
5. Olwen: Oh yea, Emma’s good at that
6. Olwen: Seven fourteen two, fourteen ....equals
7. Diane: Seven (Diane counts on her fingers)
8. Olwen: Yes, exactly, you don’t have to count it to work it out

And then the three children look at double 3.

Dialogue 8.A1.7

1. Olwen: (to Emma) Ok, so six, what is the multiplication?

2. Emma: Six, six, six

3. Olwen: Yea I know, so what’s like...

4. Emma: Why do I have to do it?

5. Olwen: Because I can’t do it, you can do it.

6. Olwen: Ohhh... Three times three equals six

7. Emma: You mean six divided by two equals three

8. Olwen: Ok, I know, I was just playing up and that one’s wrong

As the dialogue continues the turn taking of the non-maths talk becomes more apparent. The children did complete the task together. They were sharing the resources and they did work on one problem together at a time. There are some indications that the children were cooperating. They stated what they needed to start with (Dialogue 8.A1.6 utterance 2) and Diane and Olwen come to an agreement that double seven is fourteen (Dialogue 8.A1.6 utterances 6 and 7). Olwen stated that Diane did not need to count but she did not give an explanation of how she found the answer. Emma and Olwen appeared to be confused over the double three function and Emma did give some help in this (Dialogue 8.A1.7 utterances.6 - 7). Olwen then suggested that she had been ‘playing up’ (Dialogue 8.A1.7 utterance.8) but she did agree (‘Ok, I know’). Even though the talk seemed disputational at times they were working together to complete the activity. A question arises; how were they exchanging meaning in this dialogue?

In the post-intervention session, A2, the children were given the task to draw their own representations for given word problems. The teacher had not modelled how they might represent the problem; they were to decide their own way. The children recorded their representations on a mini-whiteboard. The first problem was ‘there are ten worms take away four’.
Dialogue 8.A2.2

1. Emma: So let’s start, so there’s, ok we have ten worms, 1 2 3 4 5 6 7 8 9 10
2. Olwen: Yea and then you put something like
3. Emma: And then we’re going to ... and then can we take away four?
4. Emma: Take away four
5. Olwen: No there has to be like a line between them because the four of them have been taken away
6. Emma: Take away four
7. Olwen: So you have to make a line
8. Emma: Take away four?
9. Olwen: Mm, that leaves 1 2 3 4 5 6
10. Emma: And it leaves
11. Olwen: 6
12. Emma: 1 2 3 4 5 6.

In this dialogue the children described the mathematics that they were doing and gave directions to each other on what to do. Utterances 2 and 3 have a sense of following on from each other such as; ‘then you put something like’ followed by ‘And then we’re going to…’ This is contrasted with the talk from the pre-intervention dialogue ‘Yeah I know, so what’s like’ and ‘Why do I have to do it’.

In this extract of dialogue the children did challenge each other, for example Olwen insisted that there ‘has to be like a line between them’ (utterance 5 & 7). This suggested that Olwen is remarking on the need to show the subtraction. This is another example of use of a modal verb and is examined further in Chapter 10 in the word level analysis.

It seems that Emma and Olwen came to an agreement on what number of worms would be left in a non-antagonistic way. The three children all seemed to agree on this. There was no sense of individual approaches such as ‘You put what you think’ as was stated in Dialogue 8. A1.5. utterance 8, or a statement that suggested that ‘Yes, exactly, you don’t have to count it to work it out’ (Dialogue 8. A1.6. utterance 8), or even the statement ‘I was just playing up
and that one’s wrong’ (Dialogue 8. A1.7. utterance 8). There was a sense that
they were working with the same idea as they arrived at the solution ‘Mmm that
leaves…’ and ‘And it leaves’ (Dialogue 8. 8 A2.2. utterances 9 & 10). They
appeared to be finishing each other’s speeches and hence ideas.

Later Emma talked about the subtraction as ‘splitting’.

**Dialogue 8.A2.3**

1. Emma: There was ten worms, I split them, no you split them, so you
can take away like three then take away a two

2. Olwen: No four, he took four

3. Emma: I know but you can take away like a three then take away
one.

4. Emma: Then you’d have 1 2 3 4 5 6

5. Olwen: So it would be...(inaudible)

Emma has given a rudimentary explanation in the utterances 1, 3 & 4. She
initially talked about taking three and then two, Olwen interjected to say that it
was ‘took four’ and Emma went on to say how she would take three away and
then another one using the representation to help her. These utterances had
been coded as explanations as Emma seemed to attempt to give a meaning to
what she was doing rather than just thinking aloud.

Later the children were given a set of cards with number line representations of
different calculations and a set of cards with word problems. The task was to
match each word problem with a number line representation.

**Dialogue 8.A2.4**

1. Olwen: Ten worms were under a stone, a bird took four of them; how
many were left?

2. Diane: 6

3. Olwen: 6

4. Emma: That one’s the one *(points to one of the number line
representation cards)*
5. Olwen: Do we agree? Diane do you agree and Emma agree?
6. Olwen: So do we all agree?
7. Diane: Correct
8. Emma: Put it like that so *(puts the cards down as a pair)*
9. Olwen: So do we all agree
10. Emma: Yes! So now Diane...

In Dialogue 8.A2.4 the use of the ground rule to agree on a solution was apparent. The children knew the solution to the word problem. Olwen repeated the answer 6 after Diane. So was agreeing to this. Emma then pointed to one of the cards. Olwen then asked if they all agreed (utterance 6). Diane confirmed this (utterance 7). Hence they reached an agreement on which cards should be matched. However there is no explicit explanation of what is meant by the word problem or the number line. Apart from giving the answer, six, there was no indication from the children that they understood the calculation. They did not explain how they worked it out. The children seemed to know what was being talked about by pointing to the examples.

This type of talk continued as the children matched further cards.

**Dialogue 8.A2.5**

1. Olwen: Right 15 flies were on a cake, 5 more came along, how many were there altogether?
2. Emma: 15, 5, 10, 15, 20. It’s that one then. Is it that one? *(Emma looks at one of the number line cards and then points to it)*
3. Olwen: Yes, it’s definitely that one. Isn’t it Diane? *(Olwen points to the same card)*
4. Olwen: Look, 15 flies were on a cake, 5 more came along, how many were there altogether?
5. Emma: How many were there?
6. Diane: 20
7. Olwen: Yea, so that’s the one isn’t it?
8. Emma: 5 10 15 20
In Dialogue 8.A2.5 there was some further indication that the children were looking at the meaning of the number line representation. Once Olwen had read out the problem Emma then skip counted in fives as she looked at the number line on the card and pointed to the one she thought it might be and asked if the others agreed (utterance 2). Olwen agreed (utterance 3). Olwen seemed to think that Diane was less certain. Olwen's way of explaining was to read out the problem again, with the announcement 'look'. Emma reaffirms the question 'How many were there (utterance 5) and Diane then agreed on the answer of 20 (utterance 6). Olwen then pointed to the number line card again to reinforce that it was the one (utterance 7) and Emma repeated the skip counting. In this case the children were drawing further attention to the relation in the word problem by following the skip counting on the number line representation. This gave an indication of how they worked it out but they did not give this as a full explanation of the calculation and they did not explain to each other how the number line could have represented the problem.

For another problem the argument given for the matching was even more rudimentary.

Dialogue 8.A2.6

1. Diane: A ladybird has 6 legs, how many legs would four ladybirds have?

2. Emma: It’s that one, definitely, it’s definitely (Emma points at one of the number line cards)

3. Olwen: It’s easy that one (Olwen points to the same card)

4. Emma: What?

5. Olwen: It works

There was little explanation other than pointing to the specific examples by stating it is ‘that one’. Emma’s declaration that it was ‘definitely’ that one (utterance.2) might have been meant as a more convincing argument but there was no explanation. The other argument for the matching pair was that ‘it
works’ (utterance 5). However Olwen and Emma seemed to have understood each other and reached an agreement.

In the post-intervention dialogues 8.A2.2 and 8.A2.3 I have suggested that the children were collaborating further in their mathematics talk than they had been in the pre-intervention dialogues 8.A1.5, 8.A1.6, 8.A1.7. In the post-intervention dialogues rudimentary explanations were given as the children came to an agreement about the solution and the representations that they were drawing together. The evidence of reaching agreement was more apparent in the dialogues 8.A2.4, 8.A2.5 and 8.A2.6. However the arguments for these were more like opinions as the children pointed to the cards that they thought should match. There was some evidence of matching the skip counting to the number line representation in the dialogue 8.A2.5 but in both 8.A2.4 and 8.A2.6 the children reached an agreement through pointing to examples. In fact in 8.A2.6 the notion that ‘It works’ was enough to seal the agreement. What Olwen might have meant by ‘It works’ is considered in the word level analysis in Chapter 10.

**Group K: changes in ‘maths’ talk**

By examining the transcripts for the pre-intervention and the post-intervention sessions for Group K, sections of the dialogue that included speech acts for ‘call attention’, ‘direct’, ‘question’, and ‘respond’ were selected and analysed. Extracts from these sections of dialogue are presented as examples of the children’s talk in both of the session.

In the pre-intervention session the children were working in pairs; Pierce with Ben and Iris with Fran. One child picked a card with a multiplication problem such as 7 x 10 and gave the answer. The other child then asked for an explanation “Show me...” or “Why...?” The teacher had modelled this first. The children had materials to help them with their explanation if they wished to use them.

Pierce picked a card with 8 x 10.

*Dialogue 8.K1.2*

1. Pierce: Ok, I can tell you what, I’ve got 8 times 10 equals 80
2. Ben: Show me, you’ve got the 8.
3. Pierce: You get 10 tens and 10 tens, you can count up in your fingers, so imagine 10 20 30 40 50 60 70 80 90 100 like that and if it’s on there, *(Pierce points to the card)* that means times. So ten times. So its first times whatever it is. I mean, you get 8 first then it is 80.

4. Ben: So can you do it to me now? You pick up one.

*(Pierce picks a card and gives it to Ben)*

5. Ben: Because like you know, when you like. How it’s up on here.

   Look, One 10, one zero.

6. Ben: Now it’s your go *(Ben picks a card and gives it to Pierce)*

Pierce did suggest an explanation (utterance 3) as he attempted to give an exact meaning to the multiplication that he had answered. However Ben did not ask about the explanation, challenge it or attempt to extend it. When Pierce finished his explanation Ben asked Pierce to pick a card for him (utterance 4). The meaning of Ben’s utterance (utterance 5) was not clear. Although it seemed to be an attempt at an explanation it could not be coded as such. There was no response from Pierce as to whether he had understood what Ben was trying to explain. Ben continued with the turn taking and gave Pierce a card so that he could take the next turn. Although an explanation was given it did not seem that the ideas were used by either child.

Iris and Fran were also carrying out the same task.

*Dialogue 8.K1.3*

1. Iris: How do you know its 10?

2. Fran: If you have one 10 it’s 10 but if you have 5 then it’s 50. *(Fran takes five Numicon ten frames)*

3. Fran: If you have 5 tens then you add 6 it would be 60 *(Fran adds another Numicon ten frame to make six frames)*

Iris had asked Fran more about her explanation so there was an element of response. Fran’s utterances 2 and 3 were coded as explanations as there was an attempt to give an exact meaning to what she was thinking.
As Fran and Iris did seem to be responding there was a suggestion that these children were sharing ideas but this was not so evident with Pierce and Ben. In either case, the children did not build on the ideas or reach an agreement, hence it is not possible to know if they have understood each other’s explanations or not.

In the post-intervention, K2, session Pierce, Iris and Fran were working in a group of three. The teacher had revisited the use of inequality signs from a previous teaching session and had recorded the signs with the words ‘more than’ and ‘less than’ on a mini whiteboard. The whiteboard was left on the table with the children. The teacher also left the children a sheet of squared paper which had >50 written on one side and <50 on the other. The children were asked to write numbers that would be true for each inequality.

To start with Pierce misunderstood the > sign to be the numeral 7. Fran pointed this out to him. In order to decide what the > sign meant, they referred to the inequality signs recorded on the white board from their talk with the teacher.

**Dialogue 8. K2.3**

1. Iris: Ok  
2. Pierce: 750 is loads more  
3. Fran: That’s not 750  
4. Pierce: Oh yes  
5. Iris: Yes it is  
6. Fran: That’s the sign  
7. Iris: Oh yeah  
8. Iris: Is that more than or less than, which one?  
9. Pierce: That is....  
10. Fran: If we look at, if we have a look, that’s less than *(Fran points to the inequality signs on the white board)*  
11. Iris & Fran: That’s more, that’s more,  
12. Pierce: That’s more, more than  
13. Iris: That’s more than  
14. Pierce: Is it?  
15. Iris & Fran: Yes
The children were responding to each other in coming to an agreement on the meaning of the > sign. Fran pointed out further as she said ‘If we look at...’ (utterance 10) and directed them to the whiteboard where the inequality examples had been left by the teacher. There was no explanation of what the sign meant other than ‘more than’ or ‘less than’. The children did not attempt to give an exact meaning of their thinking or of the inequality signs. As the children responded to each other they pointed to the signs and gave their opinions of what the signs meant.

The children then took turns to write numbers on the >50 side of the paper. Iris and Fran gave their ideas but Pierce was still uncertain about the inequality sign initially.

**Dialogue 8.K2.4**

1. Iris: I know, I'll do 500
2. Fran: Then something is more, is bigger than 500...
3. Fran: 600
4. Pierce: Is it more than or less than?
5. Fran: Less than, that’s a more sign and that’s a less than,
6. Fran: 500
7. Iris: And then this is less,
8. Fran: what are you doing?
9. Pierce: 6000 is less uumm..
10. Fran: 600 is bigger than 500
11. Iris: No that’s the less one, that’s the more one
12. Pierce: I really get confused, 6000 is more than... Yeah that’s right.
13. Iris: Yea, write 70, 70
14. Pierce: 6000
15. Iris: 6000 that’s a big one
16. Iris: Are you not doing 6000?
17. Pierce: No 60
18. Pierce: 80 90 100
19. Iris: 700
20. Pierce: I’m going to do 7000 million
21. Iris: 80 or 800 or 1000
22. Pierce: Yes, I'll just do a thousand

By now it seemed that Pierce had got the idea.

Fran and Iris’ way of helping Pierce with his understanding was to point to the two inequalities on the whiteboard again (utterance 11). Although this did not seem to be an explanation, Pierce seemed to have understood the sign after this and was able to give further examples for numbers greater than 50. Although no explicit explanations were given, it seems that the children came to an agreed understanding. Once this had been established the children took turns in giving numbers greater than 50. However rather than just waiting for each to put a number they seemed to be using each other’s numbers to think of further examples.

There had been little explanation but the children were all clear about the meaning of the task as they offered ideas they built on each other’s examples. This building of the numbers continued as the children decided to change over to finding numbers less than 50.

Dialogue 8.K2.5

1. Pierce: Less than 50
2. Fran: Don't just do multiples of 10
3. Iris: 40, just do multiples of 10, you only get to do two multiples of 10 each
4. Pierce: Yea
5. Iris: Multiple of 10 now and then you get one more turn
6. Pierce: Minus 1
7. Fran: Minus 1?
8. Pierce: Yeah that's less than 50
9. Fran: Oh yeah, minus 1
10. Pierce: If I just said add 1
11. Fran: You could do zero
12. Pierce: Yeah
13. Fran: Ok, I'm not going to do a multiple of 10 now, no no more multiples of 10 now.
14. Iris: I'm not ever going to do a multiple of 10
15. Iris: Who is going to do less than zero
16. Fran: We're the maths people aren’t we?
17. Pierce: Yeah,
18. Iris: Yeah
19. Pierce: Minus 30, cool, I am with it, yeah..

To some extent there seems little else to add to the children’s’ discourse. The children seemed to challenge each other on two accounts. First they brought in a rule regarding their use of multiples of ten (utterances 2-5). Pierce then introduced negative numbers (utterance 6) and there was agreement between the children that the use of negative numbers would be valid (utterances 7 to 9). The children then suggested the use of zero (utterances 10 & 11). It seemed that the children were building and sharing on ideas as they thought of further numbers.

The declaration from Fran that ‘We’re the maths people aren’t we?’ (utterance 16) was intriguing and it is interesting to speculate what she might have meant by this. I examine this closer in Chapter 11, the discussion and in Chapter 12, conclusions and implications. However Fran’s statement did seem to suggest that they were feeling confident in what they were doing. There was a sense that the children were playing with the numbers and enjoying the challenge of the task. It would seemed possible that Pierce’s exclamation when he used negative 30, ‘Minus 30, cool, I am with it, yeah..’ (utterance 19) also suggested an element of play and enjoyment in the challenge.

What I had found intriguing with the children’s discourse in the group session K2 was that there was no explicit justification or reasoning. I had not coded the speech acts as explanations but as descriptions, directions or questions. I had recognised the long sequence of response but had not considered that, in pointing to examples the children were showing each other what the signs meant. Whilst there was no explicit explanation other than to name what the signs meant, this must have made sense to the children to such a degree that they then developed and played with the numbers.

These children seemed to approach the task in a playful way. The children were turn-taking and this seemed an important part of the discourse and gave it a
sense of a game. However the turn-taking was not approached in a controlled way as it had been by other groups in managing turns, such as Group A in sessions A1 or even still in A2. Taking turns was intrinsically part of the task in the group session K2 and was talked about only briefly (Dialogue 8.K2.1 non-maths talk). Taking turns would be an intrinsic element of communication and this seemed key to the children’s discourse. The children built on each other’s ideas and the children appeared to be exchanging meanings as they did so. Is this what Fran meant by being the maths people? I discuss this later.

8.3.4. Summary of the analysis of the ‘maths’ talk speech acts

From the quantitative analysis of the maths talk the utterances related to the speech act ‘describe’ seemed to be used most frequently by most of the groups and this use was still used consistently after the intervention. Changes in the mathematics talk appeared to relate mostly to an increase in disagreement but there was a decrease in the use of explanations. The percentage frequencies of these had been small. An initial impression was that the intervention had not changed the nature of the talk to any extent and may not have been effective in supporting children’s collaboration in their mathematics talk. There was little evidence of explanations of exact meanings being given in the post-intervention sessions so it was difficult to see how the children were exchanging ideas. The increase in disagreement also gave the impression that there was more disputational talk.

However qualitative analysis indicated that much more was happening. Even in the sessions that seemed disputational (Group F) there was evidence that opinions were being given and the very nature of disagreeing meant that the children were taking notice of each other’s ideas. Even if the children were unable to come to an agreed solution (Group B and I) there had been some attempt to engage with each other in the mathematics task that they had been given.

The increased use of disagreement was not always evidence of disputational talk and where this was associated with direction (Group E) it seemed that the children were working within the mathematics of the task and directing each other what to do by giving opinions and pointing. Further examination of the
discourse related to responding (Group D) showed that the children were engaging in each other’s ideas over a sequence of utterances. The exchange of ideas were given as opinions and were often associated with pointing.

Two groups, Group A and Group K, were presented as those that may have shown the greatest changes in the different speech acts. In Group A both of the talk in the pre-intervention and post-intervention sessions had elements of dispute, although this seemed less in the post-intervention session, but the main change seemed to be in reaching an agreed solution, particularly in dialogue 8.A2.4, 8.A2.5 and 8.A2.6.

In the examination of the ‘non-maths’ talk for this group the level of dispute regarding turn taking decreased after the intervention and the children appeared to negotiate rather than to argue. It would seem that this enabled the group to collaborate further on the task. They also seemed to use the idea of agreement to share ideas in the mathematics talk in the post-intervention session. Whereas they had been prepared to accept that they could all have different ideas in the pre-intervention session they worked towards an agreement.

In Group K the children’s independent talk in the pre-intervention session had been limited to a few examples. The children were working on a task together and took turns in giving their explanations but these did not seem to be used or built on. In the post-intervention session the idea of coming to an agreement was not explicit but the children directed and pointed to the signs and the children seemed to come to an agreed understanding of the meaning of the signs. They then used this understanding to build on each other’s suggestions of numbers as they took turns.

From the analysis of the mathematics talks across the different groups it seemed that a key part of the intervention had been the children’s attempts to take on board the ground rule for agree, even if they did not use the term explicitly. In some groups, for example the post-intervention session F2, this seemed to have created confrontation, and the talk would be best described as disputational (Dialogue 8.F2.4 - 8.F2.7). This may have been due to the social authority positioning of the children involved. In other post-intervention group sessions, B2 and I2, although there was less dispute the children seemed
unable to reach agreements or arrive at solutions for the problems. However in three post-intervention group sessions A2, D2 and K2, and to some extent in E2, agreements were met and solutions arrived at. However these were not arrived at through explicit explanations. Children rarely gave the exact meanings of their solutions or their thinking. The agreements were met through giving opinions and rudimentary arguments. These were often accompanied by the children pointing to examples or to the signs that they were using.

Although the use of ‘describe’ speech acts appeared consistent across the intervention, qualitative examination of the talk related to this speech act suggested its use had changed and that this change was related to the children’s use of argument (agreeing and disagreeing), directing and responding. Although the utterances could not be related to explanations of exact meanings of the mathematics that the children were working on, the speech acts that had been coded as ‘describe’ or ‘direct’ in the post-intervention sessions could have been seen as more akin to opinions. In order to make their opinions known to each other the children were pointing to examples, to draw attention to them.

Such talk would not be inconsistent with incipient exploratory talk as defined by Rojas-Drummond (2008; 2003). Rojas-Drummond had made a distinction between elaborate and incipient exploratory talk. In elaborate exploratory talk counter viewpoints are given and arguments are reasoned and justified whereas in incipient exploratory talk arguments are rudimentary and relate to specific examples and tasks.

8.4 Summary

Key points that arose from the analysis of the ‘maths’ talk speech acts were that:

- Although the percentage frequency of utterances referenced to the ‘describe’ speech act was consistent over the intervention, the children’s talk in relation to giving opinions and in deixis may have suggested that there had been a change in the intentions of these utterances that was not initially evident.

- The increased use of agreement (and disagreement) was often seen to
encourage the children to give opinions. In giving their opinions, children did not give exact meanings of their ideas but they would point to examples. This would suggest talk that was consistent with incipient exploratory talk.

In the examination of the patterns of speech acts carried out for this doctoral study there are some examples of the children’s mathematics talk that can be related to the types of talk, and in some group sessions, A2, D2, and K2, the talk could be aligned to incipient exploratory talk. The recognition of the various nuances in examining the speech acts in relation to the types of talk has helped to give a greater understanding of the changes that had happened. This closer examination has also helped to understand the way these children had collaborated when working independently in their talk about the mathematics of a task.

Qualitative analysis of the speech acts has also shown how some groups were able to respond to each other’s ideas and so come to solutions in the mathematics tasks that they had been given. However the analysis of the speech acts does not yet answer the research question related to the children’s exchange of meaning about mathematical objects. It has not yet analysed the learning.

A key characteristic of incipient exploratory talk that Rojas-Drummond (2003; 2008) had identified was deixis and this seemed to have been evident in the children’s talk in this study, particularly in the post-intervention sessions of A2, D2, and K2 as the children pointed to examples of representations and signs. As well as the use of the gesture in pointing, linguistically deixis is seen as a device for cohesion and meaning making and, as referenced in Chapter 2 and 3, has been used to analyse children’s learning in mathematics (Rowland (1992; 1999; 2000) and Radford (2002)). Within SFL, (more in Chapters 2 and 3) deixis is one function of various classes of words. Within this study it appeared to be a function that indicated the children were exchanging meaning as they talked about the mathematics. This is examined further in the next chapter.
9.1 Introduction

In order to understand better the learning that was taking place across the intervention there was a need not just to determine the nature of the children’s talk but to examine how children’s learning related to the nature of the talk.

From the analysis of the speech acts (as presented in Chapter 8) it seemed that there had been changes in the nature of the children’s talk, particularly in relation to reaching agreement. In the post-intervention sessions of several groups (Group A, Group D, Group K and to some extent Group E) the talk seemed to resemble incipient exploratory talk. The children were giving opinions in order to agree or disagree. Rather than giving exact meanings to support their opinions the children often gave rudimentary arguments. These had been coded as describing or directing speech acts. One key characteristic of incipient exploratory talk was that these rudimentary arguments were often associated with deixis. This could be noted as children pointed to examples. In analysing the talk at word level the intention was to determine if the children were also using linguistic pointers.

The term ‘incipient’ suggests an emerging type of the more elaborate exploratory talk. Whilst evidence (such as Mercer & Sams, 2006) has suggested that elaborate exploratory talk would be effective in supporting learning, could this be the case also with incipient talk? If so what role would linguistic devices such as deixis have in this?
The analysis of the speech acts of the ‘maths’ talk would suggest that the children gave descriptions of the mathematics that they were engaged in. As such the children were referring to mathematical objects. However an emphasis on consensus that appeared in the post-intervention sessions would suggest the descriptions had become arguments, albeit in a rudimentary way. Had this made a difference to the children’s reasoning about the mathematical objects? Also had the emphasis on agreement made a difference to the children’s exchange of meaning in relation to the mathematical objects?

The talk coded as ‘maths’ talk was further analysed at word level. Which words did the children use to associate with the mathematical objects as they used them to support their opinions? What function would these words perform as children exchanged meaning? What could this tell about the learning that was happening?

To determine if the children’s word use was associated with agreement or disagreement text searches were carried out using NVivo 9 to investigate the frequency of words that were explicitly associated with agreement. Table 9.1 shows the children’s use of words explicit to agree or disagree. It is also acknowledged that agreement or disagreement could be conveyed through gestures but this has not been analysed.

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<td>107</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>OK</td>
<td>9</td>
<td>0.3</td>
<td>26</td>
<td>0.3</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 9.1: Frequencies, percentage frequencies and proportional changes of words explicit for agree for groups A, B, E, F, I, and K.

As the data show the words ‘agree’ and ‘disagree’ were used rarely by the children in the mathematics talk. There was still little use in the post-intervention sessions, even though they had been encouraged to use these terms, ‘disagree’ appeared only once. However the use of ‘yes’ and ‘no’, would also suggest agreement and disagreement, and the use of these did increase
proportionally. Although these words seem trivial, their use would suggest the children were responding to each other’s ideas.

The word level analysis was carried out within three classes of words related to cohesive devices: conjunctions, deictic pronouns and demonstratives, and modal verbs.

i. Conjunctions were included in the analysis as their use provides continuity by relating one clause to another. They allow one clause to ‘elaborate, extend or enhance’ another earlier clause (Halliday & Matthiessen, 2004). So if a child was responding with ‘yes’ or ‘no’ then the use of a conjunction such as ‘because’, ‘but’, and so on could be used to elaborate on the agreement or variance.

ii. Deictic pronouns and demonstratives words were included in the analysis. Deictic words have new meanings, depending on the physical context. For example the use of a demonstrative adjective or pronoun in their talk would suggest that new meanings would be created to refer something different in each situation. Also the arguments the children gave were often associated with the physical gesture of pointing. As well as using deixis linguistically to direct the meaning, the children seemed to be directing meaning through gestures.

iii. The use of modal verbs indicates interpersonal deixis, an exchange within the dimension of uncertainty (Halliday & Matthiessen, 2004). Halliday and Matthiessen referred to modality as “the space between ‘yes’ and ‘no’” (p.147). Whereas the primary tense locates the exchange in a present time, modality locates the exchange within the dimension of assessment. So rather than ‘yes’ or ‘no’ or ‘it is’ or ‘it isn’t’, which are statements of certainty, responses such as ‘it can be’ have relative probabilities.

For each of these classes of words, comparative analysis was carried out to determine any differences in their uses with the six groups A, B, E, F, I, and K where there had been evidence of independent pupil-pupil talk before the intervention. This entailed low-level analysis with quantised analysis of the children's talk using text searches and word frequency queries in NVivo 9. The
data from these searches and queries was then used to highlight the function words that seemed relevant and to examine the children’s use of these in more depth or high level analysis.

The group sessions where examples of incipient talk had been identified (A2 and K2, and to some extent, D2 and E2) were used to illustrate uses of these words. As Group A and Group K had evidence of independent pupil-pupil talk before the intervention there was an opportunity to examine any changes with these two groups in more depth. Other examples of use of words were also taken from D2 and E2 to illustrate further the children’s use of words.

As the word searches were carried out in NVivo 9 it was found that many of the uses of the function words were from the excerpts of dialogue that have already been presented in Chapter 8. These are presented again in this chapter but are examined further in relation to the use of words. In order to do this, the video material was re-analysed along with the transcripts. Hence more details of the children’s gestures, in particular pointing, are presented in this chapter.

9.2. Use of conjunctions

NVivo 9 text searches were used to investigate the frequencies of conjunction words in the pre-intervention and post-intervention sessions of the six groups where there was evidence of pupil-pupil talk in both sessions. The text search was carried out with the utterances coded as mathematics talk only. Percentage frequencies were calculated to take account of the increased talk in the post-intervention sessions. These could then be used to determine proportional changes. The frequencies, percentage frequencies and proportional changes are set out in Table 9.1. The conjunctions ‘because’, ‘but’, ‘if’ and ‘so’ are the only ones presented as other conjunctions were not evident or their use was very limited. For example the use of ‘though’ was limited to two occasions in the pre-interventions sessions and only one occasion in the post-intervention session.

Even the percentage frequencies for ‘because’, ‘but’, ‘if’ and ‘so’ were small, so it is not possible to generalise from these, except to indicate that the children rarely used these words. The other indication from the analysis was that there was no increase in the use of these words, apart from ‘because’. This had been
a word that was emphasised in the ground rules in many of the classrooms and so an increase would have been expected, however its use remained small.

<table>
<thead>
<tr>
<th>Word</th>
<th>Frequency</th>
<th>Proportion (%)</th>
<th>Frequency</th>
<th>Proportion (%)</th>
<th>Change in proportional use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conjunctions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BECAUSE</td>
<td>15</td>
<td>0.4</td>
<td>39</td>
<td>0.5</td>
<td>1.3</td>
</tr>
<tr>
<td>BUT</td>
<td>10</td>
<td>0.3</td>
<td>24</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>IF</td>
<td>10</td>
<td>0.3</td>
<td>13</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>SO</td>
<td>37</td>
<td>1.1</td>
<td>52</td>
<td>0.7</td>
<td>0.6</td>
</tr>
</tbody>
</table>

*Table 9.2: Frequencies, percentage frequencies and proportional changes of conjunction words for groups A, B, E, F, I, and K.*

As the word ‘because’ had been part of the ground rules in the classrooms during the intervention, and there had been an indication of some change, the children’s use of this word was investigated further. In carrying out a text search for each group it was found that there had been a particular increase in one group, Group K. It must be remembered that for this group there was a substantial amount more independent talk in the post-intervention session so the increased frequency did not suggest a proportional increase. However the children’s uses of the word are of interest.

In the post-intervention session, K2, the children had been working with the inequalities > 20 and < 20. The use of the word ‘because’ became apparent in a later stage of the task when the children had been asked by the teacher to find addition problems that would be valid for the equality □ + □ = 20 and for the inequality □ + □ < 20. The children found examples for the equality and the inequality and recorded these on each side of the paper. As the children were finding different solutions for the inequality they realised they could use addition facts to ten and to the ‘teens’ numbers.

The teacher then asked them to decide which side of the paper would have more addition problems; the equality □ + □ = 20 or the inequality □ + □ < 20. The children were then left to make a decision.
Dialogue 9.K2.1

1. Iris: I’m probably going to think this one *(Iris points to the side of the paper closest to her with the sums for the inequality)*
2. Fran: I probably think....
3. Pierce: I know, I know, that one **because**... *(Pierce points to the inequality sign)*
4. Iris: That one **because**... *(Iris points to the side of the paper with the sums for the inequality)*

It seemed that the word ‘because’ (utterances 3 and 4) was used as the children pointed to a sign or the side of the paper. No elaborations were given. This use may have been perfunctory. The children had been asked to use the word by the teacher as part of the ground rules. However it might have been that the children were using the word to try and elaborate but were unable to verbalise this. As the talk continued some elaborations emerged.

**Dialogue 9.K2.1 (cont.)**

5. Pierce: **Because** it has that sign *(Pierce points to the inequality sign)*
6. Fran: I think that one *(Fran also points to the side of the paper with the sums for the inequality)*
7. Iris: Yes I think this one **because** it’s got the teens and the 1, 2, 3, 4, 5 up to ten *(Iris points to the inequality side)* and these ones *(Iris now points to the equality side and then hesitates)*... I think it’s the same.
8. Pierce: I think I know why **because** that *(Pierce points to the inequality sign)* makes it more...
9. Iris: I think it’s the same

In utterances 5 and 8 Pierce’s elaboration related directly to the inequality sign as he pointed to it. Pierce seemed to be suggesting that having the inequality sign < should mean that there were more addition problems. It is not clear why Pierce may have thought this. His elaborations, ‘it has that sign’ and ‘that makes it more’, did not give an exact meaning and so would be classed as descriptions or rudimentary arguments. It did indicate that he thought there would be a larger number of possibilities for the inequality than there would be for the equality but there was no explicit indication of why he thought this.
Iris’ elaboration in utterance 7 gave more indication of her thinking. Iris seemed to suggest that there were more possibilities with the inequality and she related to the addition facts to ten and to the teens numbers that they had used in finding possible solutions. This would seem a valid reason if working with positive integers. Why she hesitated when referring to the equality and then changed her mind is unclear, she seemed to be unable to elaborate on this. As a group the children were not able to come to an agreement on which should be more. The teacher rejoined them to talk further on this but there was no more independent pupil-pupil talk.

In the examples given above for Dialogue 9.K2.1 the children used the word ‘because’, and Pierce and Iris did give some evidence of their thinking. With Iris we also had an idea of why she might have thought there was more with the inequality. However we do not know why she changed her mind to think that they were the same.

Whilst there was more evidence of the thinking that supported Iris’ opinion both Pierce and Iris were attempting to elaborate. The children used pronouns and demonstrative adjectives as they pointed to the sign or related to the examples. I return to this dialogue when examining the use of pronouns in relation to the children’s use of deixis.

Use of the word ‘because’ was rare in the independent mathematics talk of the other groups, but a further example in the post-intervention session A2 is also of interest. In this group session the children were drawing their own representation for the problem ‘ten worms take away four’. Emma had drawn ten dots on the whiteboard and was about to use an eraser to rub out four of the dots.

*Dialogue 9.A2.1*

Olwen: No there has to be like a line between them *(Olwen points to a position on the whiteboard)* **because** the four of them have been taken away.

Olwen gave an opinion about using a line. She stated ‘there has to be’ and I come back to this use of modality later. She gestured to a position on the board to show where she thought the line might be and her elaboration was ‘the four
of them have been taken away'. She was relating to the function ‘subtract four’ as given in the word problem. What is interesting is that Emma’s reaction to erase the dots (or worms) would model the problem exactly, they would be taken away. However Olwen had disagreed. Her reason ‘the four have been taken away’ is not sufficient to explain why the line was needed. Even more interesting is that all the children accepted this as a justification. As I say, I return to this later.

The quantised analysis of the children’s use of conjunctions suggested that they were rarely used. ‘Because’ was examined qualitatively as an example to illustrate the children’s elaborations when giving opinions. It would seem that the children were relating to (and sometimes directly through pointing) the specific examples that they were working with in solving the problem as a justification. In Dialogue 9.K2.1 the examples also related to children’s use of deixis both gesturally and linguistically and in Dialogue 9.A2.1 the example related to use of modal verbs. These dialogues are examined again in relation to the two other classes of words; deixis and modality.

9.3. Use of deixis

Along with the characteristic of rudimentary arguments, a key characteristic of incipient exploratory talk was the use of deixis. Analysis was carried out to determine if there had been a change in the use of words related to deixis, first as low-level analysis in determining the frequencies of use using a larger corpus of data, and then as high-level analysis with a small sample of data.

<table>
<thead>
<tr>
<th>Word</th>
<th>Group session 1 (A, B, E, F, K, I)</th>
<th>Group session 2 (A, B, E, F, K, I)</th>
<th>Change in proportional use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percentage frequency</td>
<td>Frequency</td>
</tr>
<tr>
<td>IT(‘s)</td>
<td>84</td>
<td>2.5%</td>
<td>200</td>
</tr>
<tr>
<td>THAT(‘S)</td>
<td>45</td>
<td>1.3%</td>
<td>167</td>
</tr>
<tr>
<td>THIS/THOSE</td>
<td>24</td>
<td>0.7%</td>
<td>54</td>
</tr>
<tr>
<td>THERE(‘S)</td>
<td>35</td>
<td>1.0%</td>
<td>84</td>
</tr>
<tr>
<td>YOU(’RE/’VE)</td>
<td>138</td>
<td>3.9%</td>
<td>176</td>
</tr>
</tbody>
</table>

Table 9.3: Frequencies, percentage frequencies and proportional changes of deictic words for groups A, B, E, F, I, and K.
A text search was carried in NVivo 9 for the utterances coded as mathematics talk only. The data are presented in Table 9.3. The data show that there had been frequent use of the words ‘it’ and ‘you’ (along with stemmed words) in the pre-intervention session. The data also show that there was a substantial increase in use of the word ‘that’ or ‘that’s’ in the post-intervention sessions but that there had been a proportional decrease in use of the word ‘you’.

These three words, ‘that’, ‘it’ and ‘you’ (along with stemmed words), were analysed further to determine their frequency relative to other function words. A word frequency query was carried out using NVivo 9. It was set to search for the most frequent 20 words and to include stemmed words. Stop words were set to content words, including children’s names and words for mathematical objects (numbers and processes) as well as words that would be associated with contexts of the problems. The function words ‘I’ and ‘a’ were also stopped as these were used to code the names of children in the groups and this would have distorted the count. The use of the function words were ranked according to their frequencies with the most frequent listed first. The six most frequent function words for the pre-intervention and the post-intervention sessions are presented in Table 9.4.

<table>
<thead>
<tr>
<th>Pre-intervention Sessions</th>
<th>Post-intervention sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Word</td>
<td>Count</td>
</tr>
<tr>
<td>you’ve</td>
<td>108</td>
</tr>
<tr>
<td>it</td>
<td>64</td>
</tr>
<tr>
<td>there</td>
<td>45</td>
</tr>
<tr>
<td>and</td>
<td>42</td>
</tr>
<tr>
<td>so</td>
<td>42</td>
</tr>
<tr>
<td>that</td>
<td>42</td>
</tr>
</tbody>
</table>

Table 9.4: Ranking of use of function words for groups A, B, E, F, I, and K.

From the data presented in Table 9.4 it seems that the stemmed words related to the pronoun ‘you’ were used the most frequently in the pre-intervention session but the pronoun ‘you’ then became the third most frequently used word in the post-intervention session. On the other hand, the word ‘that’ became the
most frequently used function word in the post-intervention session. The pronoun 'it' remained as the second most frequent function word in both sessions.

The ranking of frequency of use in the pre-intervention and the post-intervention sessions are also presented visually as Tag Clouds in figures 9.1 and 9.2.

The word ‘that’ is not generally seen to be the most frequently used word in everyday speech. Rowland referred to studies of the most frequent words used by 7 year olds from the 1960s and 1970s and the word ‘that’ was not ranked as one of the most frequent. I have been unable to find any more recent studies of children's use of function words but Davies and Gardner’s (2010) frequency dictionary of American English gives the top twelve ranking function words as (from most frequent) ‘the’, ‘be’, ‘and’, ‘of’, ‘a’, ‘in’, ‘to’, ‘have’, ‘it’, ‘I’, ‘that’. ‘That’ is the twelfth most frequently used. According to (Chung & Pennebaker, 2007) the top twelve ranking function words published in text are ‘I’, ‘the’, ‘and’, ‘to’, ‘a’, ‘of’, ‘that’, ‘in’, ‘it’, ‘my’, ‘is’, ‘you’. This ranks the word ‘that’ slightly higher. Remembering that, in this doctoral study, the function words ‘I’ and ‘a’ were stopped, then the ranking for ‘that’ in the pre-intervention session would not seem unusual. However the position for ‘that’ as the most frequently used function word in the post-intervention session would be unusual. It is also noted that the use of ‘it’ and ‘you’ were ranked higher than would be expected in both of the sessions.

Figure 9.1: Tag cloud for pre-intervention sessions showing the twenty most frequent function words. Font sizes are larger for the words that appear most frequently.
It would seem that the children were using the words ‘that’, ‘it’ and ‘you’ more frequently than would be expected and that there had been an increase in the use of the word ‘that’ following the intervention. These three words have been studied in the literature on mathematics education (Radford, 2002, 2003; Rowland, 1992, 1999, 2000). The uses of these three words were examined further in this doctoral study.

Whilst the three words are deictic they have different functions in making meaning (Halliday & Matthiessen, 2004). The word ‘that’ can be used deictically as a demonstrative adjective in pointing to a particular noun (‘look at that person’), or as a demonstrative pronoun in replacing the noun that it is pointing to (‘we like that’). The word ‘that’ can also have a clausal function (‘the one that worked’ or ‘we know that it is real’) but it is its use as a demonstrative adjective or pronoun that is of interest in this doctoral study, the clausal use is not examined here.

The interpretation of ‘that’ depends on the immediate physical context of the discourse. ‘That’ is used to refer to something that is visible to the speaker (Radford, 2002). ‘That’ is generally associated with objects far from the speaker whilst ‘this’ is used for objects near to the speaker. This distal use of ‘this’ and ‘that’ is referred to as spatial deixis and is often associated with a gesture such as pointing. ‘That’ can also be used anaphorically to refer to something that has been said already in the discourse or something that has happened. The anaphoric use is referred to as discourse deixis.

The pronoun ‘it’ is deictic as its interpretation depends on the context. Rowland (2000) defined the deictic use of ‘it’ as a linguistic pointer to a shared idea.
Children used the word ‘it’ to hold an idea and talk about a mathematical object that they do not or cannot name (Rowland, 1992). The children’s use suggested that they were referring to an idea that they had in mind with the understanding that the other speakers would also know what they had in mind.

Although the words ‘it’ and ‘that’ can be interchangeable, it would seem that ‘it’ is used in a general way or as a conceptual variable (Rowland, 2000) whereas ‘that’ is used in a more specific way. ‘That’ is used in pointing directly to a specific sign or a representation physically present or “in the visual field of the speakers” (Radford, 2002, p. 17). ‘It’ is used to refer to an idea that may or may not be physically present. Both ‘it’ and ‘that’ can be used anaphorically to stand for an idea or something that happened before in the discourse but their different uses for generality and specificity would still stand. The use of the three function words and their deictic use are summarised and set out in Table 9.5.

<table>
<thead>
<tr>
<th>Linguistic feature</th>
<th>Examples of use</th>
<th>Deixis</th>
</tr>
</thead>
<tbody>
<tr>
<td>That</td>
<td>Demonstrative adjective</td>
<td>Look at that person</td>
</tr>
<tr>
<td></td>
<td>Demonstrative pronoun</td>
<td>Look at that</td>
</tr>
<tr>
<td></td>
<td></td>
<td>That was good</td>
</tr>
<tr>
<td>It</td>
<td>Pronoun</td>
<td>Look at it</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It is right</td>
</tr>
<tr>
<td>You</td>
<td>Pronoun</td>
<td>I am talking to you</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When you multiply these together</td>
</tr>
</tbody>
</table>

Table 9.5. Use of ‘that’, ‘it’ and ‘you’ in relation to deixis
The pronoun ‘you’ is deictic in that it refers to a participant in the discourse where the intended participant depends on the context and the direction of the speaker. The use of ‘you’ in this sense is termed participant deixis. ‘You’ can also be used in an absolute sense, meaning ‘one’ can. A further use of ‘you’ in this absolute sense has been identified by Pimm and later studied by Rowland (1999). Rowland’s study showed that this absolute use in mathematics suggested a reference to a generality. ‘You’ was used to suggest a generalisable way of doing something, something that always happens and that anyone could do (Rowland, 2000).

9.3.1. ‘It’s that one’: The use of ‘it’ and ‘that’

‘That’ appeared to have been used more frequently in the post-intervention session and text searches were carried out to investigate where the word was used. As there appeared to be a relationship between the demonstrative use of ‘that’ and the more ephemeral use of ‘it’ the examination of the children’s use of the word ‘that’ was carried out along with use of the word ‘it’.

As some group sessions had been seen to resemble incipient exploratory talk then it was anticipated that these groups would show a greater frequency in the use of the word ‘that’. This seemed to be the case. For example, in comparing group session B2, which had not been seen as incipient exploratory talk, with the group sessions A2, which had been seen as resembling incipient exploratory talk there is a clear difference in their uses of the word ‘that’. Word trees from the text searches for each of the group sessions for A2 and B2 are shown below in Figures 3 and 4. Word trees for the two other group sessions K2 and D2 are presented later in Figures 5 and 6 but still show a contrast with group session B2.
As Group A and Group K had been two groups that showed evidence of incipient exploratory talk in the post-intervention sessions and were groups where there had been evidence of independent pupil-pupil talk in the pre-intervention session, analysis of their deictic use of the ‘that’ and ‘it’ was carried out in both group sessions for comparison across the intervention. The text searches indicated that these two groups had an increased use of the word ‘that’ in the post-intervention sessions.

In the pre-intervention group session, A1, the children were representing the function ‘double seven’ on the card with the basket and eggs.
Dialogue 9.A1.1

1. Diane: No, we need to know what it equals (Diane points to the two baskets)

2. Olwen: Seven times...Oh yea, Emma’s good at that (Olwen looks at Emma)

3. Olwen: Seven fourteen two, fourteen ....equals (Olwen seems to be using knowledge of doubling)

4. Diane: Fourteen (Diane is pointing to the eggs to count them and gives an answer)

5. Olwen: Yes, exactly, you don’t have to count it, just work it out.

In the dialogue ‘it’ is used more often than ‘that’. In utterance 1 Diane pointed to the two baskets and the referent for ‘it’ would seem to refer to the total number of eggs. ‘It’ did not relate to the eggs but to the product (7 x 2). This use is repeated in utterance 5 when Olwen stated ‘you don’t have to count it, just work it out’. Again it would seem that ‘it’ referred to the product (7 x 2).

Olwen’s statement ‘Emma’s good at that’ (utterance 2) is an interesting departure. This is the only use of the word ‘that’ in this dialogue. In the preceding phrase Olwen had said ‘seven times’, hence there was a specific function stated. Does Olwen make an anaphoric reference here suggesting that Emma would know this? In the uses of ‘it’ in utterances 1 and 5 there was no reference to the function, ‘it’ seemed to stand for an idea or ‘something that is in mind’. What is interesting is that the other children seemed to have understood the ‘something in mind’.

In the pre-intervention session K1, the children were explaining to each other how they knew the answer to a multiplication fact. They asked for an explanation “Show me...” or “Why...?” (See dialogue ... in Chapter 9). It was Pierce’s turn to give the explanation and he demonstrated skip counting on his fingers to show how to calculate 10 x 10.

Dialogue 9.K1.1

1. Ben: Ten, ten tens what’s that? (Ben has picked a card with 10 x 10)
2. Pierce: You can count up in your fingers, so imagine 10 20 30 40 50 60 70 80 90 100 like that (Pierce counts ten as a unit for each finger ten times) and if it's on there, that means times (Pierce points to the multiplication sign on the card). So ten times. So if it says first then it turns out whatever it is. So it will be a hundred (Ben is nodding his head)

3. Ben: So can you do it to me now? You pick up one. (Pierce picks out a card for Ben)

The word ‘that’ was used three times in this dialogue. First by Ben in utterance 1 ‘ten tens, what’s that’ and then by Pierce in utterance 2 ‘so imagine... like that’ and ‘that means times’. Ben’s use was anaphoric; he referred to the product 10 x 10 that had been indicated on the card. As above in the dialogue 9.A1.1 Ben has just stated ‘ten tens’ so ‘that’ refers to the statement that he has just made.

Pierce’s first use (‘like that’ in utterance 2) was also anaphoric as he referred to the skip counting that he had just carried out. However Pierce’s second use is interspersed with ‘it’; ‘if it’s on there that means times’. It would seem that both ‘it’ and ‘that’ refer to the multiplication sign. Pierce used the conjunction ‘if’ as an introduction to a conditional clause, so did he mean ‘suppose there is this sign’? He was then specific in stating ‘that [sign] means times’.

Pierce’s gesture in pointing to the sign was also indicative of spatial deixis. In the phrase, ‘So if it says first then it turns out whatever it is’, Pierce was referring to the multiplicand and the multiplier. Again he used the conjunction ‘if’ as in ‘suppose it says...first’. Pierce’s use of ‘if’ to introduce a conditional may have suggested a generalised statement. If it is... then it will be... This would seem to be a generalisation as he was relating to the multiplicand and the multiplier as variables.

In the two example dialogues from the pre-intervention sessions the children’s use of deictic words could be seen to indicate where they were referring to mathematical objects in different ways. The use of ‘that’ was associated with something specific that had just been said or done or that they could all see. The children were also referring to an idea, something in mind or to a conceptual variable, and this was associated with the word ‘it’.
Whilst these interpretations would seem to concur with those of Radford and Rowland the intervention appeared to change the frequency of the children’s use of these deictic terms. The children’s use of the word ‘it’ did not appear to change but the use of the word ‘that’ increased proportionally and became the most frequently used function word in the post-intervention session. So it is shown that the children were using the word ‘that’ more. Did this change the way that the children were making referents to the mathematical objects? A closer examination was carried out to investigate how the words ‘that’ and ‘it’ were used in the post-intervention sessions.

A text search query for the group session A2 is presented as a word tree (Figure 9.3). In the word tree for group session A2 the use of the word ‘that’ seemed to be associated mostly with the phrase ‘it’s that one’. This is illustrated further in Dialogue 9.A2.2

In the post-intervention session, A2, the three children were matching word problems to number line representation. Olwen read out the first word problem.

Dialogue9. A2.2

1. Emma: 15 flies were on a cake, 5 more came along, how many were there altogether? (Emma reads out the word problem on the card). Do you think it’s that one or that one Diane? (Emma points to two different number line representations) That one? (Emma points to one of the number line representations)

2. Olwen: It’s definitely that one Emma (Olwen points to the same representation)

3. Emma: Do you think it’s that one? (Emma looks at Diane)

4. Diane: It’s that one.

5. Emma: So do you think that one might go with that one? (Emma places another pair of word problem and number line representation in front of Diane. In this case the word problem is ‘A ladybird has 6 legs, how many legs would four ladybirds have?’)
6. Diane: I don’t know if it’s this one, I’m checking, 6, 12... (Diane is looking at another number line representation for the new word problem. She is skip counting on the number line)

7. Olwen: 18... 24 (Olwen continues skip counting on the number line)

In this example of post-intervention dialogue ‘that’ is used frequently in utterances 1-5, alongside the gesture of pointing to the number line representations. The use of ‘that’ in these instances would appear to be spatial deixis as the children were directing each other’s attention to the number line representation that they were referring to. These were specific and made direct references to examples as the children asked each other and stated their own opinion.

In these examples the children did not give clear or exact meanings for their opinions but they were able to come to an agreement. In utterances 6 and 7 Diane and Olwen were examining a specific representation and used the demonstrative adjective ‘this one’. This may have been referring to an example that was physically closer or it may have suggested an example with a more specific focus. Maybe with this example there was no shared understanding in the meaning of the number line representation and the two children had to examine the calculation that the number represented more closely. They carried out a procedure (skip counting) to do this.

The pronoun ‘it’ was used throughout the dialogue to state ‘It’s definitely that one’ or to question ‘Do you think it’s that one?’ It would seem that ‘it’ was referring to the correct representation for the word problem. Hence ‘it’ was standing for an idea which, in this case, was the correct solution. This is not something the children could point to directly; it was something they needed to determine. In the first word problem there was no evidence of why ‘it’ should be the one and the children did not appear to determine this, other than to state ‘it’s that one’. However in the second matching the children did use a procedure.

The dialogue continued and showed a further use of deixis. Diane reads out the word problem again.

Dialogue 9.A2.3

1. Diane: A ladybird has 6 legs, how many legs would four ladybirds have?
2. Emma: **it’s that** one, definitely, **it’s definitely** *(Emma points at one of the number line cards)*

3. Olwen: **It’s easy** **that** one *(Olwen points to the same card)*

4. Emma: What?

5. Olwen: **It works**

Emma and Olwen used ‘that’ as a demonstrative adjective in pointing to an example, hence spatial deixis. The word ‘it’ was also used in the same way to stand for the correct representation. There was no indication of why they thought this. Although Diane and Olwen had carried out a procedure of skip counting earlier this was not given as a reason for identifying the representation. Olwen stated simply that ‘It works’.

Figure 9.5: Word tree showing the use of ‘that’ in the post-intervention session K2.

The phrase ‘it works’ has been identified by Rowland (2000) and related to a general relationship or procedure. In this case the phrase ‘it works’ would seem to refer to the matching of one pair. Rather than relating to a general relationship, this was related to one specific relationship. However Olwen used the word ‘it’ suggesting reference to the idea of a matching pair. This was not
something the children could point to directly. In order to agree with Olwen that ‘it works’ the children had to understand what was meant by ‘it’ and what was meant by ‘works’. However they all agreed and moved on to the next word problem.

Whilst the phrase ‘it’s that one’ was also apparent in the word tree for the post-intervention session K2 (figure 9.5), the use of ‘that’ seemed to be more varied. Other uses occurred with verbs such as ‘have’, ‘think’, ‘noticed’, and ‘know’ and with the conjunction ‘because’.

In the first part of the post-intervention session the children were given a sheet of paper with inequalities >50 on one side and <50 on the other. They were asked to write numbers on each side that would be true for each inequality. They talked together to decide what the > sign means and referred to other recordings of the signs of > and < that were recorded on a white board when they talked with their teacher earlier.

Dialogue 9.K2.2

1. Fran: **That**’s the sign (*Fran points to the > sign on the sheet*)
2. Iris: Oh yeah
3. Iris: Is **that** more than or less than, which one? (*Iris points to the > sign*)
4. Pierce: **That** is. (*Pierce points to the > sign*)
5. Fran: If we look at, if we have a look, **that**’s less than... (*Fran picks up the whiteboard with the recordings and points to the < sign*)
6. Iris and Fran: **That**’s more, **that**’s more (*Iris and Pierce are pointing to the > sign*)
7. Pierce: **That**’s more, more than (*Pierce points to the > sign*)
8. Iris: **That**’s more than
9. Pierce: Is **it**?
10. Iris & Fran: Yes

In Dialogue 9.K2.2 from the post-intervention session K2, there was frequent use of the word ‘that’ as the children pointed to the inequality signs in deciding which one represented ‘less than’ or ‘more than’. In each case the use of ‘that’
related to spatial deixis and was associated with the child pointing to the sign. ‘That’ had been used as a demonstrative pronoun or a demonstrative adjective in each case to direct attention to the sign the child was referring to, but at no point did the children give an exact meaning of what the sign meant other than to state ‘more than’ or ‘less than’.

In this dialogue the word ‘it’ was used once as Pierce asked ‘Is it?’ when Pierce was still uncertain about the meaning of the sign. Other than this the children referred directly and specifically to the signs on the paper and on the whiteboard. Even though there was no exact meaning given, Fran and Iris came to an agreement on what the signs meant.

Pierce realised what the signs meant later on into the task, as was illustrated in Dialogue 8 K2.4 presented in Chapter 8 and is presented again here as Dialogue 9.K2.3

*Dialogue 9.K2.3*

1. Pierce: 6000 is less uumm...
2. Fran: 600 is bigger than 500
3. Iris: No that’s the less one, that’s the more one (*Iris points to the inequality signs on the sheet of paper*)
4. Pierce: I really get confused, 6000 is more than... Yeah that’s right.

In this extract Fran again pointed to the two inequality signs and reinforced their meaning. Fran did not give an exact meaning but re-emphasised ‘that’s the less one’ and ‘that’s the more one’ (utterance 3) along with the demonstrative pronoun ‘that’. The use of spatial deixis here was specific and related directly to the two signs. Maybe the meaning became apparent to Pierce as he gave the example ‘6000 is more than...’ (utterance 4). Its use within the example must have made sense as Pierce then stated ‘Yeah that’s right’. In this final phrase Pierce’s use of the word ‘that’ was anaphoric, he was referring back to the use of 6000 as more than 20. With reference to the continued dialogue presented in Dialogue 8 K2.4 presented in Chapter 8, it would seem that Pierce had determined the meaning the inequality signs.
When examining the use of ‘because’ with this group of children earlier in this chapter examples of deixis had been noted. This was presented with the Dialogue 9.K2.1 as the children were working with the equality □ + □ = 20 and the inequality □ + □ < 20. The children were asked which side would have more answers. The dialogue for this was presented in Dialogue 9.K2.1 above to illustrate use of ‘because’. This is now considered as Dialogue 9.K2.5 in relation to the children’s use of deixis.

Dialogue 9.K2.5

1. Iris: I’m probably going to think this one (Iris points to the side of the paper with the sums for the inequality, this is on the side of the paper closest to her)

2. Fran: I probably think....

3. Pierce: I know, I know, that one because... (Pierce points to the inequality sign)

4. Iris: That one because... (Iris points to the side of the paper with the sums for the inequality, she uses the word ‘that’ even though this is the closest side to her)

5. Pierce: Because it has that sign (Pierce points to the inequality sign)

6. Fran: I think that one (Fran also points to the side of the paper with the sums for the inequality, not the closest to her)

7. Iris: Yes I think this one because it’s got the teens and the 1, 2, 3, 4, 5 up to ten (Iris points to the inequality side) and these ones (Iris now points to the equality side and then hesitates)... I think it’s the same.

8. Pierce: I think I know why because that (Pierce points to the inequality sign) makes it more...

9. Iris: I think it’s the same

Pierce and Fran used the demonstrative ‘that’ in utterances 3, 6, and 8. In both cases the two children were pointing to the sign or the side of the paper to indicate what they meant in giving their opinion. As the sheet of paper was visible to the three children the use of the demonstratives along with pointing was sufficient to show what they were referring to.
When Pierce first elaborated in utterance 5, this was supported by spatial deixis as he gestured to the sign he was referring to. When Pierce elaborated again in utterance 8, again he pointed to the sign and stated ‘that makes it more’. Whereas the pronoun ‘that’ was standing for the sign that he was pointing to, an object that was visible to all, the pronoun ‘it’ was standing for the number of possible solutions. What is particularly interesting is the use of the verb ‘makes’. Why should a sign ‘make’ something and why would this be ‘more’ than the equality? We can only presume.

Iris’ use of deixis also changed. First Iris used ‘this’ and not ‘that’ (utterance 1), and as the inequality side was the closest to her this would follow the rule for spatial deixis. However Iris later used ‘that’ (utterance 4) even though she was referring to the same side, possibly she was mirroring Pierce’s use of ‘that’ in utterance 3. In utterance 7 Iris reverted back to using ‘this’, again referring to the inequality sign nearest to her. However she also then referred to the equality addition examples as ‘these ones’. In using the plural she was focusing on the solutions that they had written earlier and these would have been on the side away from her.

Although the use of ‘this’ and ‘that’ is generally seen as distal this may not always be a physical distance. In Dialogue 9.A2.2 Diane stated ‘this one’ (utterance 6) as she was closely examining a number line representation. This notion of proximity may have been embodied within the notion of an example needing closer examination.

Iris then used the pronoun ‘it’ after she had used the word ‘because’ (utterance 7, ‘because it’s got the teens’). ‘It’ now stood for the inequality side of the paper and related back to her use of ‘this’ when she had pointed to the inequality. Hence the use was anaphoric and directed back to the earlier spatial reference. Notably she used the word ‘it’ as she considered how the number facts to ten and to the teens were possible solutions. She would not have to look at every example to know that all the number facts up to ten and to the teens would count, so it is possible to surmise that she was generalising here.
Iris then announced ‘it’s the same’ with ‘it’ now referring to the number of possible solutions. In the same way as Pierce had done Iris was now referring to an idea rather than a specific mathematical object that was in front of her. It is still intriguing why Iris changed her mind and why she thought that they should be the same. Remember that these children had been using negative numbers in finding solutions for the inequality < 20 earlier. So was Iris thinking beyond positive integers? I can only speculate but it is a frustration that results from being an observer of video data.

Another session that had a frequent use of the word ‘that’ was D2, and extracts from the mathematics talk of this group were also considered. Figure 9.6 shows the word tree for the children’s use of ‘that’ in the mathematics talk for the group session D2. The data show the word was used in various phrases, for example ‘like that’, ‘that equals’, ‘that is’, ‘that isn’t’ and ‘that would’. In particular the phrase ‘Can you recognise that’ seemed to be a frequent one. In this session the children were finding arrangements where they could subitise a number of
counters rather than counting in ones, hence the use of the phrase ‘can you recognise that’ would seem to fit with the context.

In Dialogue 9.D2.1 the children had arranged seven counters in a diagonal line and the teacher had asked them to decide if they could recognise how many counters there were without counting them.

Dialogue 9.D2.1

1. Harry: You’ve got to recognise **it**

2. Joe: You could do **it** like that *(Joe points to each counter)*

3. Vera: But **that** would be just the same as counting like **that** *(Vera moves one hand as a gesture down the line)*

4. Harry: But can you recognise **that**? Just going down there? No you can’t, I’ve got to count like 22, 24 *(Harry moves one hand as a gesture down the line)*

5. Vera: I can recognise **it**, sort of *(Vera does not point to or gesture towards the line)*

In this extract Joe (utterance 2) pointed to each counter. Joe had stated you could do ‘it like that’, possibly using ‘it’ to refer to any counting but ‘that’ to suggest a particular way. Vera also gestured towards the line and used the word ‘that’ as she referred to Joe’s way of doing it (anaphoric) but then suggested that his way (as in one-one correspondence) was ‘like that’ or a specific way. Harry then asked if they recognised ‘that’ as he pointed to the diagonal line. Vera then replied that she could ‘recognise it’, possibly referring to ‘it’ as the total number of counters. With the use of ‘it’ Vera did not gesture towards the arrangement. Again the children’s talk showed movement between the use of demonstratives to direct attention to a specific way and the pronoun ‘it’ to refer to an idea (or something that I have in mind).

The examples of dialogue from the post-intervention sessions A2, K2 and D2 illustrate how the children were using deixis in the mathematics after the intervention. Whilst there had been use of the generalising pronoun ‘it’ in the pre-intervention sessions as well as the post-intervention sessions there was an increased use of the demonstrative ‘that’ in the post-intervention sessions and these uses suggested the children were referring to specific examples. It was
also possible that the word ‘this’ was used for an example that required particular attention. It seemed that there were examples in the dialogue that showed children’s changed use of deixis from use of a demonstrative in directing attention to a specific example, to the use of the pronoun ‘it’ as an idea (as in something in mind or something that could not be pointed to directly). There was also an indication that one child had used the word ‘it’ when moving to a generalisation.

These uses would concur with the findings of Rowland (1999; 2000) in the use of ‘it’ and with Radford (2003) in the use of ‘that’. What is significant is that with the intervention the use of ‘it’ did not increase proportionally whereas the use of ‘that’ did. Had the ground rule to reach an agreement encouraged children to point to specific examples so that they could substantiate opinions? If so how would this relate to children’s learning in mathematics?

9.3.2 What do ‘you’ mean?

As related above, the pronoun ‘you’ had been regarded as further evidence of generalisation by Rowland (2000). Children’s use of this pronoun suggested they were referring to a general procedure. In this doctoral study ‘you’ appeared to decrease proportionally. It would seem that an intervention to support collaboration and talk in mathematics should have increased this use. It is not clear if this was a decrease due to less use of the pronoun as participant deixis or as a generality. In both cases we would have anticipated that these would have increased proportionally.
One aspect to consider was that in Rowland’s (2000) study the children were talking to the researcher, an adult. As Rowland stated the use of ‘you’ can seem to relate to a notion of power and children rarely use you as participant deixis when talking to adults; it would seem impolite. In this study only children’s peer talk was examined so there would not seem to be a reason why the children did not use the word you as participant deixis.

Analysis of the use of the word you in relation to participant deixis or generality had been carried out but the use of you seemed ambiguous in many cases. From the examination of the use of ‘you’ in the A1 and K1 pre-intervention sessions and the A2 and K2 post-intervention sessions, it seemed evident that some uses were participant deixis. These utterances had been extracted from the word trees presented in Figure 9.7 and Figure 9.8.
Figure 9.8: Word tree showing the use of ‘you’ in the post-intervention sessions A2 and K2.

**Examples E9: from pre and post intervention session for groups A and K**

1. ‘Do you agree?’
2. ‘Which one do you think?’
3. ‘You did that wrong’
4. ‘I told you that there was nine’
5. ‘You make up some sums’

The utterances presented in Example E9 appeared in each of the pre-intervention and post-intervention sessions for these two groups and suggest the children were making direct statements to each other in using the pronoun ‘you’. These utterances would seem to be within the present tense, they are statements of certainty (Halliday & Matthiessen, 2004).

Other uses were more ambiguous with utterances such as:
Examples E9.A1.: from A1 pre-intervention session

1. ‘You put fourteen in there’
2. ‘You start with the bigger number’

Examples E9.K1.: from K1 pre-intervention session

1. ‘How do you know it’s ten?’
2. ‘You can count up in your fingers’
3. ‘If you have 5 tens then you add 6 it would be’
4. ‘If you have ten tens…’
5. ‘You get ten tens’

In the examples E9.A1. and E9.K1. above, it is possible to interpret each utterance from two perspectives. First, the children could have been referring directly to the other children they were talking to (participant deixis). Second, the children could have used the word in a general sense suggesting ‘one’. There is a mix of direct statements suggesting the primary tense (E9.A1. utterances 1 and 2; E9.K1. utterance 5) and other statements related to modality (E9.K1.1 utterance 2: ‘You can count up…;) or to a conjunction introducing a conditional clause, (E9.K1.1 utterances 3, 4: ‘If you have…’). The uses of ‘you’ in these utterances are ambiguous it would seem that the children could have intended a generality (a possibility that anyone could do this) or they could have been referring directly to another child.

There were also some uses in the post-intervention sessions that suggested an ambiguous use of ‘you’.

Examples E9.A2: from A2 post-intervention session

1. ‘So you have to make a line’
2. ‘I split them, so you can take away like a three...’
3. ‘20 add five, you need to add some’


1. ‘You can do three 0s’
2. ‘You can reverse that one’

3. ‘You can’t reverse 5 and 5’

These could be examples of the use of ‘you’ as participant deixis or the more ambiguous use of ‘one can’ or ‘anyone could’. These seemed to be present in both the pre and post intervention sessions so it is difficult to determine any change.

Rowland’s (2000) work had suggested that children’s move from the pronoun ‘I’, in describing what a child is doing or thinking, to ‘you’ as an absolute could indicate a move to a generalisation. There does not appear to be sufficient evidence of this phenomena happening in this study. The use of ‘you’ decreased proportionally and the examples above taken from the text searches, whilst interesting, do not suggest any increase in use as a generality.

If the use of the personal pronouns are examined further in context with the dialogues then there is still little evidence, in fact it would seem that the general use of personal pronouns was more evident in the pre-intervention sessions. For example in the pre-intervention Dialogue 9.B1.1 (given above as an example of use of demonstratives), where the children in Group B were solving the problem with the egg boxes, the children’s uses of personal pronouns were ambiguous.

Dialogue 9.B1.1

1. Lucy: 19, 20... So we have three boxes and then two eggs in another box.

2. Ann: There are 20 eggs and you’ve got, right so 20 eggs, so you put all of those 20 eggs in a box and there are six eggs to go in a box each. 1, 2, 3, 4, 5, 6.

3. Lucy: So we have three boxes,

4. Ann: Yea, yea

5. Lucy: And we have two eggs in the fourth box, yea? You get it?
Ann’s use of ‘you’ (utterance 2) could have been meant as participant deixis or as a generality. The suggestion that this was a generality is that Ann was working this out herself but, instead of using ‘I’ she used ‘you’. In utterance 5 it would seem that Lucy was using ‘you’ as participant deixis. There is also a use of the pronoun ‘we’. Whilst the children could have been referring to themselves collectively with the pronoun ‘we’ it could also have been used in a general absolute way.

There is another example of the ambiguous use of ‘you’ in the pre-intervention session with Group K. These extracts were presented as part of dialogue …

Pierce: You can count up in your fingers, so imagine 10 20 30 40 50 60 70 80 90 100 like that (Pierce counts ten as a unit for each finger ten times) and if it’s on there, that means times (Pierce points to the multiplication sign on the card). So ten times. So if it says first then it turns out whatever it is. So it will be a hundred (Ben is nodding his head)

Fran: If you have one 10 it’s 10 but if you have 5 then it’s 50. (Fran takes five Numicon ten frames)

In both of these examples it would seem that the children were talking about generalities.

However in the post-intervention session for group K, the children were using the pronoun ‘I’.

1. Fran: I think that one (Fran also points to the side of the paper with the sums for the inequality)
2. Iris: Yes I think this one because it’s got the teens and the 1, 2, 3, 4, 5 up to ten (Iris points to the inequality side) and these ones (Iris now points to the equality side and then hesitates)... I think it's the same.
3. Pierce: I think I know why because that (Pierce points to the inequality sign) makes it more...
4. Iris: I think it’s the same

In this post-intervention session the children were specific in expressing their own opinions and the use of ‘I’ was more prominent.
The use of personal pronouns as participant deixis is also illustrated in the group session D2. I refer back to group session D2 when they were trying to determine if you could find the number of counters without counting. This excerpt was presented in dialogue 8 D2.1 and 9 D2.1.

Harry: But can you recognise that? Just going down there? No you can’t, I’ve got to count like 22, 24 (Harry moves one hand as a gesture down the line)

Vera: I can recognise it, sort of (Vera does not point to or gesture towards the line)

In Harry’s statement it would seem that the first use of ‘you’ in ‘but can you recognise that?’ is participant deixis, he was referring to Vera (and possibly Joe as well). The next statement ‘No you can’t’ is ambiguous. Does he mean Vera? He then stated ‘I’ve got to count like...’ suggesting that it was not possible for him to see the total number of counters, so how could Vera? Vera then moves back to the use of ‘it’ but she related this to herself. ‘I can recognise it...’ Again she was expressing an opinion.

In encouraging the children to reach an agreement, the children were giving opinions. This may have related to an increased use of demonstrative deixis. It is also possible that, in giving their opinions the children did not use the generalisable ‘you’ any more than they would have done in the pre-intervention sessions, and possibly less.

9.3.3. Summary of use of deixis

From the examination of the children’s uses of ‘that’ and ‘it’, it would seem that these relate to different ways that the children exchanged meaning.

That: Something we can all see and it is the one that I am interested in at the moment

This: Something we can all see and it is closer to me or I am focusing on it more closely

It: Something specific that I have in mind (a function, operation, number fact, process). This use could be anaphoric in referring to a use of ‘that’ or ‘this’ given earlier
It: Something that I have in mind that goes beyond the specific (a generalisation).

From the analysis that I have carried out this final use of ‘it’ as a generalisation was very rare and in fact I could only point to one example with any confidence and that would be with Iris in Dialogue 9.K2.5, as Iris was seeing beyond the examples of the equalities and inequalities that they had found.

Two points arise here. First it would seem that the children were using demonstrative pronouns and adjectives more in the post-intervention sessions in some of the groups. It would seem that these were the groups where analysis of the speech acts suggested that talk was more productive. This would confirm their identification with incipient exploratory talk. Deixis is a key characteristic of this type of talk. Second, in this study the intention was to determine a better understanding of how the children were learning. The examination of how children exchanged meaning was considered a way to gain insight into this learning.

In these examples it would seem that, through the use of demonstratives, the children were exchanging meanings about specific mathematical objects that were in their sight. These were used in conjunction with the pronoun ‘it’ as the children referred anaphorically to the mathematical objects already pointed out or to those that could not be seen directly, such as a process or function. However they were still specific. Any examples of generalisations or inductive reasoning were rare. This would not seem unusual in relation to reaching an agreement about a correct solution, the children were pointing to the examples that they were using in giving their opinions.

From the use of personal pronouns it is also possible to surmise that there was no increase in the absolute use of ‘you’. This had been seen in Rowland’s studies as an indicator of children moving towards a generalised view of a process, something that anyone could have done. It is possible that in reaching an agreement the children were again focused on their point of view, what ‘I think’.

It would seem that in these groups there had been a change in the nature of the talk and that the children were exchanging meanings within the specific. It so,
how does this relate to learning mathematics or to mathematisation? This is considered further in the discussion chapter.

9.4 Use of modal verbs

The children’s uses of modal verbs were examined as they were also seen as an example of a cohesive device (Gee, 1996; 1999). Halliday and Matthiessen (2004) had related modality to interpersonal deixis. According to Halliday and Matthiessen, through the use of modality, information is conveyed regarding uncertainty and this offers an exchange within the dimension of assessment, hence modality is a cohesive device. So the children’s use of modality would seem important in looking at how children exchanged meaning.

A text search was carried out to investigate any changes in the use of modal verbs and these are set out in Table 9.6. Table 6 shows some of the modal verbs that were used, others such as ‘allowed’ were used only once or twice over all the mathematics talk so are not presented in a quantised form. The percentage frequencies for the modal verbs that are shown in Table 6 are still very small in most cases, however, there was an increased use of the words ‘could/couldn’t’, ‘need/needs’ and ‘supposed’.

<table>
<thead>
<tr>
<th>Word</th>
<th>Group session 1 (A, B, E, F, K, I)</th>
<th>Group session 2 (A, B, E, F, K, I)</th>
<th>Change in proportional use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percentage frequency</td>
<td>Frequency</td>
</tr>
<tr>
<td>Modal verbs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAN('T)</td>
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<td>0.8%</td>
<td>38</td>
</tr>
<tr>
<td>COULD('NT)</td>
<td>3</td>
<td>0.1%</td>
<td>15</td>
</tr>
<tr>
<td>NEED(S)</td>
<td>7</td>
<td>0.2%</td>
<td>33</td>
</tr>
<tr>
<td>HAS TO</td>
<td>3</td>
<td>0.1%</td>
<td>12</td>
</tr>
<tr>
<td>SUPPOSED</td>
<td>0</td>
<td>0%</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 9.6: Frequencies and percentage frequencies of modal verbs for groups A, B, E, F, I, and K.

As suggested by the small number of modal verbs most of the children’s talk would seem to have been in the primary tense, what was there present at the time of speaking (Halliday & Matthiessen, 2004). For example ‘It’s that one; ‘It’s that way’; ‘It’s more than’. According to Halliday and Matthiessen modality
locates the exchange within uncertainty and would include use of terms related to a degree of probability. In this study I examined these terms of uncertainty in relation to statements of obligation or requirement (you need to, you have to) and to statements of permissibility (you can, you’re allowed to) or impermissibility (you can’t, you’re not allowed to).

An example of the children’s use of modal verbs that related to obligation or requirement appeared in the post-intervention session, A2. The children were drawing a representation for the problem ‘ten worms take away four’. Extracts of this dialogue have been examined in relation to use of conjunctions (Dialogue 9.A2.1.) and Olwen’s use of ‘because’. Here the analysis is in relation to the use of modal verbs.

Dialogue 9.A2.3

1. Emma: So let’s start, so there’s, ok we have ten worms, 1 2 3 4 5 6 7 8 9 10 (Emma draws ten dots on the whiteboard)

2. Olwen: Yea and then you put something like... (Olwen gestures towards the whiteboard)

3. Emma: And then we’re going to ... and then can we take away four? (Emma moves to pick up the board rubber)

4. Olwen: No, no, no, don’t with a rubber,

5. Emma: Take away four?

6. Olwen: No there has to be like a line between them (Olwen points to a position on the whiteboard) because the four of them have been taken away

7. Emma: Take away four?

8. Olwen: So you have to make a line

9. Emma: Take away four? (Emma draws a line on the whiteboard to separate four dots. Emma looks at Olwen. Olwen nods her head)

10. Emma: And it leaves...

11. Olwen: 6
Emma’s first use of modality in utterances 1 and 3 indicate permissibility. The use of ‘let’s start’ would seem an invitation to work together on the problem. As Emma stated ‘then can we take away four?’ (utterance 3) it seemed that she was opening the space to enquire how this would be possible. At this point Emma attempted to erase the four dots (or worms) that were to be taken away but Olwen suggested to the group that they used a line to separate the dots (or worms) that were to be subtracted. Olwen had stated this as a requirement ‘there has to be’ a line (utterance 6). She repeated this later (utterance 8) with the statement ‘so you have to...’. The children were in agreement and they continued to use a line to separate the worms that were to be subtracted.

Emma’s suggestion of erasing the dots (that is taking the worms away) would seem to represent the problem in a physical sense. However Olwen’s suggestion would seem a better way to illustrate the problem mathematically. Erasing the four dots (worms) would have lost the minuend (the original number of worms). Drawing a line to show the subtrahend would also leave the minuend. At no point did the children state that this was the reason for having the line or that the line would be better than erasing the four worms. Once it had been drawn the first time, and they all nodded their heads in agreement, this strategy was used in further representations.

The use of ‘has to be’ was a statement related to an obligation. Another example of modality as an obligation appeared in the post-intervention session E2. The children were finding the combinations of bears and houses. (See Dialogue 8 E2.5).

Chas: It [the yellow bear] ‘s **supposed** to be there

As Chas referred to the requirement that the yellow bear be in that position and this was related to the rules of the problem, combinatorial positioning of three different coloured bears on the three different coloured houses. This was further reinforced by his statement related to impermissibility

Chas: No, they’re **not allowed** to be...

Later Chas also suggested a further obligation. At this point the children were positioning the bears and houses on a grid.
Chas: You can't have yellow yellows, so you may need a blue to separate them.

Again Chas was using modal verbs first to indicate an impermissibility (you can’t have) and then an obligation or requirement (need). These were both stated in relation to the rules of the mathematics in the task. Chas also introduces the use of the word ‘may’ and so increased the uncertainty.

When Chas stated ‘it is supposed to be there’ or Olwen stated ‘there has to be’ the statements were given as directions that related to degrees of obligation such as, supposed to and required to, or to impermissibility (not allowed). The children were not saying ‘don’t do it’ or ‘do it’, they were saying it is ‘supposed to’, ‘it needs to’, ‘it has to’ or ‘it’s not allowed’.

These statements of obligation were not to do with managing the task. There was more frequent use of the word ‘need’ or ‘allowed’ within the ‘non-maths’ talk, but the examples given here were related to the mathematics talk. Examples of this kind were few but there were more in the post-intervention sessions. The children were involved in statements of validity in relation to the mathematical objects in the tasks that they were completing together.

9.5 Summary

The children’s discourse was analysed according to the function of the words that they used. In talking together the children chose to use certain words and their use suggested that they meant something. In this study the words associated with connection building or cohesion that had been apparent in the text searches were studied.

- Conjunctions were seen to be used in both pre-intervention and post-intervention sessions but elaborations in the post-intervention sessions were seen to be supported by demonstratives.

- There was clear evidence of change in the use of the demonstrative ‘that’ but any change in the use of ‘it’ was less clear.

- There was a decrease in the proportional use of ‘you’ in the post-intervention sessions. The absolute use of ‘you’ was evident in both the
pre-intervention and the post-intervention sessions and change in this use was less clear. It may have been that there was less use of the absolute use of ‘you’ as children gave their opinions.

- Uses of modality, in particular obligation or requirement, were more apparent in the post-intervention sessions.

So what does all this mean in relation to children’s learning in mathematics in the post-intervention sessions?

The deictic use of demonstratives as children gave opinions in reaching consensus, and in the few examples where they elaborated on these opinions, suggested that the children were referring to specific examples that were in sight or specific examples of processes that they had in mind. There was limited evidence of generalisation. The use of modality suggested that the children were referring to the rules of the mathematics task that they were involved in.

From these interpretations of the children’s use of words one could surmise that the thinking was mostly deductive. The children were directly pointing to the rule that was happening in any specific case. There was a ‘top-down’ use of rules to solve a problem rather than a ‘bottom-up’ use of examples to generalise from the specific examples (inductive reasoning).

If the thinking was mostly deductive how was the talk supporting learning? What role did the children’s use of words have in this learning?
CHAPTER 10 DISCUSSION

10.1 Introduction

In this chapter I review the findings from the multi-level analysis that were presented in chapters 7 to 9. The data in these chapters presented a rich description of what was happening in the discourse. In this chapter I aim to develop a thick description by relating the findings to other research and to theory. I consider the commonalities and the distinctions regarding the nature of the talk and the changes to the talk. I draw out key ideas regarding the relationship between the children’s talk and their learning. I then discuss these key ideas within a wider theoretical context and in relation to existing research. The aim is to move from the particular to the general and in doing so I discuss emerging hypotheses that will further our understanding of children’s learning in mathematics.

The focus of the doctoral study is on the children’s learning in mathematics and its relationship with their independent pupil-pupil talk. From the review of literature and the refocus on the sociocultural emergent theories and constructionist philosophical perspectives in Chapters 4 and 5, I had further refined the focus to examine how the children exchanged meaning in mathematics within their independent pupil-pupil talk. In using existing data from the TC Project I was able to investigate if the intervention had changed the way the children exchanged meaning. This entailed an analysis of the function of the children’s language based on key theories from discourse theory and analysis (Gee, 1999; Taylor, 2001). The children’s language in use was examined with regard to connection and relationship building both from a social perspective, as the children talked about managing the task, and from an academic perspective as they talked about the mathematics. Fundamental to connection and relationship building was the children’s use of language, the functions of their utterances and use of cohesive devices, such as deixis, conjunctions and modal verbs. The children’s uses of language and any changes in their use are discussed in relation to emergent theories of objectification.
Specific research questions had been presented in Chapter 4 regarding an investigation into the nature of the talk. The findings of the different levels of analysis are reviewed within the following sections:

**Section 10.2 The nature of the children’s talk.**

- Were there similarities or differences in the nature of talk, both social and academic, between different groups of children?
- Were there changes in the nature of talk, both social and academic, between the pre-intervention and the post intervention sessions?

I review the findings of the social and mathematics talk in relation to the questions regarding the similarities and differences in the talk and the changes following the intervention.

**Section 10.3 The nature of the talk and learning in mathematics**

- Was there evidence that these changes, both social and academic, supported the children in working collaboratively and productively on the mathematics tasks?
- How did the children use language to share intentionalities and exchange meanings?
- Did the intervention change the way the children used language to exchange meaning?

The two categories of talk, social and academic, are reviewed together in relation to the Gee’s connection and relationship building and to Seeger’s social and emotional elements in sharing intentionalities. Is there a relationship between the social talk, the mathematics talk and the children’s learning?

**Section 10.4 The use of words as cohesive devices in objectification.**

- Which words were used to support the children’s shared intentions and exchange of meaning?
- How did these relate to generalisations?

In Section 10.5 I discuss potential hypotheses in what this means regarding mathematising or objectification within the peer discourse of young children.
10.2 The nature of the children’s talk

10.2.1. The children’s social talk

In carrying out the research for the TC Project, the social aspect of the children’s talk had been seen as a critical element in the children’s group work. In this doctoral study I examined this in more depth by carrying out a detailed situational analysis of the video material. The data for this were presented within the findings for Level 1 of the analytical approach (Chapter 7). Analysis was further carried out by a systematic interrogation of the ‘non-maths’ speech acts in Level 2 and were presented in Chapter 8.

The Level 1 analysis had suggested that much of the talk seemed to be on managing the task with many children focusing on social aspects such as turn-taking or the valued use of resources. In analysing the categories of talk overall, it seemed that half of the talk was related to these social aspects. The intervention did not seem to change the proportion of social talk overall. However the proportion of social talk varied for each group and the changes in the proportions of social talk varied for each group. The proportions of social talk did not seem to relate to the productivity of the groups, where productivity was seen to be the children arriving at a solution of the problem together, be it a correct solution or otherwise. For example both Group A and Group K were seen as examples where the talk in the post-intervention sessions had seemed to be productive. Whilst there had been little talk on managing the task (less than 20%) in Group K, almost half of the talk had been on managing the task in Group A (see Table 7.4 chapter 7).

In the Level 2 analysis further interrogation of the speech acts within these categories suggested that social talk related to disagreement did not increase proportionally overall (table 8.1 Chapter 8) but there was a proportional increase in controlling, facilitating and agreeing. Therefore, whilst the intervention had not increased the proportion of ‘maths’ talk it did seem that there was more agreement and the children were more helpful in managing the task and cooperating with each other. This was particularly the case with Group A where the post-intervention session A2 had suggested the children seemed to negotiate turn taking, rather than argue over it. However the intervention had
not supported a move to more negotiation in all groups. In Group F, for example, the amount of disagreement had increased over the intervention.

It also seemed that in some groups the children attended to the task almost as a ‘job to do’. It seemed that they did not focus on the mathematics of the problem but on completion of the task in the way the teacher had set it. Children also saw the mathematics tasks as a game and so the turn-taking and use of resources became part of the game. It also seemed that some children saw themselves in an authority position and this was illustrated explicitly with statements such as ‘I am the captain’ or ‘I am the master’ (see Dialogue 9.A1.1 and (C2.1)). These views were apparent in both the pre-intervention and the post-intervention sessions.

As such it seemed that some of the social aspects of the talk, such as focus on the tasks, disputes and social positioning were limiting the learning opportunities of the groups. Whilst there has been research on children’s peer interaction in mathematics this has not always been linked to their learning, and little research has looked at the social aspects of children’s peer interactions in relation to learning mathematics. Wood and Kalinec (2012) studied how the social aspects of group work created or limited learning opportunities. Wood and Kalinec’s suggested that if we knew more about how children identify socially within a group we could then encourage them to be more productive in carrying out mathematical tasks.

Whilst not within mathematics education, ethnographic studies of young children in preschool settings have suggested that within young children’s peer culture there is an expected set of routines, values and concerns, such as turn taking and sharing of valued resources, and these routines can give the children security (Corsaro, 1986, 1994). Seeger (2011) had referred to some children’s need for a ‘secure base’ that they can attach to. In changing the expected routines by introducing the strategies for exploratory talk some children may have found the secure base was no longer there for them to attach to. This may have meant that some children were anxious about the exploratory habit of talk that was now expected of them. Hence the group may have focussed on these routines, values and concerns and the mathematical problem became a job to
complete. Sharing resources or taking turns dominated the nature of the discourse and the talk was about the task rather than the mathematics.

Corsaro further noted that even young children can create, control and enact communal sharing but will negotiate, manipulate and defend their interactive space within a peer group. In independent pupil-pupil talk the authority figure of the teacher is removed. Some children may have seen a need to fill the void for authority when left to work as an independent group. Cobb (1995) had referred to the social authority of some children in small group work in mathematics. Cobb defined this as a social construct where one child controlled the way the other children interacted. Also referred to as power this was seen as one child’s viewpoint or interpretation of a situation dominating the other children’s perspectives.

Mercer and Sams’s (2006) study had given the example of children’s disagreement as disputational talk (transcript 4, p. 522). This was recognised as something that was not productive and would limit opportunities for learning. The investigations from this study would concur that talk that involved similar disputes were not productive. However in Mercer and Sam’s study there had been little consideration of why this might have happened, other than the children not following the ground rules for exploratory talk. Whilst recognising this as non-productive and hence limiting the learning experience, there had not been a consideration of how this had limited the learning.

10.2.2. The children’s mathematical talk

Analysis of the speech acts suggested that the most frequent speech act in the children’s mathematics talk for most of the groups had been describing, that is they described or recounted what they were doing, rather than giving any explanations of their thinking. There had been little evidence of the children’s utterances being lexically explicit as would be expected for explanations. The proportional use of the describe speech act did not seem to change to any extent following the intervention but there was a decrease in explanations, that is utterances were less explicit. There also appeared to be an increase in responses that suggested the children were agreeing or disagreeing.

Qualitative analysis of the speech acts suggested that, where talk was more
productive (in that the children arrived at a solution together), there was evidence that the children were responding to each other and that these responses were often related to attempts to arrive at a consensus regarding solutions to problems. Even in the sessions that seemed disputational (Group F) the very nature of disagreeing meant that opinions were being given and the children were taking notice of each other’s opinions. Even if the children were unable to come to an agreed solution (Group B and I) there had been some attempt to engage with each other in the mathematics task that they had been given.

These responses were often not explicit in explaining or giving an exact meaning of the children’s thinking, so they had been coded as descriptions. The teachers had employed ground rules related to asking why another child thought something and to give explanations using words such as because. Hence the expectation was that children would be more explicit lexically and give exact meanings.

However this does concur with other research. It is often seen that the teacher introduces the explicit use of mathematical words as they “apprentice children to the sorts of explicit language” (Gee, 2008, p. 145) that are used in mathematics. It is also noted that young children’s mathematics talk is often given as descriptions of the actions that the children are taking within the task rather than elaborating on mathematical ideas (Corsaro, 1986). This would also concur with Pimm (1987) and Rowland’s (2000) studies of children using vague terms. However the quandary was if the children were actually sharing their ideas or exchanging meaning when they arrived at a consensus and at a solution to a problem. In examining the children’s talk qualitatively it was seen that the children were giving opinions but were not explicit about their thinking. However they were expressing their ideas somehow.

10.3 The nature of the talk and learning in mathematics

In this section I discuss possible relationships between the social talk, the mathematics talk and the children’s learning in mathematics. It has been seen that social talk may create or limit learning opportunities (Wood & Kalinec, 2012) so it would seem important to consider how and why some of the talk
seemed to be limiting the learning whilst other talk seemed to be creating learning opportunities. I also consider why the talk may have happened the way it did and how the intervention may have influenced this. Theoretical underpinning of the doctoral research had been informed by Gee’s discourse theory as connected items of speech, and I consider this in relation to the children's social talk in supporting cohesion within the mathematics talk. The doctoral study is further underpinned by emergent theories of objectification and how shared intentionalities (Seeger, 2011) were fundamental to children’s exchange of meaning. Hence the findings from the analysis of the social and mathematics talk are discussed in relation to these theories.

Social aspects of the talk appeared to indicate that some children focused on the task as a job to be done or as a game. The children had been concerned about turn-taking and the valued use of resources. Within the mathematics aspects of the talk, the children attempted to arrive at a consensus. This entailed the children giving their opinions. They were expressing their ideas but not using lexically explicit language to do this. In some cases the elements of turn-taking, use of resources and the consensus, particularly where there was discord, were not seen as productive to the children’s problem solving, that is, they did not find a solution together, be it a correct solution or otherwise. In relation to Radford and Seeger’s theoretical perspectives conveyed in Chapter 4, the children’s talk was productive if there was evidence of shared intentionality and exchange of meaning. That is they understood the intentions that the other children had conveyed. These points are discussed further in order to hypothesise a relationship between the talk and the learning.

The intervention of the TC Project had changed the way the children were working in mathematics for many of the groups. Level 1 analysis had indicated that in all the classes (apart from School H) there was an increased amount of independent pupil-pupil talk. For some children it appeared that they had not worked independently from the teacher in solving mathematical problems previously, or where they did, this had been as individuals and not as a group. For those children who had worked in groups independently from the teacher it would seem that the exploratory habit of reaching a consensus was new. So this was new territory for many of the children and, as Seeger (2011) has
pointed out, new territory can bring fear or anxiety as children have a need for a 'secure base' that they can attach to. For some children this habit of consensus may have removed that secure base.

For example in Group F attempting to reach a consensus had caused discord. The children in this group were attempting to follow the ground rules. Even though the children had worked together independently from the teacher prior to the intervention the children had not been encouraged to agree or disagree with each other but they were attempting to do this in the post-intervention session. Previously the children had stated their intentions or the solution to a problem, they had not been asked to agree or disagree with the intentions

From Dialogue 9.F1.3:

9. Avril: Right you did 5 did you?
10. Avril: Right, ok?
11. Avril: I've done mine, yours Libby? Or did you do that one?

Being asked to arrive at a consensus opened a path for contradictory viewpoints and in the post-intervention session the children were in a position where they were giving a judgement about another's intention. As suggested by Cobb there may have been a notion of power in controlling the way the other children were thinking. As Avril had said when Libby asked to try and partition 14 counters across the ladybird’s wings,

From Dialogue 9. F2.6:

Avril: Yea, but we might not think, agree with that

Libby had not yet stated her solution but Avril was indicating that she had control over this in judging what Libby would be saying. It would seem that Avril had stepped in to fill the void of the teacher. One could speculate that this was because Avril did not herself have a secure base to attach to. In this group the children's social view of agreeing and disagreeing would seem different to that intended by the ground rule. Argument suggested by the exploratory talk is a valued form of dialogue but one that may have removed a secure base for some children if they had a different social value attached to these ground rules.
Further to this, agreeing or disagreeing with another child’s intention meant that the children had to understand what each other was conveying, what they saw as significant and what they were directing attention to. In the example of the post-intervention session for Group F there seemed to be little attempt from the children to understand each other’s intentions but to be in a position to judge them subjectively. To refer to Seeger’s point there was little perceptual sensitivity regarding sharing intentions in the mathematical ideas.

Whilst not always resulting in dispute this inability to share or understand each other’s intentions was evident in other group sessions such as the post-intervention sessions for Group B and Group I.

In the post-intervention session I2, the children were trying to determine whether the value of the coins represented on a card was equivalent to 6p. (Dialogue 9.I2.3)

7. Jack: This equals 6
8. Martin: Let’s have a look, 1, 2, 3, 4, 5, 6. 6p, there’s no 6p
9. Harvey: No for 6p, you need...
10. Jack: 1 2 3, 1 2 3 4 5 6
11. Martin: I disagree
12. Harvey: I agree, No, I don’t agree

Whilst there was not the level of social conflict that there had been in the session F2, in session I2 Jack, Martin and Harvey did not come to an agreement on what the value was. They stated their ideas but did not share their intentions. There was no attempt to help another understand what the other saw as significant in determining the value of the coins. For example Martin’s utterance 2 ‘Let’s have a look’ might have meant that he was looking at the card himself without regard for why Jack had said it was 6.

This was also evident in session B2 where the children had been finding the value of four squares on a grid where each square represented four (4 x 4). The children were attempting to determine this by counting in ones but arrived at different solutions.

From Dialogue 9.B.2.1:
Mary: So this is hard, cos Jane ended up with 14, I ended up with 16; you *(to Ann)* ended up with 21.

Whilst appearing to work together the children were not sharing intentions. The children did not attempt to understand the intentions of the others, what they saw as significant. Even though Ann had repeated the counting this was done as an individual.

These points regarding the authority aspect of attempting consensus and also the lack of shared intentionalities are contrasted with other group sessions where the talk did seem productive.

In Group A these points are illustrated by contrasting the pre-intervention session with the post-intervention session.

From the pre-intervention session Dialogue 9. A1.5

Olwen: Well you think that, Emma don’t! You put what you think and then I’ll put what you think, then Diane puts what she thinks

This pre-intervention session further illustrates how the children were not seeking a consensus and seemed prepared to accept that they had different solutions. This is contrasted with the post-intervention session.

From the post-intervention session Dialogue 9.A2.3:

2. Olwen: No four, he took four
3. Emma: I know but you can take away like a three then take away one. Emma: Then you’d have 1 2 3 4 5 6
4. Olwen: So it would be...*(inaudible)*

In this example of talk from the post-intervention session there did seem to be an attempt to understand each other’s intentions. This is also illustrated in the post-intervention sessions for Group D and for Group K.

From group D (Dialogue 9.D2.1):

18. Vera: How about if we do the 6 and then put the last one in the middle
19. Harry: What’s six then?
20. Vera: Look, 6
21. Harry: Aha, 3 add 3 equals 7
22. Vera: 3 add 3 add 1
23. Harry: Equals 7

From group K (Dialogue 9.K2.4):

11. Iris: No that’s the less one, that’s the more one
12. Pierce: I really get confused, 6000 is more than... Yeah that’s right.

This was not just that the children were following the rule for consensus but that they were also attempting to share intentions, not finding the solutions on their own and then giving subjective judgements on solutions that had been stated. They were somehow helping each other understand their intentions, what they saw as significant.

Communication requires reciprocity and so turn taking is a “crucial feature of verbal exchange, conversation and discourse” (Seeger, 2011, p. 220). However communication is more complex than just turn taking and Seeger has referred to the complex interplay between the social and the individual. In arriving at a consensus in conjunction with shared intentionality, the children need to be sensitively perceptive of each other. Hence sharing intentions is cognitive, social and emotional (Seeger, 2011). Emotional in that a child needs to be aware of other children’s understanding of what they mean.

Closer analysis of the group sessions in relation to this theoretical viewpoint has suggested that there is evidence of perceptual sensitivity. Somehow the children are helping each other understand their intentions. I postulate that the intervention in encouraging consensus had instilled a need to share intentions which may not have been there before and illustrate this with examples from the pre-intervention session and post-intervention sessions for Group K.

Dialogue 9.K1.3:

4. Iris: How do you know its 10?
5. Fran: If you have one 10 it’s 10 but if you have 5 then it's 50. *(Fran takes five Numicon ten frames)*

In this pre-intervention session the children were asked to explain to each other and they do appear to be helping the other child to understand their intentions.
What they see as significant in the multiplication problem (1 x 10). However the children were not required to solve the problem together and arrive at agreed solutions. They may have understood each other's intentions but this is not evident as they did not solve the problem together, they took turns in giving explanations. However in the post-intervention session the children were asked to agree with each other's solutions to the inequalities as they recorded them. First they had to agree what the signs meant and in the extract below Pierce was not certain. Iris and Fran were sharing what they knew.

From Dialogue 9.K2.4:

11. Iris: No that's the less one, that's the more one
12. Pierce: I really get confused, 6000 is more than... Yeah that's right.

The elements of reciprocity and turn-taking with this group along with shared intentionality meant that they were able to build on each other's understanding and as shown in Chapter 9 the children become almost playful in using each other's ideas (Dialogue 9.K2.4 Dialogue 9.K2.5).

Shared intentionality requires an awareness of the other children’s need to understand, that is it requires perceptual sensitivity. It relies on the children’s awareness that other children can understand what is significant about their personal intentions. The discord that was sometimes present in groups where this did not happen may have been because one or more of the children perceived arriving at a consensus as one of personal subjective judgement and not an understanding of another's intentions. These different perspectives or values may have explained the social authority or control that appeared to happen in some groups. They also begin to shed light on the relationship between social and emotional aspects of communication and children’s learning in mathematics. Key to this is that where the talk was productive, that is a solution, correct or incorrect, was found together, the children were sharing intentions, helping the other children to understand what was significant to them somehow. In the next section I discuss the somehow in relation to the words that the children used.
A further consideration in relation to the role of consensus in the children’s talk was that in arriving at a solution the children are working with mathematical objects. As Radford had pointed out the meaning of mathematical objects is intrinsically cultural. Objectification is a product of a personal subjective construct and a cultural construct. Hence not only are the children sharing intentions by helping the other children to understand what they see as significant, they are relating this to what is culturally significant. Consensus cannot be entirely social; it has to be a product of social and cultural. This was illustrated by the extract from dialogue 9.K2.4 given above. As Fran and Iris pointed to the inequality signs they were referring to a sign with a cultural meaning. In sharing intentions they were working with personal intentions and the underlying cultural meaning of the sign. With reference to Radford’s (2006) theory of semiotic mediation as presented in Chapter 4, in making meaning about the inequality signs, both subjective and cultural constructs were conveyed by the children. In sharing intentions they directed attention to what they saw as subjectively significant but the meaning was related to attending to what was significant culturally. However the way the children directed attention to what they saw as significant was to point to the signs. This was not lexically explicit and it was hard to see how pointing to the signs would help the other child see what was significant.

10.4 The use of words as cohesive devices in objectification.

From the discussion above it has been postulated that turn-taking and consensus had been critical in the children’s communication and that both had been encouraged by the intervention. Where talk was seen to be productive there was evidence that in reaching a consensus the children were somehow sharing intentions. Where the talk was not seen as productive the children appeared to be making subjective judgements of each other’s ideas without shared intentionality. With reference to emergent theories I suggest that, where the talk was productive, the children were exchanging meaning. This had been encouraged through the introduction of the ground rule to agree. Hence the intervention had changed the way the children were talking about the mathematics in some groups. In making meaning the children were directing attention to subjective personal constructs and to cultural constructs of what
was significant. The children’s use of language to share these intentions in relation to mathematisation or objectification is discussed further. To do this I refer to the findings from the Level 3 analysis of the children’s use of function words in relation to cohesion, situated meaning and objectifying deixis.

Whilst there had been little explicit use of the words ‘agree’ and ‘disagree’ it did appear that there was an increased use of agreement and disagreement within the group work where the talk was seen as productive. Some of this was through use of the words ‘yes’ and ‘no’, but evidence was also from re-examination of the ‘direct’ and ‘describe’ coded utterances. It seemed that children were giving opinions but they did not give lexically explicit detail. Arguments were rudimentary; the children pointed to examples and used deictic pronouns and demonstratives.

As considered in Chapter 9 this was seen as consistent with incipient exploratory talk. Whilst recognised as a type of talk in the research literature, it has been seen as a step towards (hence use of the term incipient) the more effective elaborate exploratory talk (Rojas-Drummond & Mercer, 2003). We do not know if the emergence of this type of talk was a step on the way to elaborate exploratory talk. It could be that with continued support in using the ground rules the children would take that step. It was also not possible to suggest that incipient exploratory talk was prevalent as the children were young or were lower attaining as there was no comparison with older or higher attaining children. Even so, children’s learning in mathematics within incipient exploratory talk has not been examined and the data from the TC Project provided an opportunity to further understand how this type of talk could support learning in mathematics.

In the Level 3 analysis of word use in this doctoral study, word frequency queries and text searches indicated that the greatest change in use of function words had been use of the word ‘that’ but that other deictic pronouns, in particular ‘you’ and ‘it’ were also more prevalent than would be expected in natural talk. Other function words of interest were the children’s use of conjunctions and modality. The uses of conjunctions and modality were small but intriguing.
In Chapter 4 I explained how deixis is seen as a cohesive device in discourse and in meaning making. It is cohesive in providing a link between what had been said already (anaphoric) or to what was in front of the speakers (spatial). It was possible that the children were using deixis as a cohesive device, that is as the somehow in sharing intentions and in directing attention to what was seen as personally and culturally significant.

**10.4.1. The children's use of spatial deixis**

With the use of spatial deixis such as ‘that’ the reference itself is of key importance. Cairns (1991) has described the use of spatial deixis as egocentric as the location is relative to the speaker rather than to the listener. However within a dialogue the reference of a deictic term switches according to the context and the speaker. Where there is cohesion within the mathematics talk it would seem that the children are taking part in each other’s understanding as they participate in a shift in referencing. Rowland (1992) referred to it as a “linguistic pointer to a shared idea” (p.47).

How this provided for exchange of meaning needs further discussion. In the dialogue of the group session K2, the only direction to what was important was pointing to the inequality sign and use of the word ‘that’. As Rowland (2000) explained the deictic principle does not “provid[ing] descriptions of images” instead it is a “use of language to point to private concepts, meanings, beliefs, feelings, or attitudes in the context of their mathematical thinking” (p.3). The use is situated within the discourse, within the context of the task, and with the mathematical objects that are being used.

In using deictic words children make reference to mathematical objects that would be difficult for them to define or describe verbally. Objects with a material existence (eg a tree) can be shown directly to another person. Mathematics objects are conceptual, however the children can give an ostensive definition of a mathematical object by pointing to an example. In doing so they are making mathematical objects ostensive and can show them to another person directly. As Font et al (2013) proposed this means that “something that cannot itself be shown directly” can be “complemented by another something that can be shown directly” (p.114).
In deixis the meaning is gathered by pointing to an example but the example represents a conceptual object. As Rowland had stated, the deictic principle does not provide descriptions, there is no explicit detail. In order to recognise another child’s intention the children must already have sufficient understanding. This understanding would come from the context of the problem and the situated nature of the discourse in reference to a child’s personal construct and the cultural construct of an object. Cairns (1991) has referred to this as a ‘deictic shift’ as the children have to “recover the intended reference” (p.72). An ostensive definition only “explains the use - the meaning- of the word when the overall role of the word in the language is clear” (Wittgenstein, 1953, p. 30).

A tentative hypothesis is that where the talk was productive and there was evidence of spatial deixis, the children must have had sufficient understanding of the mathematical objects to recognise the intentions of another child. The children’s shared intentionality was served through spatial deixis in pointing to an example as an ostensive definition of a non-ostensive mathematical object. This idea is illustrated in the use of spatial deixis in group sessions A2, D2 and K2 in section 9.3.1.

In the talk where there was little evidence of sharing intentions the use of spatial deixis was not prevalent, for example group session B2 (see dialogue 8 B2.1 and word tree figure 9.4). It is not clear why these children were not pointing to examples to the extent that the other groups were. It could have been that the children were not aware of the need to share intentions or it could have been that they did not have sufficient understanding to make ostensive reference to examples or where an attempt may have been made the children did not recognise the intentions so this was not used as a cohesive device.

10.5 Summary

In defining the notion of mathematisation in Chapter 4, reference was made to the need to abstract the common elements of situated meanings. With the use of deixis, the situated meaning of a problem is referenced to with sufficient mutual understanding within the context of the activity. Hence mathematisation could be said to emerge from ostensive definitions of examples and the need to
see common elements of the meanings situated within the problems of the task. Mathematisation can be seen as an ostensive/non-ostensive duality (Font et al., 2013).

The children’s use of meanings within the mathematical tasks related to the social, personal and situated meanings or “the bottom-up action and reflection” (Gee, 1999, p. 50). The children were using non-ostensive mathematical objects alongside the manipulation of ostensive objects and sharing their intentions. Arriving at a consensus required the children to share their intentions by directing each other’s attentions to what they saw as important, what they were focusing on. Hence they were focusing on the common elements of the meanings within the task. Whilst referring to non-ostensive mathematical objects this was done in an ostensive way and the children used cohesive devices such as spatial deixis to point out examples and direct focus. As Rowland (2000) quoted, with reference to Moxey and Sanford (1993), the use of deixis is as an “index and probe for the state of focus” (p.58). The deictic words enabled the children to say what the focus of attention was; what was important to notice in coming to an agreement about the solution.

Within Radford’s notion the outcome of the objectification process is a personal object, where that personal object is a combination of individual/subjective and institutional constructs (Font et al., 2013; Radford, 2006). Hence a combination of personal cognition, or an individual’s thought and action, with institutional cognition (Font et al., 2013). I am proposing that in this doctoral study personal objects were a result of dialogue and agreement where meaning was exchanged by referring to ostensive definitions of cultural conceptual constructs.

From the evidence in this study there were two ways that the meaning exchange may have been happening. One was the reference to signs and the indexical focus on the signs. For example when the children in group session K2 were determining the meaning of the inequality sign they were referring back to the examples left by the teacher and then using their own examples. The role of deixis was to share their intentions of the sign, their personal constructs. These were mediated socially in taking turns and in arriving at a consensus, but
the meaning of the sign is cultural and the concept of inequality is also cultural. Whilst it seemed that the children were simply pointing at signs, there must have been sufficient understanding of each other’s meaning in relation to the inequality sign. The children were able to give possible solutions and to use numbers that had not been anticipated, such as negative numbers.

The other was the reference to the logical consistencies and application of the rules in a particular context through modality. Although modal verbs were used rarely their use suggested the children were working within the logic of the task and, it could be said, that the logic of the task mediated between the context and the cultural constructs. For example in stating that ‘There has to be like a line between them’ (Dialogue 9.A2.1.), Olwen was referring to one view of subtraction as the separation of two sets of objects, that is an ostensive example of a cultural construct. Chas was also referring to the logic of the task, a cultural construct of combinatorics when he stated that ‘It [the yellow bear]’s supposed to be there’ (Dialogue 8.E2.5.). Mathematical rules are conventions and children are agreeing with the result by following a rule (Font et al., 2013). The rules are part of the Discourse of mathematics. Hence in exchanging meaning, agreement is not arbitrary but “an agreement of practices that are subject to rules” (Font et al., 2013, p. 110). Hence when Olwen stated “It works” in saying that the number line representation matched with the word problem, she was not referring to an arbitrary notion of ‘works’ but to a convention or a cultural construct.

As considered in Chapter 4 meaning was theorised according to Gee’s notion of the product of ‘bottom-up action and reflection’ with the ‘top-down cultural guidance’ which is normed by a particular practice. Key to mathematics are the processes, concepts, and so on, that are used to solve problems or to generalise within the world of mathematics. In mathematics a child needs to know which commonalities to focus on in order to abstract generalities. In seeing meaning as situated, the focus is on what is significant both within a context and within the culture of mathematics and what is significant is mediated through language (including gestures and signs). In the case of this study, I propose that in the group sessions where the talk was seen to be
productive, words were used cohesively to exchange meaning. In particular the cohesive devices used were spatial deixis.
CHAPTER 11 CONCLUSION

11.1 Introduction

The focus of the doctoral study was on children’s learning in mathematics and its relationship with independent pupil-pupil talk, where independent pupil-pupil talk was seen as one context for conversations in mathematics. The examination of children’s talk within this doctoral study was underpinned by Vygotsky’s sociocultural theory and the aim was to further our understanding of children’s learning in mathematics in talk.

Previous studies of exploratory talk in mathematics (Mercer & Sams, 2006) had examined learning as a product or as performance in solving problems. Whilst these aspects of learning were still taken into consideration in the doctoral study, the interest was in examining the learning that took place as the children collaborated and talked together on mathematical tasks. An initial theoretical stance had been to study the learning from a Piagetian perspective in relation to the notions of procept (Gray & Tall, 1994) and Representational Redirection (Karmiloff-Smith, 1992). This stance had not seemed sufficient to understand how the talk related to learning. By shifting the theoretical perspective of cognition to a social semiotic perspective (Radford, 2006) and relating this to functional language (Gee, 1996; Halliday, 1978) it was possible to understand how the children were exchanging meaning as they collaborated and talked together in solving a problem.

From the analysis it seemed that by encouraging consensus through the notion of exploratory talk, the intervention instilled a need in the children to share intentions. The children’s shared intentions were evidenced through the use of spatial deixis as a cohesive device for exchange of meaning. This exchange of meaning was mediated socially and contextually as well as semiotically and culturally as the children directed each other to ostensive examples within the cultural logic of the mathematics tasks.

In this concluding chapter I consider how theoretical position and the findings of the doctoral study have contributed to current understanding. In section 11.2 I consider how the doctoral study has provided alternative theoretical perspectives and presented new methods of analysis. I identify how the
alternative perspectives and research methods have furthered our understanding of children’s learning in mathematics. I present a case suggesting that the doctoral study has provided an alternative theoretical approach for examining pupil-pupil talk, and how the study of functional language as a social phenomenon has enabled me to step back from the existing definitions and categorisations of types of talk and to re-examine what is meant by effective talk. As such I claim that the doctoral study has contributed to both our understanding of children’s learning in mathematics and to methodology.

In section 11.3 I reflect on the implications of the doctoral study to a wider sociocultural perspective by referring back to the levels of perception of sociocultural theories as presented in Chapter 4, Section 4.2. I arrive at a critical review of the paradigmatic perspectives of the study and consider how exploratory talk is a cultural mode of learning. I also consider how a critical paradigmatic perspective has implications for research into children’s agency in learning mathematics as well as cognition.

In section 11.4 I review the relationship between theory and practice and consider implications for teaching. In section 11.5 I identify where there is a need for further research from a theoretical and empirical perspective and as well as in classroom practice. Section 11.6 presents a final summary of key premises and hypothesis of the study.

11.2 Contribution of the doctoral study to current understanding

11.2.1 Contribution to theory

The theoretical background of the doctoral study was underpinned by a distinctive sociocultural view. As posited in Chapter 4, Section 4.4, this distinct view relates to a level of perspective that focuses on a social view of an individual’s learning. This social view of learning is integrated with the functional use of language in meaning making within the context of a mathematical task. This distinct view allowed me to underpin the study from a theoretical perspective that saw a dialectical dynamic relationship between cognition and socially situated theory, rather than a view that would mean grappling with the dichotomy of individual and social. As Roth and Radford (2011) suggested,
within a dialectical view the individual and social are *imbricated* (overlapping) or *coterminous* (equal in scope).

This dialectical view enabled me to study personal meaning making within a social context. Radford (2006) had proposed that meaning is central to knowledge formation and that exchange of meaning is correlated to the sharing of intentions, but that this sharing is socially, culturally and semiotically mediated. As such Radford recognised the “central role of culture in the production of objects of knowledge and the way we come to know them” (p.42), and that “we have recourse to language, gestures, signs or concrete objects through which we make our intentions apparent” (p.52).

One particular outcome in examining exchange of meaning and sharing of intentions was the identification of the use of spatial deixis. Radford (2003) referred to the use of deixis in exchange of meaning as *objectifying deixis*, where meaning and shared intentions are created within factual generalisations. Factual generalisations happen within a situation, for example a particular problem. No new generalities are abstracted, and no new mathematical objects enter the discourse. Factual generalisation enables the children to carry out the calculation that is situated in a particular problem, according to the task needs. The use of deixis and factual generalisation was evident in the children's talk and was seen to be more prevalent in the talk where the problem solving was productive.

This finding relates to other studies of face-to-face communication and group work but empirical studies of children’s use of deixis and factual generalisation in mathematics education are still limited. Sabena, Radford, and Bardini (2005) have studied the use of deixis and gestures with Grade 9 students in pattern generalisation and Koukkoufis and Williams (2005) have studied the use of deixis and factual generalisation with Year 5 children’s use of integers. This doctoral study has provided further empirical evidence of objectifying deixis and factual generalisation with younger children’s learning in mathematics.

Further to this the dialectical view enabled me to relate sharing of intentions to the notion of perceptual sensitivity (Seeger, 2011). From the evidence of the video material analysed in this study, the intervention of the TC Project had not
been successful in promoting the use of cohesive devices, such as deixis, in all the groups. In reviewing social and emotional aspects of the talk it could be surmised that there was a lack of perceptual sensitivity of the need to share intentions in some groups, or even the realisation that intentions could or should be shared. It seems possible that where some children’s talk was more productive than others, this may have been due to the awareness that intentions could or should be shared. Hence an emerging hypothesis is that effective talk is related to perceptual sensitivity. Further research is needed to examine this hypothesis.

11.2.2 Contribution to research methods

The study of the change in use of functional language, and in particular deixis, provided an alternative way of understanding how pupil-pupil talk is related to learning within exploratory talk studies. Previous research on exploratory talk has analysed the talk in relation to types of talk (Mercer & Sams, 2006; Mercer et al., 1999; Rojas-Drummond et al., 2003). In these studies typifying the talk provided a way of examining the correlation between productivity of solving problems and talk, but it did not provide a way of examining how learning was happening in the talk. Whilst deixis was seen as a key characteristic of incipient exploratory talk (Rojas-Drummond et al., 2008), it was associated with rudimentary arguments as a step towards more elaborate reasoning and justification in exploratory talk. Deixis was not seen as a way to examine learning within exploratory talk studies.

By examining the use of deixis in relation to semiotic objectification in this doctoral study, it is suggested that the use of deixis is valuable to the talk of young children in learning mathematics. The use of deixis may not just be a step towards more elaborate reasoning, but that the use of deixis is the way young children share intentions and exchange meaning in coming to an agreement. The increased use of the deictic word ‘this’ following the intervention suggested that the introduction of the need to agree on a solution together (even if not correct) meant that the children were sharing intentions and focusing attention on what they saw as important. In relation to Rowland’s (2000) perspective the children were using deixis to express what they had in
mind. This would seem to represent exploratory talk in the sense that Barnes (1976) had suggested, it is *thinking ideas aloud*.

As such, the use of functional language in examining the pupil-pupil talk provided an alternative analysis to investigate the changes in use of language across the intervention. Analysis of pupil-pupil talk has been seen as problematic since the 1970s. Studies such as Barnes and Todd (1995) had realised the difficulty in categorising utterances in pupil-pupil talk. As Barnes (1999) further indicated, unlike teacher-led talk, pupil-pupil talk is less structured. Whereas in teacher-led talk the teacher decides who is to talk, what is relevant to talk about and which answers are acceptable, in pupil-pupil talk the children are making these decisions and organising the turn-taking. Analysing the talk regarding functions of utterances is also complicated by the problem that one utterance can have several functions. This has made quantitative analysis of functions of talk problematic.

Reference to cohesion in discourse (Gee, 1996) and SFL (Halliday & Matthiessen, 2004) provided a systematic approach to studying the functions of utterances. This approach enabled a comparison of the functional use of language across multiple cases and across pre-intervention and post-intervention group sessions. Whilst it is acknowledged that limitations still existed some of these were overcome, for example the use of NVivo enabled the recognition that one utterance can have several functions. In reflecting on the analysis it is also recognised that any attempt to use the categories in a quantised way needed to be supported with qualitative examples. Multilevel analysis, and the more direct inspection of the children's talk through use of functional grammar, provided for further reliability. However it is acknowledged that the interpretations are mine and, as has already been stated, we cannot know for certain what the children were intending in their utterances.

Whilst it is acknowledged that there remain some limitations in analysing children's talk through the use of functional linguistics, this approach has enabled an examination of exploratory talk that went beyond determining the type of talk or whether the talk was productive. A dialectical view of the social and the individual provided a way of looking at cognition in relation to the nature of talk. This perspective enabled me to pull back from typifying talk as
exploratory, cumulative or disputational and to re-examine the essence of what it means for talk to be effective in collaboration and how this supported meaning making in mathematics with these children. There is a need to be careful not to reduce such an examination to a use of deictic terms, but to consider how the children’s use of deictic terms indicate collaborative interaction and a sensitivity that the children can share ideas with each other in solving a problem together.

11.2.3 Summary of contributions to current understanding

The contributions to research from this doctoral study have been developed through a distinct theoretical view. This distinct view enabled a new approach to studying children’s learning in mathematics in pupil-pupil talk. In doing so, the findings have provided further empirical evidence in relation to objectifying deixis, and an emerging hypothesis in relation to perceptual sensitivity and effective talk. The distinct theoretical view has provided an alternative method for analysing pupil-pupil talk in exploratory talk studies which further considers the relevance of deixis in incipient exploratory talk.

11.3 Reflection on wider sociocultural perspectives.

In Chapter 4, Section 4.4, I presented a review of some sociocultural theories in order to position the distinctive sociocultural view adopted for this doctoral study. These sociocultural theories had been presented at different levels of perspective. The focus of the doctoral study had been on a level that integrated the social with the individual in understanding learning. In this section I reflect on how the findings of the doctoral study relate to the wider field of sociocultural theory.

The findings indicated that the children rarely used lexically explicit detail in sharing intentions. However the directed attention and focus on ostensive examples would suggest that they were exchanging meaning. Gee (2008) has pointed out that “everyday argumentation has deeper purposes than just validating a claim and it is quite rational in its own terms” (p.120). Hence this lack of lexically explicit detail may have been an illustration of acculturation, as children’s everyday peer discourse met mathematical discourse.

Mathematics discourse is different to other social discourses (Khisty, 2002; Sierpinska, 1998). Forman (1992) had observed how the mode of discourse
required in school mathematics was different to the conversational discourse which children are more used to in the home with parents and at play with their peers. Children learn the new discourse of mathematics with their teachers. Within peer collaboration we are asking the children to co-construct further new modes of discourse.

Hence, the engagement of young children in independent group work would seem to be two-edged. On the one hand it can “provide children with an opportunity to practice academic discourse and learn how to coordinate it with the discourse of everyday life” (Forman, 1992, p. 155). Within peer collaboration children are able to relate back to a verbal/non-verbal discourse that is more like that of play and conversational inferences. On the other hand we are expecting children to engage in mathematically explicit discourse which is not in tune with normal peer discourse and where they do not have guidance from the teacher.

The differences in modes of discourse may be more apparent for some children and even though there is the opportunity to practise mathematics discourse with their peers some children may still not be able to access this new mode of discourse without the support of the teacher. This inability to access the discourse points to the notion of equity in children accessing mathematics. Critical theorists have related the different propensities to mathematical discourse to social and economic status. Street, Baker et al. (2005) suggested that the rules and patterns of discourse in school are seen as the discourse of middle class homes. One of the problems that pupils have in succeeding in mathematics is that they are confronted not only with a problem of language as in mathematical vocabulary but also the different rules and patterns and how they are different from home (Lubienski, 2000).

In relation to the hypothesis emerging from this doctoral study, this new mode of discourse relies on a perceptual sensitivity in sharing intentions. Whilst the discourse of play or natural conversations may involve the sharing of intentions, these intentions are not likely to relate to formal mathematical ideas. Whilst the TC Project had intended to support lower attaining children, it is possible that the mode of discourse may have been a contributing factor in their lower
attainment in the first place. Whilst endeavouring to support such lower attaining children by encouraging pupil-pupil talk and hence engagement in a Discourse there is a danger that the intervention provided learning opportunities for those children already conversant to some extent in the Discourse of mathematics. So rather than providing an opportunity for effective learning in all cases such an intervention may continue to acerbate the inequity.

However it would seem that the intervention of the TC Project had been successful in positioning some of the children as doers of mathematics. Within a peer culture children are seen to identify “as a member of a socially meaningful group or ‘social network’ or to signal (that one is playing) a socially meaningful ‘role’” (Gee, 1996, p. 143). Hence it was encouraging to hear Fran declare “We are the maths people aren’t we”. Did this suggest that they had seen themselves as members of a socially meaningful group within mathematics? I would like to think this was the case.

The potential to enable children to exchange meaning and reciprocate in problem solving in a collaborative way would suggest the children are empowered to take action and to make choices in solving a problem together. This cultural mode of collaborative work would create, in many classrooms, a new norm that would see children working as mathematicians where a collaborative nature is highly valued (Burton, 1998).

Whilst the focus on perceptual sensitivity in sharing intentions had been a way to study the children’s learning within the groups work, it is also recognised that this may have been a way for young children to participate and find a way around the world of maths. This has suggested that participating in mathematics is not just about knowing ways of talking mathematics but knowing that you can talk about mathematics to each other. In instilling this perceptual sensitivity children can work independently and draw on mathematical ideas themselves to solve problems. This independence could be seen as an empowering identity (Boaler & Greeno, 2000) in becoming the ‘maths people’.

Why the TC Project intervention had changed the way children related to each other and exchanged meaning in some groups and not in others was beyond the scope of the TC Project and hence the doctoral study. However this non
exchange of meaning in some groups does raise issues of equity and empowerment which were not addressed. Data had not been collected that might have allowed an investigation of the intervention in relation to cultural or social status and whilst teachers had commented on the children’s increased confidence, neither the TC Project or the doctoral study had realised the positive self-image that may have been happening. However further consideration of developing pupil-pupil talk as the discursive construction of an individual might suggest that positive images of competent participants in mathematics were also developing.

The focus of the study had been on the children’s learning rather than in the changing norms or dynamics of the classroom or on the agency of the children. However implications from the doctoral study resonate back through the levels to the subjective notion of identity and agency, the cultural norm of the classroom situation and to the view of mathematics as a Discourse. As such the study indicates how the social study of linguistics is relevant at different levels of perception and within a wider field of sociocultural theory. Hence the use of SFL could inform other studies at different levels of perception.

The lack of focus on equity and agency are acknowledged as shortcomings of both the TC Project and the doctoral study. It is realised that there is a need for further work on developing exploratory talk with pupils and to study the subjective notions of agency and identify and alongside the learning in mathematics. Such further studies would be positioned methodologically within the critical paradigm as represented in the model of social cartography (Paulston, 1994) and by Crotty’s review of paradigms (1998) where an examination would not just be on perceptual sensitivity and cognition but also on subjective aspects of agency and identity.

11.4 Implications for classroom practice

There was evidence from the TC Project that the intervention had an impact on the teachers’ practice. The findings from the interview suggested that many teachers had changed their way of planning and teaching mathematics. However it was not the intention of the doctoral study to examine the impact on teachers’ practice, the intention was to study the mathematical learning of the
children. Radford (2011) suggested teaching and learning are two sides of the same coin and are both concerned with signifying and meaning-making and that there is a relationship between theory and practice. This relationship is what Roth and Radford (2011) have called *togethering*; how individuals engage and tune in to each other. As such the doctoral study cannot claim contributions to research on classroom practice. However due to the relationship between theory and practice, the emerging hypothesis does have implications for the classroom and I present the potential of the findings of the doctoral study in relation to instructional practice.

The theoretical view of the doctoral study was focused on a social view of individual learning. Hence implications for practice are not only at the situated level of dynamics of classroom interaction but at the level of the emergence of concepts within a situated context. As such the findings of this doctoral study consider how to work with the discourse of young children, whilst supporting mathematical discourse. In particular, the findings point to the need to encourage perceptual sensitivity in enabling young children to share their intentions. That is not just to encourage ways of talking in mathematics but to enable children to realise that they can share intentions in their talk in mathematics.

By relating pupil-pupil talk to learning through social semiotic mediation, pupil-pupil talk is seen as a way of using language within a socially situated context bound by a task, it is a way of enculturating young children in sharing intentions and has the potential as a mode of classroom practice in helping children understand mathematics. So the findings not only raise the importance of language and ways of talking mathematics, but consider how children are enculturated into sharing intentions. The potential in sharing intentions suggests that the development of talk in mathematics is not limited to teacher-pupil encouragement in giving clear explanations to the teacher. This potential also questions whether an insistence on using mathematically correct language can be effective in helping children to explore ideas.
11.5 Implications for further research

The findings of the doctoral study suggest an alternative mode of instruction that encourages children to make their intentions clear to each other and further research is needed in developing this alternative mode of instruction. There is a need to support teachers in managing collaborative work that will enable the children to make mathematics explicit to each other through sharing their intentions and there is a need to design tasks that will encourage such collaboration.

Whilst teachers may intuitively feel that collaborative group work is important they are less certain on how to support its use in their classroom. Much professional development has focused on teacher-directed instruction in making the mathematics explicit through modelling and images. There is also resistance from some teachers to work with collaborative groups. In collaborative group work pupil-pupil talk relies on something spontaneous and informal in nature, the teacher is not in control of the mathematics and the pupils’ learning. There is a need to research pedagogical strategies that realise the importance of the teacher’s role in managing effective group work and the design of tasks that will focus children on the mathematics.

I have carried out a small-scale study that examined task design and teacher involvement in relation to children’s focus on mathematical ideas such as cardinality and equivalence (Murphy, 2011). The tasks presented formats such as sorting or matching representations of number problems. A key finding was the importance of the role of the teacher in presenting the task and in prompting the children as they engaged with the task. Still further work is needed to evaluate the affordances of the tasks. In particular to evaluate how the children focus on the mathematical content of the task, the cohesion in the group in collaborating and in managing the task, and how the children’s use of language is supported.

The doctoral study has presented one way of studying the learning through classroom communication by relating to social semiotic mediation and the use of systemic functional linguistics (SFL). In this doctoral study SFL was used to examine pupil-pupil talk but such an examination could be also carried out with
teacher-pupil talk. The use of deixis was prominent in determining meaning making in pupil-pupil talk and the study has shown how deixis can highlight the development reciprocation in pupil-pupil interactions. The study of deixis could also be used to examine of teacher-pupil interactions to in relation to reciprocation.

We do not know from this doctoral study if a more sustained support in the use of talk in mathematics would have resulted in more use of elaborate exploratory talk. The intervention with the groups of children in this doctoral study was over one school term. Longitudinal studies would be needed to determine if the talk that developed was a characteristic of younger children generally or if more time was needed to move the children to elaborate exploratory talk. It is also not possible to determine from this study if incipient exploratory talk is typical of lower attaining children and further studies would be needed with other attainment groups to investigate this. Such longitudinal studies or studies with more diverse children using a dialectic theoretical approach could provide further understanding of how the nature of young children’s talk in mathematics develops and how the development of exploratory talk would impact on the children’s exchange of meaning.

There are still knowledge gaps in relating this theory to empirical studies of semiotic mediation and objectification within children’s learning. Radford (2010) has studied the different layers of generalisation with older pupils’ learning in algebra, including factual, contextual and symbolic. With factual generalisation no new generalities are abstracted and this would seem to have been the case in nearly all the group tasks except Group K where the children were exploring the idea of inequality in relation to the signs. It is possible that Group K’s generalisation related to Radford’s contextual layer in that there was a situated description of what is happening but it was not limited to the one context, the children went beyond particular numbers. The children’s ability to use other generalities could have been limited by the tasks themselves and further research would be needed to find tasks that might support such generalities.
11.6 Summary

The doctoral study has been underpinned theoretically by a distinct sociocultural view. Based on a Vygotskian perspective of concept formation, the view integrates semiotic mediation theories with social functional linguistic theories. By combining these existing theories, an alternative theoretical view is presented that has enabled new research approaches in studying learning in relation to talk.

In this doctoral study this distinct dialectical sociocultural view provided a lens to examine and understand the relationship between learning and pupil-pupil talk in young children. In understanding this relationship further empirical evidence has been presented in relation to objectifying deixis and factual generalisation, in this case with younger children. The analysis has provided further evidence to support our understanding of learning as exchange of meaning and how this is socially, semiotically and culturally mediated.

The distinct sociocultural view also enabled an alternative analytical approach into a study of the nature of children’s talk in mathematics by connecting the cognitive with the social. From the examination of the use of functional language across groups it is asserted that, where the talk was productive, the intervention instilled a need to share intentions but that this sharing of intentions was not upheld for all groups. Hence a hypothesis is posited that effective talk in young children is related to a perceptual sensitivity, or awareness that intentions can be shared.

A key premise of this doctoral study is the realisation that teaching and learning relate to communication and mutual understanding. Hence the study recognises the importance of the child in learning in the classroom and how communication in a classroom context, including collaborative group work, involves reciprocity and empathy. As such, although the study focused on learning, agency resonates throughout in considering the child taking charge of their talk.

A concern that some groups of children were not enabled to exchange meaning and share intentions suggests that further research is needed into developing perceptual sensitivity of young children in mathematics, so that we are not
continuing an exclusive practice. This would require further examination of talk from a dialectic sociocultural perspective and the study of practical implications in professional teacher development and the design of tasks to support children in sharing intentions.
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297


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302


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APPENDIX 1

TALKING COUNTS: AN INTERVENTION PROGRAMME TO INVESTIGATE AND DEVELOP THE ROLE OF EXPLORATORY TALK IN YOUNG CHILDREN'S ARITHMETIC

END OF AWARD REPORT

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Signed..........................                      Date..........................

Introduction
The project involved the application of sociocultural theory to a specific knowledge domain. It explored the potential of exploratory talk in developing learning tools for children in arithmetic.

The project was carried out between January 2009 and December 2009, although analysis of the data continues. Data collection was completed by July 2009 as planned. Some further resourcing of strategies for introducing talk was also carried out in October and November 2009.
A resource pack for teachers has been developed (Appendix 1). We are currently waiting consent for use of material from schools and parents before disseminating to partnership schools. A website will be developed in July/August 2010.

Short papers have been presented at the following conferences:

Murphy, C. ‘Children’s use of procedures in early arithmetic’ International Symposium Elementary Mathematics Education, Charles University, Prague, August 2009

Murphy, C. ‘Analysing children’s calculations: the role of process and object’, British Congress of Mathematics Education, University of Manchester, April 2010

Tricia Nash was employed on a part time Research Fellow contract from January –Dec 2009. Tricia was also employed in a casual basis to complete the resource pack in March 2010. Emma Pipe was employed as an occasional Research Assistant to collect diagnostic data in May to July 2009. Emma also assisted in analysis of the diagnostic data in October/November 2009 and April 2010.

**Aims**

The project was set within the context of current national concern for achievement in mathematics and a need for greater awareness of how to support the development of mathematical understanding. It was aimed at a band of children who are often tentative about their own understanding in mathematics and have difficulties in explaining their own thinking.

Exploratory Talk (ET) has been typified as “a way of using language effectively for joint, explicit, collaborative reasoning” (Mercer et al., 1999, p. 97). It was proposed that as children engaged in collaborative reasoning they would test out their understanding of mathematics. In particular we wished to investigate if Exploratory Talk would support a cognitive change in children’s approaches to arithmetic. Many lower attaining children rely on counting procedures when carrying out calculations. They are less likely to view operations, such as addition and subtraction, as objects that can be used to support more flexible strategies (Sfard, 1991; Gray and Tall, 1994). In this way they can become reliant on counting strategies and less able to engage actively in the calculation strategies that are taught in KS2.

It was proposed that the early intervention in arithmetic through exploratory ‘pupil-pupil’ talk would improve children’s engagement and achievement in mathematics. It is hoped that this would have a longer impact in children becoming more active learners in KS2. As a one year project it would not be possible to examine progress into KS2 but data collection methods were put in place to determine progress in learning over the short period of the project.

Aims of the programme:

- To develop a teaching intervention based on research that will have an impact on the teaching of arithmetic at KS1 in the UK.
- To work with practising teachers to develop practical classroom strategies that will encourage exploratory talk within collaborative group work across a range of abilities within the specific context of arithmetic.
- To analyse the group interactions (verbal and gesture) that occur through exploratory talk, how the quality of the talk changes and how the change in quality relates to cognitive shift in arithmetic.

Further aims:
e) To develop detailed guidelines and a professional development pack for use in teaching through collaborative group work within the specific content of arithmetic at KS1.

f) To evaluate the effectiveness of the teaching approaches through analysis of both quantitative and qualitative data.

g) To evaluate the effectiveness of the professional development pack in transferring the approach from the classrooms in which it has been originated to other schools and classrooms.

h) To disseminate the findings and products of the project in such a way as to have the maximum possible impact on the way in which arithmetic is taught.

**Project outline**

In order to achieve these aims the project was set out in three phases:

*Phase 1: Developing Resources (Jan – March 2009)*

We worked initially with two teachers who had an expertise in teaching mathematics at KS1 (development teachers and classes). These teachers were identified with support from consultants at Devon Curriculum Services. The two development teachers were asked to explore strategies to develop talk and to identify teaching strategies to transfer the talk to mathematics activities. It was intended that the two teachers would meet to observe each other and share ideas in designing activities. Teaching strategies developed by these teachers were used to introduce exploratory talk to the transfer teachers in the next phase.

*Phase 2: Evaluation and Transfer (April – July 2009)*

The teaching strategies were presented to ten transfer teachers with the support of the two development teachers. The transfer teachers used the strategies to develop exploratory talk in their classrooms. They were asked to carry out collaborative talk activities twice a week at least with six focus children in their class. Evaluations of the strategies were used to further explore teaching strategies and develop a resource pack. It was intended that the ten teachers would meet to observe each other and share evaluations.

*Phase 3: Dissemination (September to December 2009)*

This phase was intended for dissemination through the following:

- Production of the professional development resource pack
- Design and set up website
- Hold conference with ITE partnership schools in the South West
- Further dissemination through professional organisations such as National Centre for Excellence in Teaching Mathematics (NCETM), Association of Teaching Mathematics (ATM) and Mathematics Association (MA), Teacher Training Resource Bank (ttrb)

**Further Impact**

Further impact was planned through:

- Support for teachers to publish in professional journals such as Primary Mathematics (Mathematical Association).
Dissemination through research associations such as British Society for Research in Learning Mathematics (BSRLM), British Congress of Mathematics Education (BCME), British Educational Research Association (BERA).

Advisory Panel

The project invited academics and policy leaders with an interest in the development of primary mathematics and learning through talk to join an Advisory Panel. The members of the panel are:

Neil Mercer, University of Cambridge, academic and expert in talk for learning
Tim Rowland, University of Cambridge, academic and expert in discourse analysis in mathematics
Sue Pope, QCDA, Programme Manager Mathematics
Fiona Jeffery, Primary Consultant (mathematics), Devon Learning and Development Partnership

This panel has met twice: 3rd June 2009 and 8th September 2009. A further meeting is planned for 8th June 2010.

Research Findings

Development of resource pack

A key output of the project was to produce a professional studies resource pack that could be disseminated both locally to partnership schools and nationally to all interested bodies.

Data collected from evaluations of the research meetings, teacher interviews, teacher notes and resources and video material were used to identify a range of teaching strategies to introduce the talk with KS1 children. These were presented as stages:

Stage 1: Introducing talk to young children.
This was mainly carried out in generic speaking and listening sessions or in personal/social education. Key strategies used for this appeared to belong in the following categories:

Why is it important to listen?
Introducing talk with listening
What is the purpose of talk?
Beginning talking in trios
Asking good questions

Stage 2: Introducing prompts for good talk.
This appeared to be developed in sub stages as follows:

Developing prompts for good talk
Reinforcing the use of prompts for good talk
Displaying the prompts for good talk
Managing agreement and disagreement

Encouraging children to reflect on talk and collaboration

Stage 3: Developing the use of talk in mathematics activities.

These were categorised as follows:

- Same and different – identifying equivalence
- Introducing problem solving and problems with more than one solution
- Checking number bonds
- Testing children’s assertions and misconceptions
- Matching representations

Each stage is illustrated with photographs of children working on the activities and short transcripts to indicate the children’s learning. The resource pack is not intended as a prescriptive step-by-step series of lessons but as a bank of ideas that are known to have worked for practising teachers.

It was hoped that the resource pack would have been produced for December 2009 but further material for introducing talk was gathered in October and November when the teachers were more confident with their new classes. This has helped to present a more comprehensive resource pack. A first draft of the resource pack was produced in February and March 2010 and sent to project teachers for their views. A small working group of project teachers met with the research team at the end of March to review the pack. The resource pack was further revised in April 2010.

The resource pack is included in Appendix 1 but it is noted that we do not, as yet, have permission for some of the material to be used outside of the project. This is currently being obtained and where necessary adjustments will be made before this is disseminated publicly.

**Standardised tests**

Analysis of the Hodder Progress in Numeracy Tests have been carried out. Results need to be viewed in the light of the difficulties that we encountered in using the tests as indicated above on p.5. The tests have not been used in a controlled experiment. Although the tests were carried out with the whole class this was mainly used to support selection of focus group children. In many classes all children worked in groups on the talk activities in mathematics. Where this did not happen whole class inputs on effective talk were a matter of course and were to be encouraged as this was seen as a way of establishing a dialogic ethos in the classroom. Data from the other children in the classes can be provided if required.

We present data from the focus groups from 10 of the schools in Appendix 2 (59 children). Two of the schools (Schools G and K) did not complete the post test so there is no comparative data. The tables indicate where the children were tested using the Baseline, Level 1 (NPT1) and Level 2 NPT2) tests. Apart from the Development Teacher’s class (School L) the progress was measured over one term.
The chronological age (CA), number age (NA), raw score and standardised score for each child for both pre and post test is given, along with a National Curriculum Level. One key point to note is that 14 children’s attainment had been identified at an ‘alert’ level at the start of the project. This reduced to 5 children by the end of the project. In fact 10 children moved out of this ‘alert’ level, as one child, who was absent from school for much of the project, moved into the ‘alert’ level.

The direction and amount of difference between the CA and NA was found to be an indicator of how the children were attaining against the norm and this is also reflected in the standardised scores. These were used to analyse the children’s progress in learning. Further analysis has been carried out to investigate progress in learning regarding these two indicators (Appendix 3). Overall the children in the ten focus groups progressed 6 points above the expected progress in the standard score and 6 months above the expected progress in number age.

Although this is not compared with a control group it does indicate that overall the children did continue to make expected progress and that some children made greater than expected progress. It must also be noted that 25% of the children did not meet the expected progress (14 children out of 57 children). Further analysis needs to be carried out to determine if this was due to limitations of the test or related to the children’s engagement with the activities and talk during the project.

It is also noted that decreases in performance were smaller than increases in performance. Changes in CA/NA difference and standard score over the project ranged from an average 1.83 months decrease in CA/NA difference and an average decrease of 1.17 in standard score (School B) to an average 21 month increase in CA/NA difference and an average increase of 20 standard points (School J). This would suggest that the children in School J’s focus group appeared to make the most progress. The pre-test showed that School J’s focus group had the lowest average CA/NA difference score (-22 months) and lowest average standardised score (77.33) at the start of the project. This is compared to School B’s average CA/NA difference of +7 months and an average standard score of 107 which was one of the highest average scores. Although we have not carried out any correlation analysis there is a possibility that the lower attaining children appeared to make greater progress according to the Hodder Test and this will be examined further.

Diagnostic tests

As the Utrecht Early Numeracy Test was not carried out in the standardised form analysis of this will be carried out in a non-standardised diagnostic form related to children’s changes in approaches to the questions. This is yet to be carried out.

Analysis has been carried out for the Diagnostic Calculations Tests. The results for each child across the twelve focus groups (50 children) are set out in Appendix 4.

The analysis of the diagnostic tests was carried out according to the principle of change from procedural counting based strategies to object based strategies. Each calculation strategy was coded according to the following:

Counting based strategies (these indicate a progression within counting based strategies):
CA: Count all (counting both sets)
CO/CB: Count on/Count back (counting on or back from one set)
COMIN: Count on from larger number (counting on from the larger number to reduce the count)

Part whole strategies (these include a range of strategies that show children are reasoning about the operations as objects):

N10 – sequencing, jumping strategy
1010 – partitioning strategy – both numbers are partitioned
UF – use of fact, for example 8 + 8 = 16 so 8 + 7 = 15 (one less)
KF – recall of known fact – no strategy used.

We also included the following:
NG – not given (often when it was felt that the child would not be able to continue)
R – refusal (the child refused or did not attempt the calculation)
O – ineffective strategy
E – error or slip when carrying out an effective strategy

The pre test calculations and the post test calculations were coded and compared against each other for each child. Changes in the types of strategies were identified. Yellow highlight indicates the child has used a more object-based strategy in the post test. No highlight indicates the child used the same type of strategy. Blue highlight indicates the child used a more procedure-based strategy in the post test.

Yellow and blue highlights were seen to cancel each other out. That is, if a child showed a change to an object-based strategy in one calculation but then showed a change to a procedure-based strategy in the next calculation these were cancelled out and the child’s use of strategies was said not to change. Where a child changed to object-based strategies that were not cancelled out by changes to procedure based strategies this was seen as an increased understanding in their use of number and a possible cognitive shift towards object based methods. This was then calculated as a percentage. The percentage change is then indicated for each child (Appendix 4).

74% of the children indicated a change to more object-based strategies, 14% of the children indicated a change to more procedure-based strategies and 12% of the children indicated no change. Six children indicated 70% to 100% change in their use of the strategies suggesting that they were able to use more object-based methods across all or nearly all the calculations.

The average percentage change for the focus group in each school is given in Appendix 3 (alongside the progress made in the Hodder tests). This shows variation in...
the different schools. School E showed a percentage change towards more object-based strategies of 64%. However School I showed a percentage change towards more procedural strategies of 3%. Further investigation is needed to consider why there were variations. It is possible that this is dependent on the topics that were taught and the approaches to teaching arithmetic not related to exploratory talk. For example the teachers in School A and School B used the empty number line as an approach to teaching calculations. This was not used to such an extent in the other schools.

The overall percentage change is approximately 30% towards object-based strategies across each calculation carried out by the 50 children. There is no existing data to compare this with and there is no control group so we do not know if this is a large percentage increase over the project. However we do note that the children’s approaches to calculations are generally moving towards more object-based strategies.

**Teacher interviews with the Transfer Teachers**

Details of the responses related to the strategies and activities for introducing talk have been analysed in order to develop the resource pack and are not reported in this section but key points related to the teachers’ impressions of the use of talk are commented on:

The teachers gave different reasons as to why they had volunteered for the project. Six teachers responded that it was because of their interest in talk whilst 5 indicated their desire for professional development. Another four teachers were hoping it would be of benefit to the children in promoting their language and raising attainment. Two teachers mentioned they had already seen the benefits of talk through using it in literacy sessions.

All 10 teachers reported that they had found the Research Meetings adequate in informing them about the project and what was required of them:

‘Absolutely, I found it really helpful, just giving ideas about what we needed to do, and I think the reasons why, I think were quite helpful and just, I found personally, that it gave me the authority to do what I think is best practice.’

Two teachers specifically commented how it was beneficial that the project was not prescriptive in how teachers were to carry out the exploratory talk sessions in the classroom:

‘I had a read through everything and it did seem like a lot to start with, but then once we had the day, I felt a lot calmer about it because I realised a lot of the decisions were mine to be making, so I didn’t have to follow anything specific, it was about my children and my class, so that was better.’

Nine of the teachers claimed they had not used exploratory talk prior to the project. Two teachers admitted that they had thought they were using such talk but then realised that this had not been exploratory. Just one teacher reported that she used exploratory talk in literacy lessons. Three of the 9 teachers responded that despite not previously using exploratory talk they did do a lot of ‘speaking and listening’ in their classes.

Seven of the ten teachers found that they needed more than one session on talk before applying it to mathematics activities. The Year 1 teachers found that more time was needed on listening activities. One of the Year 1 teachers gave six sessions on talk.
One teacher found that the children needed more practice in sharing activities and taking turns. It was also noted that short sessions were more beneficial than whole lessons on talk.

Teachers also managed the introduction of talk in different ways. Although the teachers introduce talk generally to the whole class some would then focus on one group as they worked on an activity. Other teachers involved the whole class in group work. All the children were working in trios on mathematics activities. Year 2 teachers were more likely to use trios with the whole class work but one Year 1 teacher also managed this successfully.

Teachers reported different methods and means to develop the ground rules for talk and their display in the classroom. It was clear that some teachers had found this task more difficult, with one teacher commenting how her class would not engage in developing such rules at all. Another teacher commented how her class had related ground rules to school rules such as no kicking or biting. Several of the teachers found that the prompts to ‘agree’ or ‘disagree’ caused problems. Teachers had to emphasise that it was not being unkind or hurtful if someone did not agree:

'I think the majority of the children are of the opinion that they are right and that any other child disagreeing with them must be wrong. So a tricky concept to grasp.'

Six of the teachers felt that their children understood at least some of the rules by the end of the project. Teachers with year 2 classes were more positive than those with Year 1 classes. One teacher commented that the children were using the rules to please her.

'No I don’t think they really did actually. I think half the time they did it to please me.'

One Year 2 teacher felt that the rules had particularly benefitted the lower attaining children as it was easier for them to listen to their peers than to the teacher for long periods. This is in contrast to the three Year 1 teachers who felt that it was only higher attaining children who understood the rules.

All the teachers had used a mixture of whole class, individual and group work prior to the project. The group work was often in larger groups of 6 to 10 children. Four teachers had used a published scheme, one of them commenting that the activities were not conducive to talk.

'No they’re not, they’re not built for talk, they’re built for, this is what you have to do, do it by yourself!'

It appeared that in the classes where the children had been used to working independently the teachers reported more difficulty in encouraging collaboration.

‘...the children adopt a selfish approach to their work. Often they want to show me what they can do they don’t want to help other members of the class’

Three teachers spoke of using ‘guided groups’ and how they continued to do so. One of these teachers endeavoured to include exploratory talk within these guided groups. Two other teachers also mentioned that they had used larger groups in the past but now realised that the children were not working as groups but as individuals within them.

‘quite often we would do things as a group of six sat around a table, you know, pretty much with me there instigating the talk, you know, sat there in the middle of them.’
Prior to the project teachers had used practical activities and games. Many of the teachers started the lessons with mental activities and continued to do so during the project. One teacher commented that mathematics was taught within an integrated curriculum and another that they had always used the connective model of teaching mathematics using real life situations. One teacher recognised how the approach in the project was different. Whereas previously the focus had been on outcomes now the focus was on the process involved.

The majority of the teachers (7) felt that there had been changes in the behaviour and attitudes of the children. Particularly highlighted was the increased confidence of the children as they realised their ideas were valued by their peers:

‘I think it has given certain children a lot more confidence, it gives them more confidence in the fact that you know, what they say is going to be listened to and you know, people are going to think about what they say rather than everybody just working independently. I think they perhaps tend, hopefully tend to question a little bit more than they did.’

Eight of the teachers confirmed that they had noticed a change in the talk used in their class. One of these thought it was too early to see much although they noted that the children did appear to use the phrase ‘do you agree’ more often and appropriately. The main observations were that the children worked more collaboratively, were less selfish and were thinking more about their maths.

‘Yes, they’re definitely talking about their maths more, rather than just saying it’s this answer, they’re definitely thinking about what they’re doing more and trying to talk about what they’re doing. I think the quality of the talk has improved.’

One teacher also observed that it was not just the children’s talk which had changed but that her talk had changed with more focus on the vocabulary and questions being used.

‘Yes I think it’s become a lot better...because it makes you think how you’re talking to them, you’re using a wider range of vocabulary as well and it does make you think about, like on my planning now, a lot of it is questions. What could I ask them? And why are you asking it? As opposed to, right we’re going to get the multi-link out and make rectangles.’

All of the teachers felt to a greater or lesser degree that the children’s learning had been positively affected through the introduction of exploratory talk. One of these teachers then went on to give an example of how one of the trios had succeeded so quickly with a mathematics activity recently when all three had lacked confidence initially.

‘I think they’re enthusiastic about the problem solving aspect and I think again that the task we did on Monday was a very interesting one and they were just so buoyed up by solving this problem.’

Other teachers commented on how children’s confidence had increased which ultimately benefitted their learning:

‘Yes, they are more confident to ask and question appropriately. And that is across the board, yes, it has been brilliant actually, for this group of children.’
'I think that they think more, and I think that they realise that they don’t have to be on their own, that it’s two brains or three brains are better than one brain and they can bounce off each other more.'

All of the teachers were keen to introduce exploratory talk right from the start with their new class in September 2009:

'I’m really quite keen to try it next year with my new class, starting it off and getting their talking threes sorted out from the beginning and doing lots of talking in all areas.'

Additional material – pen portraits

The overriding change mentioned by all 5 of the teachers who provided pen portraits was the growth in confidence of the children.

'but for those that lack the confidence, I think it’s just that boost, rather than working individually all the time and that worry about have I got it right, have I got it wrong, just being able to come together, see what other people are doing, what they’re thinking, it just helps so much.'

Other comments from teachers included the children being more able to explain what they were doing (5 teachers); more thoughtful (2 teachers); applying their knowledge better (1 teacher); more consistent (1 teacher); more focussed (1 teacher); retaining knowledge better (1 teacher); not guessing the answer but trying to work out (1 teacher) and quicker at their mathematics (1 teacher).

Video data

The video material has been analysed for examples and illustrations for the resource pack but the analysis of the material to determine quality of talk in relation to children’s learning is still in early stages. Initial observations and discussions within the research team have highlighted aspects for further investigation:

Is there any change in the quality of children’s and teacher’s talk?

Initial analysis would suggest that there is a difference in the way that the teachers and children are talking and approaching mathematics but there are few instances of classic exploratory talk. As indicated from the teacher interviews, teachers did work with children in groups before the start of the project, but often larger groups of 6 to 10 children. Often the teacher worked with the group, modelling the task and then supporting the children in completion of the task. The interaction was often between teacher and child, there was little talk between children. School K was an exception. The teacher did lead the group work but encouraged the children to answer questions in their pairs and the children were cooperating in their pairs. In many cases the discourse changed in the second video at the interim stage of the project. The teacher was no longer the main instigator of the mathematics activity. Although the talk was not exploratory in a classic sense, and was even disputational at times, the children seemed to have ‘ownership’ of the task. Although often short and infrequent there were instances of children making decisions and giving reasons.

If we can define the quality of change in the talk can we see how the change has been influenced by the teacher?
The teachers used different strategies and different emphases in introducing talk and in working with the groups. Some teachers made only brief reminders about talk whereas others focused specifically on prompts as objectives for that lesson. The emphasis on reflection on talk after the session also varied. Teachers intervened in different ways as the children were working in groups. Some teachers left the children to work independently with occasional monitoring and prompting. At the other end of the scale teachers stayed with their group the whole time. In both cases the quality of the interventions and their effectiveness in modelling exploratory talk varied. The interventions varied from working with the group and modelling the talk to observing the group and reminding the children of the rules. One teacher continued a one to one interaction between herself and the three children. Although it is obvious that in the last example there is no evidence of exploratory talk the distinctions between the other groups are less clear. These differences and the possible impact on the children’s use of talk and progress in learning are yet to be analysed in a systematic way.

**If we can define the change can we see how this has influenced the pupils’ learning?**

Several critical incidents have been identified that indicate a possible change in the children’s thinking about mathematics. We are tentatively suggesting that these do show instances of cognitive change. So far these are defined as:

- Moments of insight
- Testing assertions/misconceptions
- Using operations as objects

These are not mutually exclusive. For example an example of a moment of insight is illustrated by the transcript (featured in the Resource Pack):

Children are solving a problem that involves arranging the digits 1,2,3 onto a Magic Square:

- **Child 1**: 1 and 2 there. No, that one there and the three there and one there and another 2 there.
- **Child 2**: 4 now we need to make 4
- **Child 1**: No we need the one there
- **Child 2**: and I’ll put a three
- **Child 3**: 1, 2, 3 six. That’s six
- **Child 2**: 1, 2, 3; 3, 1, 2
- **Child 3**: That’s six. Are you just making six all the way?

Child 3 had been observing the other two children as they worked on the problem. The repeated selection of the digits 1,2,3 in different orders by the other children prompted her to note that this always made 6. This suggested a shift in the use of the operation as an object and the realisation of associativity.
In another example the three children are investigating a sequence that involves halving a number if it is even and adding 1 if it is odd. The children gave answers to half of ten and half of twelve. They then had to find half of 18. It seemed that none of the children knew this as a fact so they had to work it out. Child 2 suggests the answer is 7.

Child 3: I’m not happy about that number, can we talk about it?

Child 2: We thought it was seven because if you try to half eighteen it wouldn’t be ten because that would be half of twenty, it couldn’t be nine because you couldn’t do that. It would be seven.

Later

Child 1: You could work it out with your fingers. If you add seven more it is seven add seven.

Child 3 (checks on fingers): It would be fourteen.

Teacher (to child 2): What do you think now?

Child 2: It would be fourteen.

The teacher then asks how many groups they would need to find half. The three children gave different responses – 2, 3 or 4. The teacher then set them the task to agree on the number of groups. The conversation that followed indicated that the children were unable to reason this. One possible interpretation of this is that although the children had learnt some facts they were uncertain how these facts were obtained. This might suggest that the children were using the facts but with no understanding of the mathematics underlying them. A question is how much the use of objects in a problem-solving situation relies on understanding the process that underlies that object.

A third example illustrates children working from the process to the object. The children are joining dominoes to make 6 each time. They are seen to count the dots on the dominoes initially to find six. As they progress through the puzzle they become more and more reliant on the facts and use these to check that they are solving the problem.

Child 1: Do you think that’s going to make 6? One and zero?

Child 2: No

Child 1: Well get a six then. A six like that.

Ongoing analysis:

In order to investigate the questions arising from our initial observations and discussions multi-level analysis is being carried out using both quantitative and qualitative data. The levels are as follows:

- Concordancer analysis of transcripts to determine changes in teachers’ and children’s language. We are currently transcribing the three lessons (pre, mid and end of project) from each of the ten Transfer Teachers in order to analyse the differences in language. Words such as agree, disagree, talk, because/cos,
if, so could, should, would, how, why, idea, think, understand are used in the analysis.

- Discourse analysis of group work to determine the amount of teacher/pupil talk and pupil/pupil talk.
- Discourse analysis of group work to determine the effectiveness and the productivity of pupil/pupil talk. Multi-faceted analysis such as those used by Sfard and Kieran (2001) will be trialled.

**Summary of the Findings**

The findings are summarised with reference to the project aims as quoted on p. 2.

1. Evidence from the teacher interviews and video material indicate that the intervention has had an impact on the teaching of arithmetic in the majority of the teachers' classes. Initial analysis of the video material does indicate a change in the interactions and the approach to managing the mathematics activities.

2. Narrative evidence from teachers suggested that the children did make progress in their learning. The teachers commented how the children were more confident and engaged and that they were thinking together in their talk.

3. The analysis of the data from the standardised and diagnostic tests provides further evidence that the children made progress in their learning in mathematics. Results from the standardised test (N=59) indicate that this was above expected progress (6 points above the expected progress in the standard score and 6 months above the expected progress in number age). The diagnostic test (N=50) indicates that the children were moving towards more object-based calculation strategies (30% of the calculations carried out by the children changed to more object-based strategies; 74% of the children indicated a change to more object-based strategies). This move to object-based strategies is seen as an increased understanding in the children's use of number.

4. Exploratory Talk (ET) was an effective model for the design of the project. The explicit strategies gave the teachers the confidence to change their approach to teaching. The lack of prescription enabled the teachers to adapt the strategies for the needs of the KS1 children in their classes and across a range of abilities.

5. The two Development Teachers provided an opportunity to trial strategies for introducing talk with mathematics. These teachers in turn were able to provide examples of ideas that had 'worked for them' and gave the ten Transfer Teachers further confidence to use the strategies in their classroom.

6. In the main teachers found that the one term was not long enough to fully establish ET as a way of working with young children. However the introduction to talk in the summer term gave the teachers an opportunity to practise the use of such strategies with a class that they knew. The experience inspired all the teachers to introduce the strategies with their new class in the following autumn term.

7. The teachers seemed less confident in applying talk to mathematics tasks. This could be due to the traditional view of mathematics as an individualised subject that focuses on learning procedures correctly rather than a view of mathematics as problem solving. We had intended to use activities that focused on specific learning in mathematics related to key ideas and concepts. This seemed to be too large a step for the teachers as they were establishing the talk. Further work with teachers...
is required to examine children’s learning through activities that target a specific aspect of learning.

8. The teachers were more confident in taking problem-solving activities from known resources to develop the use of talk in mathematics. These activities provided critical incidents of learning that can be related to the notion of cognitive shift but in a more random way.

9. Our initial review of the video material has suggested changes in the quality of talk and variations in the way that the teachers developed the use of talk. We have also noted the importance of the interventions made by teachers during the group sessions. The impact of the talk on children’s learning in mathematics has been noted in relation to improved confidence. Critical incidents have been identified that show a shift in understanding. Further analysis is required to establish the exact nature of the change in talk and the teachers’ influence in order to fully investigate the interface between talk and learning in mathematics.

10. A resource pack has been developed and will be disseminated to local schools in partnership with ITE training at the Graduate School of Education. This will be more widely disseminated through a website. The use of ET with mathematics is being introduced nationally through follow-up projects with the National Strategy and the National Centre for Excellence in Teaching Mathematics.

11. We feel confident that there is sufficient evidence to indicate that such an approach does have an impact on learning. The introduction of rules and prompts to encourage group collaboration teaches children to reason and apply their early arithmetic ideas. This affords the embedding of key concepts in mathematics and we feel that there is evidence that this does support children in moving from procedural strategies to object-based strategies. Children are not focusing on the process of an operation but are using the operation to solve a problem. Even though children do check the addition or subtraction by counting this is not the end in itself, the end is to use the operation as an object.

**Dissemination and Sustainability**

**Professional Development**

We had planned a Workshop based conference for 27th April 2009. This had been postponed from the initial intention of December 2009 to coincide with the enactment of the New Primary Curriculum. Unfortunately there was insufficient interest in attending this workshop. In order to address this, the Resource Pack was developed further to include more photographs and transcripts as examples. Our intention is to send this electronically to schools that are partners in PGCE teacher training with the Graduate School of Education so that the teachers can access this in their own time.

We had intended to create a project website by January 2010 but further resourcing in October and November has meant that this has been delayed. We are now planning to have this in place for September 2010.

Further small projects are also being carried out in relation to Initial Teacher Education and Continuing Professional Development.
• National Strategies Primary ITT Leading Partnership in Mathematics Pilot Project
This project has built on the talk in mathematics and problem solving. PGCE Primary Mathematics Specialist trainee teachers have been working with six of the project teachers on their own investigation into supporting exploratory talk with young children.

• NCETM funded project: Resourcing Talking in KS1 Mathematics: Investigating pedagogy for collaboration and reasoning. Small project with four of the project teachers to investigate teacher intervention and design of tasks to support talk in relation to specific learning in mathematics.

Both of these projects will result in the preparation of case studies for publication on their respective websites.

Conference Presentations
The following presentations will be published in conference proceedings:
Murphy, C. ‘Children’s use of procedures in early arithmetic’ International Symposium Elementary Mathematics Education, Charles University, Prague, August 2009,

Murphy, C. ‘Analysing children’s calculations: the role of process and object’, British Congress of Mathematics Education, University of Manchester, April 2010

Further presentations have been accepted at:
Murphy, C., Fisher, R. Wegerif, R. ‘Dialogue and cognitive shift in children’s arithmetic: What is the evidence?’ University of Cambridge, Mathematics Colloquium, June 8th 2010

Murphy, C. ‘Dialogue and arithmetic: Defining the dialogic space and analysing the learning’ Children’s Mathematical Education, Iwonicz-Zdroj, Poland, August 24th-29th, 2010

Presentations intended for submission to future conferences:
British Society for Research in Learning Mathematics (BSRLM) Day Conference Nottingham, November 2010
Congress of the European Society for Research in Mathematics Education (CERME 7), Poland, Feb 2011
Psychology of Mathematics Education Conference (PME 35), Turkey, July 2011

Academic papers
The following papers are intended for publication in the year 2010 - 2011
Murphy, C. and Pipe, E. The use of diagnostic tests in children’s calculation strategies.
Murphy, C. and Fisher, R. Review of dialogue in learning mathematics.
Wegerif, R., Murphy, C. and Ernest, P. Cognitive shift and dialogue in arithmetic - theoretical position paper examining cognitive shift from a sociocultural perspective

Papers for professional audiences
We had intended to support teachers who wanted to write for professional publications such as Primary Mathematics (Matheamtical Association) but, as yet, teachers have not felt that they had the time.

**Further areas for investigation**

There would seem to be three main areas that would benefit from further investigation:

- Further investigation into mathematical activities that will afford exploratory talk and are targeted at specific learning in mathematics.

- Extension of the study to investigate impact over a longer term and on a larger scale using randomised research methods. Does a short one year input in exploratory talk change the children’s approach to learning mathematics that has a lasting impact? Is this an approach that needs to be maintained throughout the school key stages?

- Development of CPD for teachers. Further identification of strategies that provide autonomous development for teachers that deepens their understanding of children’s learning in mathematics and supports them in developing alternative pedagogical strategies based on this understanding.

An extra advisory panel meeting is planned for 8th June 2010 to discuss collaboration in developing proposals for funding with University of Cambridge.

**End of project statement**

A Statement of Income and Expenditure (SIE) is attached to this report. As the SIE has been prepared within a month of the end date there is a possibility of further items in the process. In this regard it should be viewed as provisional.

The SIE indicates a provisional budget under spend of £4795.20. We ask if some of this can be retained to cover payment for video transcription in order to complete the data analysis and for conference attendance in order to further the dissemination.

**References**


Shropshire Mathematics Centre (1996) *Teaching Numeracy in a Shropshire Primary School*, Shrewsbury, Shropshire Education Services


APPENDIX 2 ETHICAL APPROVAL FORM

UNIVERSITY OF
EXETER

School of Education and Lifelong Learning

Academic Staff Research
CERTIFICATE OF ETHICAL RESEARCH APPROVAL

To obtain a Certificate of Approval, you need to fill out this form and have it signed by the Chair of the School’s Research Ethics Committee (see below).

COMPLETE THE FORM ON COMPUTER (it will expand to contain the text you enter).

DO NOT COMPLETE BY HAND.

Name of principal investigator: Carol Murphy

Names of collaborating investigators: Rupert Wegerif, Ros Fisher

Title of Project: Talking Counts: An intervention programme to investigate and develop the role of exploratory talk in young children’s arithmetic

Brief Description of Project:
The main aim of the study is to investigate how exploratory talk can support children’s understanding of arithmetic at KS1. There are two strands to the study. The first is to work with practising teachers to develop practical classroom strategies that will encourage exploratory talk within the specific context of arithmetic. It is intended that this work will provide professional development materials for wider dissemination. The second is to analyse the talk within the group interactions and to identify how talk supports children in developing conceptual understanding in arithmetic. Practising teachers will be asked to work with a small group of children to develop mathematical activities that will encourage the use of exploratory talk. It is intended that the work carried out by the teachers will be part of their normal teaching role in the classroom.

Project Contact Point (incl. Email/telephone nos.)
Carol Murphy: C.M Murphy@ex.ac.uk; 01392 264974

Give details of the participants in this research (giving ages of any children and/or young people involved):
The first phase will involve two practising teachers from local schools and the children in their classes. The second phase of the study will extend the work to 10 further practising teachers from local schools and the children in their classes. The children’s ages are 6 and 7 years old.

Give details regarding the ethical issues of informed consent, anonymity and confidentiality (with special reference to any children or those with special needs) a blank consent form can be downloaded from the SELL student access on-line documents:

October 2005
Voluntary informed consent will be sought through the following statement:

"A team of researchers from The School of Education, University of Exeter, in collaboration with your school is conducting a research project into the links between talk and learning in mathematics. One aim of the project is to produce classroom activities that will engage children in the effective use of talk that will help them to understand their work in mathematics. In addition the project will try to gain a better understanding of how talking and mathematical understanding are linked. The project will involve classroom activities, which may be observed by researchers and teachers, interviews with teachers and children and teachers keeping a record of their own thoughts on the activities. Some things will be audio taped, some video taped and others kept as written records. All data collected will be kept confidentially and anonymously. Participants can withdraw from the project at any time and their data will be destroyed. Results of this study may be written up for publication in academic journals."

Children will be given a simplified version of this statement and their oral agreement sought. Schools will also provide information to parents and carers based on the statement.

**Give details of the methods to be used for data collection and analysis and how you would ensure they do not cause any harm, detriment or unreasonable stress:**

We will aim to consider the best interests of the child at all times during this project. We will encourage children to give their views, inform them of their rights to withdraw from the project and try to be sensitive to any action that may cause emotional harm. We will immediately desist from any action that is causing or may cause distress to the child.

**Give details of any other ethical issues which may arise from this project** (e.g. secure storage of videos/recorded interviews/photos/completed questionnaires or special arrangements made for participants with special needs etc.).

Data will be stored at the University of Exeter in accordance with the Data Protection Act. All identifying features will be removed from the data and pseudonyms used. The data are jointly owned by the university researchers and the participating teachers. Access to data will be negotiated through the project directors. All data will be kept in confidence and not disclosed to unauthorised third parties. The right to publish and disseminate results of the research will be agreed at project meetings. Further consent will be sought from teachers, parents and children if data is to be disseminated to a wider audience in a professional development pack.

**Give details of any exceptional factors, which may raise ethical issues** (e.g. potential political or ideological conflicts which may pose danger or harm to participants):

We do not anticipate any exceptional factors to arise regarding ethical issues.

This form should now be printed out, signed by you below and sent to your mentor to sign. Your Mentor will forward this document to the School’s Research Support Office for the Chair of the School’s Ethics Committee to countersign. A unique approval reference will be added and this certificate will be returned to you.

Approval is requested for the period:

From: Feb 2009 to: Dec 2009

by (name of principle investigator): Carol Murphy

Signature __________________________ Date 14 April 2009

(principle investigator)
Name of Mentor:

Mentor declaration. I am satisfied that the planned research procedures as described to me are ethical.

Signed (mentor) [Signature] Date 1/1/04/ 2009

School Ethics Committee approval reference: SFC081009

Signature [Signature] (Chair of School Ethics Committee) Date 2/2/04/ 09
Dear Parent/Guardian

A team of researchers from The School of Education, University of Exeter, in collaboration with your school is conducting a research project into the links between talk and learning in mathematics. One aim of the project is to produce classroom activities that will engage children in talk and in turn help them to understand their work in mathematics. In addition the project will try to gain a better understanding of how talking and mathematical understanding are linked. The project will involve classroom activities, which may be observed by researchers and teachers, interviews with teachers and children and teachers keeping a record of their own thoughts on the activities. Some things will be audio taped, some video taped and others kept as written records. All data collected will be kept confidentially and anonymously. Participants can withdraw from the project at any time and their data will be destroyed. Results of this study may be written up for publication in academic journals.

If you have any queries regarding the project please contact your child’s teacher or myself at the University of Exeter, my contact details are below.

Yours truly

Carol Murphy
Senior Lecturer in Education
University of Exeter
Email: C.M.Murphy@exeter.ac.uk
Tel: 01392 264974
Dear Parent/Guardian

Following the successful completion of the Talking Counts research project that was carried out between February and July 2009 we are preparing a Resource Pack for teachers and a website that will give information about the project.

We would like to include photographs of teachers and children in the Resource Pack and website to provide a realistic view of the work that the children did during the project. Your school has a copy of the Resource Pack that shows the photographs that we would like to use.

We hope that you are able to give consent for the use of your child’s photograph in either the Resource Pack or the website and would be grateful if you could indicate below on the consent form if you agree to this.

Yours sincerely

Carol Murphy
Senior Lecturer
Graduate School of Education
University of Exeter

CONSENT FORM

"I give permission to the University of Exeter to use my child’s photographs in the Talking Counts Teachers’ Resource Pack and the Talking Counts Research Project website

Signed…………………………………
Print name……………………………..
Date……………………………………

Data Protection Act: The University of Exeter is a data collector and is registered with the Office of the Data Protection Commissioner as required to do under the Data Protection Act 1998. The information you provide will be used for research purposes and will be processed in accordance with the University’s registration and current data protection legislation. Data will be confidential to the researcher(s) and will not be disclosed to any unauthorised third parties without further agreement by the participant. Reports based on the data will be in anonymised form.

APPENDIX 4 SCREEN SHOT OF EARLIER CODING FOR TYPES OF TALK IN NVivo 9
The children are not talking about the management of the task, cooperation in the mathematics.

Or task
The children are talking about the task. The management or cooperation of the task is the mathematics.

Cooperative or task
The children are taking about how to share the task and manage the talk.

Managing the task
The children are talking about the management of the task, how to copy it out, reading questions and writing.

Managing Task-Direct collaboration
The copying out and management of the task is divided among.

Managing Task-Assessment
Children talk constructively about how to manage the task and come to an agreement.

Managing Task-Communication
Children argue about how to manage the task, but there is no one child attempting to dominate.

Managing Task-Dominance
One or more children dominate or attempt to dominate the management of the talk and carry it out on their own.

Maths Direct Collaboration
The children are talking about mathematical ideas. Not just reading out the question or the recording.

Maths Direct Collaboration
Finding the mathematical solution or checking on-hand.

Summarise task
Children come to an agreement without conflict or discussion but this is not determined by another child.

Disciplinary talk
The task is conflict but no learning opportunity. May not come in an agreement.

Exclusion task
Conflict or discussion leads to a learning opportunity. There may be an agreement.

Maths Communication
One or more children dominate the mathematics and do it for the other children. Not just summarising but taking a

Maths Direct Collaboration
One or more children talk about the mathematics they are doing individually. They are not sharing the task.
### APPENDIX 5 VIDEO OBSERVATION NOTES FOR LEVEL 1 ANALYSIS

<table>
<thead>
<tr>
<th>School</th>
<th>Session</th>
<th>Timing and management of the lesson</th>
<th>Group session: management, teacher involvement</th>
<th>Group session: content of the task</th>
<th>Initial impressions of the pupil-pupil talk and collaboration</th>
</tr>
</thead>
</table>
| A Year 2 | A1 | 40 min lesson  
23 min teacher whole class input  
10 min independent group work  
7 min teacher group involvement  
Teacher sets a specific learning objective and models strategy | 6 independent group sessions, teacher intervenes 5 times across all the group sessions.  
Teacher checks understanding of the learning objective, emphasises sharing and it’s ok to get it wrong | Children use pictorial representations prepared by the teacher to show doubling/halving linked with ‘times 2’. | Children focus is often on the task and in taking turns to use the resources. There is a suggestion they see it as a game and there is dispute over who is ‘master’ of the game. Much of the talk is between Emma and Olwen and some of this is arguing over taking turns. |
| | A2 | 42 min lesson,  
23 min teacher whole class input  
14 min independent group work  
5 min teacher group involvement,  
Teacher does not set a specific learning objective | 7 independent group sessions, teacher intervenes 5 times across all the group sessions.  
Teacher asks why they have a particular representation and that they know the correct calculation | Initial task: children to agree on their own way to represent calculations from given word problems.  
Task development: children to match representations to word problems. | Seems that there is more talk about the mathematics in deciding on the representations.  
Still much talk on taking turns but the children seem to be ‘politer’ in doing this. There seems to be less argument managing of the |
but encourages more efficient representations.

Teacher emphasises good talk before the children start work.

<table>
<thead>
<tr>
<th>B2</th>
<th>B1</th>
</tr>
</thead>
<tbody>
<tr>
<td>43 min lesson</td>
<td>54 min lesson</td>
</tr>
<tr>
<td>22 min teacher whole class input</td>
<td>36 min teacher whole class input</td>
</tr>
<tr>
<td>18 min group work independent</td>
<td>14 min independent group work</td>
</tr>
<tr>
<td>3 min teacher group involvement</td>
<td>4 min teacher group involvement</td>
</tr>
</tbody>
</table>

Teacher gives specific learning objectives and models how to solve a word problem

2 independent group sessions, the teacher intervenes once. Teacher asks children to explain the strategies that they use, not just the correct solutions.

Teacher directs the children to work together as a group.

Children are given word problems to solve and use the strategies modelled by the teacher

Not always a shared sense of the task. Children read the problem together but tend to solve it and record the solution individually. After the teacher involvement the children seem to collaborate more in the task. One child saw the relevance to everyday life.

Lucy appears to dominate the management of the task

<table>
<thead>
<tr>
<th>B2</th>
<th>B1</th>
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<tbody>
<tr>
<td>43 min lesson</td>
<td>54 min lesson</td>
</tr>
<tr>
<td>22 min teacher whole class input</td>
<td>36 min teacher whole class input</td>
</tr>
<tr>
<td>18 min group work independent</td>
<td>14 min independent group work</td>
</tr>
<tr>
<td>3 min teacher group involvement</td>
<td>4 min teacher group involvement</td>
</tr>
</tbody>
</table>

2 independent group sessions, the teacher intervenes once. Teacher does relate to talk by suggesting they is disagreement but children say they are confused.

Problem given set on different grids with counting sequences: 2, 5, 10. Some squares are blanked (a worm has eaten the numbers in the squares). Children identify

Change in child - Mary replaces Lucy and Mary seems to take over the maths of the task. Children work individually on finding solutions but do compare with each other. They
| Year 1 | C2 | 34 min lesson, 12 min teacher whole class input at beginning; 11 min independent group work. 11 min teacher group involvement Teacher emphasises agree and disagree in the whole class input. | Teacher stays to monitor group work but does turn away to intervene with other triad. Teacher involvement to encourage children to work as a group. Emphasises use of agree and disagree and because - these words are printed on card on the table. | Children find dominoes where the total is 10. Children are finding number bonds to ten. They take it in turns to give a number bond. The use of agree and disagree tends to replace correct or incorrect but the children are given this decision. There is some attempt to justify correct answers. |
| Year 1 | D2 | 64 min lesson 33 min teacher whole class input 13 min independent group 2 independent group sessions. Teacher observes and prompts for 10 mins, then intervenes later to question the work. | Children to find patterns that they could put on a die face for numbers 7, 8, 9, 10, 11 and 12. The aim is that they can see the numbers without counting | Two children dominate the task and the mathematics. Third does not seem able to access the mathematics in the task and talk is off-task but does take on a ‘clerical
<table>
<thead>
<tr>
<th></th>
<th>E Year 1</th>
<th>E1</th>
<th>E2</th>
</tr>
</thead>
<tbody>
<tr>
<td>work</td>
<td>17 min teacher group involvement</td>
<td>Teacher involvement prompts them to move on in the task, to collaborate and directs attention to help access the mathematics.</td>
<td>each dot.</td>
</tr>
<tr>
<td>Teacher reminds children of ‘good talk’ as they start the group task.</td>
<td></td>
<td>role’. Harry and Vera do seem to be sharing ideas but there is little reasoning.</td>
<td></td>
</tr>
<tr>
<td>50 min lesson, 28 min teacher whole class input</td>
<td>Ten children are seated on one table with encouragement to talk in pairs. The teacher models the task, then moves around the table to monitor the work.</td>
<td>Children use 100 square to show one more, one less, ten more and ten less. Children to complete a 'cross' using these numbers - i.e. put 89 in the middle - other numbers 79, 99, 88, 90</td>
<td></td>
</tr>
<tr>
<td>18 mins teacher group involvement, Short moments of pupil-pupil talk</td>
<td>Children to place 9 bears (3 colours each) onto a 3 x 3 grid coloured grid so that all the combinations are different.</td>
<td>There is one example where one child explains her solution to another child. Mostly children complain that they are copying.</td>
<td></td>
</tr>
<tr>
<td>No whole class teacher input. 3 min teacher introduction 15 min independent group work</td>
<td>Teacher involvement to check the children’s solution and to set the next part of the task. Nine children are seated around the table but are grouped into 3s around the</td>
<td>Children share out the bears (one colour each) and take turns in placing them on the grid. Chas then dominates this with some direction from Lara. Communication is through pointing. Chas tends to</td>
<td></td>
</tr>
</tbody>
</table>
| Year 1 | F1 | 6 min teacher involvement  
Teacher does not emphasise ‘good talk’ | 58 min lesson,  
26 min whole class input  
32 min independent group work (some involvement by teacher – minute or so) | Teacher models the task to the whole class and then children work in pairs independently from the teacher.  
Teacher monitors and intervenes to question if they understand the mathematics. | Children use a 100 square grid to find all numbers that have a chosen digit (say 6) and to look at patterns across columns and rows.  
They do share the task but in taking turns to choose a digit to look for. The management of the task and the mathematics is dominated by one child. | check with the teacher that the solutions are correct. |
| F2 | 50 min lesson,  
30 min whole class input  
21 min independent group work (some involvement by teacher – minute or so) | Teacher has modelled the task to the whole class.  
Children work in groups of 3.  
Children have the talk rules on their table. | Children to find ladybirds whose spots add to 16.  
Children to record the ladybirds and the spots.  
Children can do 14 spots next. | Talk is dominated by disputes about managing the task, using the resources and the mathematics. It seems that all three children have difficulty accessing the mathematics. The child who dominated in the pair is in conflict with the additional child.  
This is the second group | |
<table>
<thead>
<tr>
<th>I Year 1</th>
<th>I1</th>
<th>50 min lesson, 20 min whole class input 25 mins group work but mostly teacher directed 4 mins independent work on occasions</th>
<th>Children are working in a triad but mostly teacher direction. Children are left to carry out short tasks. Teacher gives instructions, children wait to be told what to do next and how to record their work</th>
<th>Children are given a pile of cubes, they each approximate how many and then count out by grouping into tens.</th>
<th>Some collaboration in the sense that they count a pile of cubes together, compare numbers and each other in recording numbers. They do not solve a problem together – they rely on the teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>I2</td>
<td>50 min lesson 18 min whole class 28 mins independent work. Short involvement by the teacher (approx 2 mins).</td>
<td>Mostly independent work with some involvement by the teacher to reinforce how to complete the task and to monitor collaboration and completion of the task.</td>
<td>Children have one set of cards with values of money and one set with coins. The task is to match pairs and stick onto large sheet of paper</td>
<td>Children needed guidance on how to complete the task. The task is then dominated by two children and they are checking the pairing of the cards together. The third child is often distracted and talk is off-task but it does seem he can access the mathematics and does share in some of the mathematics. The third child asks to carry out the task.</td>
<td></td>
</tr>
</tbody>
</table>
| Year 1 | Year 2 | J2 | J | 32 min lesson,  
14 min teacher whole class input  
18 mins group work  
(frequent teacher, particularly for management of the task)  
approx 8 mins independent talk (longest about 1.45 min) | Teacher had encouraged group agreement on how to record but task asked for each to give an individual estimate.  
Teacher observed with frequent involvement to help with collaboration and turn taking. | Children to estimate lengths of a strip of paper using non-standard units, such as a straw.  
Disputational talk dominated as children found it difficult to agree on how to record the measurements. Task suggested individual choices and a competitive element. Collaboration was in taking turns in recording and use of resources. |
|---|---|---|---|---|---|
| Year 2 | K1 | No whole class teacher input  
23 mins group work  
Frequent teacher involvement: Independent talk is often only for two minutes or so. | Children work in pairs.  
Frequent teacher involvement that models use of why/because. The teacher models and scaffolds how to explain the mathematics and the children carry this out in pairs. | Aim of the task is to show multiples using Numicon. Children are given choices in their use of multiples work with and the task is scaffolded by the teacher as he observes the children, asks questions and carries on their ideas. | Children explain their mathematics to each other. In working with the Numicon they select a multiple together and then tend to make their own patterns. |
| K2 | 40 min lesson –  
5 min whole class input | Children work in a triad teacher reminds them of working together and on | Children finding inequalities; numbers > 50 and <50. Then children make addition problems that are | Children work together throughout and there is independent maths talk even with the teacher |
<table>
<thead>
<tr>
<th>35 mins group work. Frequent teacher observation and involvement:</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are only two occasions when the children work independently – 3 mins and 1.30 mins</td>
</tr>
<tr>
<td>the talk rules. Teacher remains with the group for much of the time, observing and asking questions.</td>
</tr>
<tr>
<td>&gt;50 and &lt; 50. present. They do not seem to rely on the teacher but does accept his help on one or two occasions. Children are sharing their ideas but there is little reasoning and justification evident.</td>
</tr>
</tbody>
</table>
APPENDIX 6 EXAMPLE OF NOTES FROM VIDEO OBSERVATIONS

D3 Lesson summary. Y2 children

Whole class warm up: Children on the floor. Move into a circle. Count in ones round circle up to 100. Then in tens – up to 100 and back. Counting in 2s to 50. Children move to look at the teacher. Teacher models sharing 12 cubes to two children (division?), then shares 12 cubes to three children – models fair sharing. One child offers solution based on multiplication, teacher later uses this to model multiplication and to show inverse in division. Then with 4 children – How will they solve this? Children give one each to the fourth child. Models how to write multiplication sentence and the inverse in division.

Plenary – children shows what they did – teacher shows 10 pattern – what can you see – double 5.

64 mins lesson, whole class input 33 mins, 17 mins teacher group intervention, 13.30 mins independent group work

(64 mins lesson, 24.30 min whole class input beginning + 8.30 mins plenary, 10.45 +6.20 mins teacher group intervention, 11.15 + 2.20 min independent group work)

Initial comments/observations.

Teacher sits with the group for the first 10 mins. Seems that her talk is not the IRF type that she has normally used, she is prompting children to move on (What are you going to do next? Why don’t you try?) and to participate (What do you think Joe?). She does direct their attention eg. when they are confused that the rotated pattern is the same she rotates the sheet and questions if it is still recognisable. There do seem to be some elements of ET as children are challenging each other and giving reasons. This is not the type of interaction we have seen from the teacher before. (Even in the warm up she asked for more ideas from the children). However not to claim that this has been an impact of the ET intervention but that the interaction seems different this time. Not sure Joe has understood why a certain arrangement should make it easier to see the number – he is counting in ones. Later he says not recognisable – they are just lines. When the teacher leaves the group to work independently, dominant and DT type talk emerge. Harry and Vera’s talk is often about taking turns to record the patterns, whose idea they should be using etc (social authority). Joe is only involved when the talk is about the task, other times he is off-task, he often lies back in his chair, sings etc. Joins in with off-task talk eg what, what, what... Vera and Harry often make out that Joe will get it wrong (maths authority) but allow him his turn to record – even then Vera tells Joe how to record. Towards the end Harry and Vera work on the blank die sheet at the far end of the table away from Joe. How much are they playing a game (Vera – ‘I win’). Then Vera shares out the tasks – ‘you’ve got the trickiest’, how much is she imitating the teacher?

Maths learning: making die patterns for numbers over 6 – they should be able to see the number, not count in ones. They seem to have realised that they need to use number facts –3 and 3 and 1 for 7; 3 and 3 and 2 for 8, 3 and 3 and 3 for 9, 5 and 5 for ten. They then get stuck
at 11. Vera gives 6 and 6 as 12; Harry and Joe 5 and 5 as 10. Vera suggests a number square, teacher intervention questions this but teacher does wait for explanation – Vera shows it is to find 6 and 5 to make 11. Joe agrees with everything the teacher asks. In making 11 and 12 Vera does show arrangements that the boys go with – by then talk is more cumulative.

<table>
<thead>
<tr>
<th>D1 Group (teacher and child)  Children: Child 1 Harry, Child 2 Vera, Child 3 Joe</th>
<th>Transcript</th>
<th>Times</th>
<th>Chronological narrative</th>
<th>Types of narrative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transcript</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher</td>
<td></td>
<td></td>
<td>Teacher has set up two groups sitting next to each other. She directs both groups. They are repeating a task from the previous week because they had ‘got lost’. Each trio has a paper with a drawing of a blank die face and some counters. They have got to come up with new patterns for numbers on the die face for numbers 7, 8, 9, 10, 11 and 12. She reminds them of the talk: talk to each other, listen, need to agree. Everyone to be included and say something before they record the die face on a recording sheet.</td>
<td>0.00</td>
</tr>
<tr>
<td>1. <strong>Teacher</strong></td>
<td>Now you've got your dice face, so you're going to do seven first of all, so just get your 7 counters</td>
<td></td>
<td>The blank die face drawing is directly in front of Joe</td>
<td></td>
</tr>
<tr>
<td>2. Harry</td>
<td>Ok, 1 2 3 4 5 6 7, got 7 there</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Harry</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>Teacher</strong></td>
<td>Right, what are you going to do?</td>
<td></td>
<td>Harry counts out the counters. Joe is making a noise into the mic</td>
<td></td>
</tr>
<tr>
<td>5. Joe</td>
<td>Mrs F, why is that there?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Teacher Just leave it, ok, so that when you say something, it can be picked up, it’s a microphone. What do you need to use, what do you need to do?

7. Harry Talk

8. Teacher What are you going to do with this?

9. Harry Draw your pattern

10. Teacher No

11. Vera Put the dice....inaudible

12. Harry But you have to make a pattern

13. Teacher Make the pattern of seven

14. Vera That’s just to help us

15. Harry That’s a good idea

16. Vera We could do it diagonal

17. Harry We could do it diagonal, but it would take quite a long time wouldn’t it?

18. Teacher Why don’t you try it?

19. Harry Yea, let’s try it, draw a diagonal, like there down to there

20. Teacher Everybody’s got to say something, so Joe you make sure you say something as well. What do you think?

21. Harry You only put seven ones on it

22. Vera Oh yea

23. Harry You’ll have to move them two up a bit,

24. Vera Yes, ‘cos then we have spaces

25. Teacher Can you recognise that easy as being 7?
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>26. Joe</td>
<td>Yea, that’s 7, 1 2 3 4 5</td>
<td>Joe counts the counters out loud, points as he counts</td>
</tr>
<tr>
<td>27. Harry</td>
<td>But you’re not allowed to count</td>
<td></td>
</tr>
<tr>
<td>28. Joe</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>29. Harry</td>
<td>You’re not allowed to count</td>
<td></td>
</tr>
<tr>
<td>30. Joe</td>
<td>Why not?</td>
<td></td>
</tr>
<tr>
<td>31. Harry</td>
<td>You’ve got to recognise it</td>
<td></td>
</tr>
<tr>
<td>32. Joe</td>
<td>You could do it like that</td>
<td></td>
</tr>
<tr>
<td>33. Vera</td>
<td>But that would be just the same as counting like that</td>
<td></td>
</tr>
<tr>
<td>34. Harry</td>
<td>But can you recognise that? Just going down there? No you can’t, I’ve got to count like 22, 24</td>
<td></td>
</tr>
<tr>
<td>35. Vera</td>
<td>I can recognise it, sort of</td>
<td></td>
</tr>
<tr>
<td>36. Teacher</td>
<td>What could you do then Harry if you don’t recognise it?</td>
<td></td>
</tr>
<tr>
<td>37. Harry</td>
<td>Well change it</td>
<td></td>
</tr>
<tr>
<td>38. Teacher</td>
<td>How would you change it?</td>
<td></td>
</tr>
<tr>
<td>39. Harry</td>
<td>Mm, that’s given me an idea, how about if put one in each corner, like a 4</td>
<td></td>
</tr>
<tr>
<td>40. Vera</td>
<td>That’s a good idea</td>
<td></td>
</tr>
<tr>
<td>41. Harry</td>
<td>Because and then you put one there, yea one there</td>
<td></td>
</tr>
<tr>
<td>42. Vera</td>
<td>And one in the middle</td>
<td></td>
</tr>
<tr>
<td>43. Harry</td>
<td>You can’t really recognise that</td>
<td></td>
</tr>
</tbody>
</table>

**On task, Maths, some maths dominance**

There are maths ideas here – recognition from a pattern rather than just counting.

Joe points to a diagonal the other way.

Harry takes Joe’s hand away from the counters.

---

340
<table>
<thead>
<tr>
<th>Line</th>
<th>Text</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>44.</strong> Harry</td>
<td>Oh yes you can, no you can't</td>
<td>Counters – two rows of 3 with one in the middle</td>
</tr>
<tr>
<td><strong>45.</strong> Teacher</td>
<td>What do you think Joe?</td>
<td>Joe nods head</td>
</tr>
<tr>
<td><strong>46.</strong> Joe</td>
<td>Yeah</td>
<td>Harry has taken the one counter out the middle so there are two rows of three</td>
</tr>
<tr>
<td><strong>47.</strong> Teacher</td>
<td>Yeah what?</td>
<td>Harry points to the sheet by the teacher (does it have a six on it?)</td>
</tr>
<tr>
<td><strong>48.</strong> Joe</td>
<td>That makes 6</td>
<td></td>
</tr>
<tr>
<td><strong>49.</strong> Teacher</td>
<td>How many is that?</td>
<td></td>
</tr>
<tr>
<td><strong>50.</strong> Harry</td>
<td>I can recognise that, because it's on there, but</td>
<td></td>
</tr>
<tr>
<td><strong>51.</strong> Teacher</td>
<td>Right, so</td>
<td></td>
</tr>
<tr>
<td><strong>52.</strong> Vera</td>
<td>How about if we do the 6 and then put the last one in the middle</td>
<td>Vera rearranges the counters to put two columns of three</td>
</tr>
<tr>
<td><strong>53.</strong> Harry</td>
<td>What's six then?</td>
<td>Vera points to the two columns</td>
</tr>
<tr>
<td><strong>54.</strong> Vera</td>
<td>Look, 6</td>
<td>Harry places the last counter back in the middle</td>
</tr>
<tr>
<td><strong>55.</strong> Harry</td>
<td>Aha, 3 add 3 equals 7</td>
<td>Harry looks at the teacher</td>
</tr>
<tr>
<td><strong>56.</strong> Vera</td>
<td>3 add 3 add 1</td>
<td>Joe points at the die face</td>
</tr>
<tr>
<td><strong>57.</strong> Harry</td>
<td>Equals 7</td>
<td></td>
</tr>
<tr>
<td><strong>58.</strong> Vera</td>
<td>That's one done</td>
<td>Vera points to a board in elsewhere in the classroom</td>
</tr>
<tr>
<td><strong>59.</strong> Joe</td>
<td>But I can't recognise it!</td>
<td></td>
</tr>
<tr>
<td><strong>60.</strong> Vera</td>
<td>I can</td>
<td></td>
</tr>
<tr>
<td><strong>61.</strong> Joe</td>
<td>That's still seven</td>
<td></td>
</tr>
<tr>
<td><strong>62.</strong> Vera</td>
<td>You recognise it on the board there</td>
<td></td>
</tr>
</tbody>
</table>
63. Joe  Board?
64. Vera  You recognised it yesterday on the board
65. Harry  Mm, can we draw it onto there?
66. Teacher  If you agree that that’s the best way of doing it
67. Harry  Do you agree or?
68. Vera  So 7
69. Harry  One on top in the corner, one at the top of the corner, like one there and one there and two on the bottom... And put one in the middle
70. Vera  one
71. Harry  No, we haven’t done that! 3 at the top, 3 at the bottom
72. Joe  And them
73. Harry  Hang on, them there, there isn’t anyone with them there, I dunno

(Have they done work on this previously?)

Joe nods his head
Vera takes up the sheet to record. Harry directs how to record.

Is Vera looking at which ones to do next?
Harry points at the counters in the corners
Joe points at the counters in the middle of the sides
Harry refers to their recording, is it the same as the counters?

Non-maths
Some talk on managing the recording, also talk on turn taking

Maths
Querying whether the recording is the same as the pattern - there are maths ideas being challenged here.