## *An exploratory study of teacher orchestration of collaborative Mathematics tasks in relation to learning and interaction in primary schools*

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# Abstract

This study explores what we can learn about the interactions between teachers and students during small-group collaborative Mathematics tasks, nested with in a classroom setting from the study of multiple audio-visual streams synchronised with each other and with a detailed transcript. The ability to capture and study large quantities of detailed data using new digital temporal analysis tools presents both a great challenge and a great opportunity for researchers. This study explores quantitative means of triaging this data, looking for salient features in teacher-student interactions. Patterns of association found to be present in the data were then qualitatively examined in detail using the tool.

This examination highlighted the potential for new forms of synchronous temporal analysis to develop our understanding of important facet s of teacher-student interaction in small group collaborative Mathematics activities which were previously shown to be significant in past research but which were not developed in greater detail in large part because the data capture and analysis technology was not present. The study looks in detail at the Engle & Conant teacher interaction coding framework (2002), focusing on the specific use of problematization utterances in the tasks. The functions which these in relation to the success of a group of students is explored.

The varied granularity of the data available in the temporal analysis also highlighted the importance of a teacher orchestration artifice which, though familiar to teaching practitioners, is overlooked in the research literature. The mini-plenary, a brief transition orchestrated by the teacher between group and whole-class interaction then back again was explored and the possible reasons why this was instigated were discussed. The practice is then discussed in relation to the existing literature on the orchestration of classroom interaction. , .It is part of the SynergyNet project which looked at developing tools and pedagogies to meet the challenges of technology rich classrooms, specifically focusing on multi-touch tables. Ninety-

six 11 year-old students participated in the study from six different schools. Their grouping was varied by school, room orientation, gender and teacher.

**Keywords:** *Classroom orchestration, temporal analysis, collaboration, mini-plenary, classroom dialogue*

# An exploratory study of teacher orchestration of collaborative Mathematics tasks in relation to learning and interaction in primary schools

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**Declaration**

No part of the material provided has previously been submitted by the author for a higher degree in Durham University or in any other university. All the work presented here is the sole work of the author and no one else.

*For James Patrick Joyce-Gibbons, the finest scholar I ever knew.*

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The project researchers were lucky enough to work with a wonderful set of teachers who were professional, cheerful and open-minded. The schools of the local area gave us their generous and enthusiastic support. The students who participated were a breath of fresh air into a lab full of researchers. They were full of ideas and fun. It made me very nostalgic for my time in Year 6. I hope that they will maintain their enthusiasm for Durham in the future and one day they will consider studying at their local university.

SynergyNet brought an eclectic and brilliant group of people together. Their ideas, obsessions and peccadilloes taught me much about them and their chosen disciplines. In particular I would like to thank Phyo Chaw, the father of SynergyView; Andrew Hatch, the father of SynergyNet; and James McNaughton, the tireless saviour of the Education team. Three great engineers; driven by curiosity and a need to see if it will work. Whatever that 'it' might be.

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Professor Steve Higgins has given me the confidence to explore my interest in teaching, and learning. He has provided guidance and feedback in every stage. I cannot better express my thanks than to borrow from Rattigan, Browning and Aeschylus:

τὸν κρατοῦντα μαλθακῶς

θεὸς πρόσωθεν εὐμενῶς προσδέρκεται.

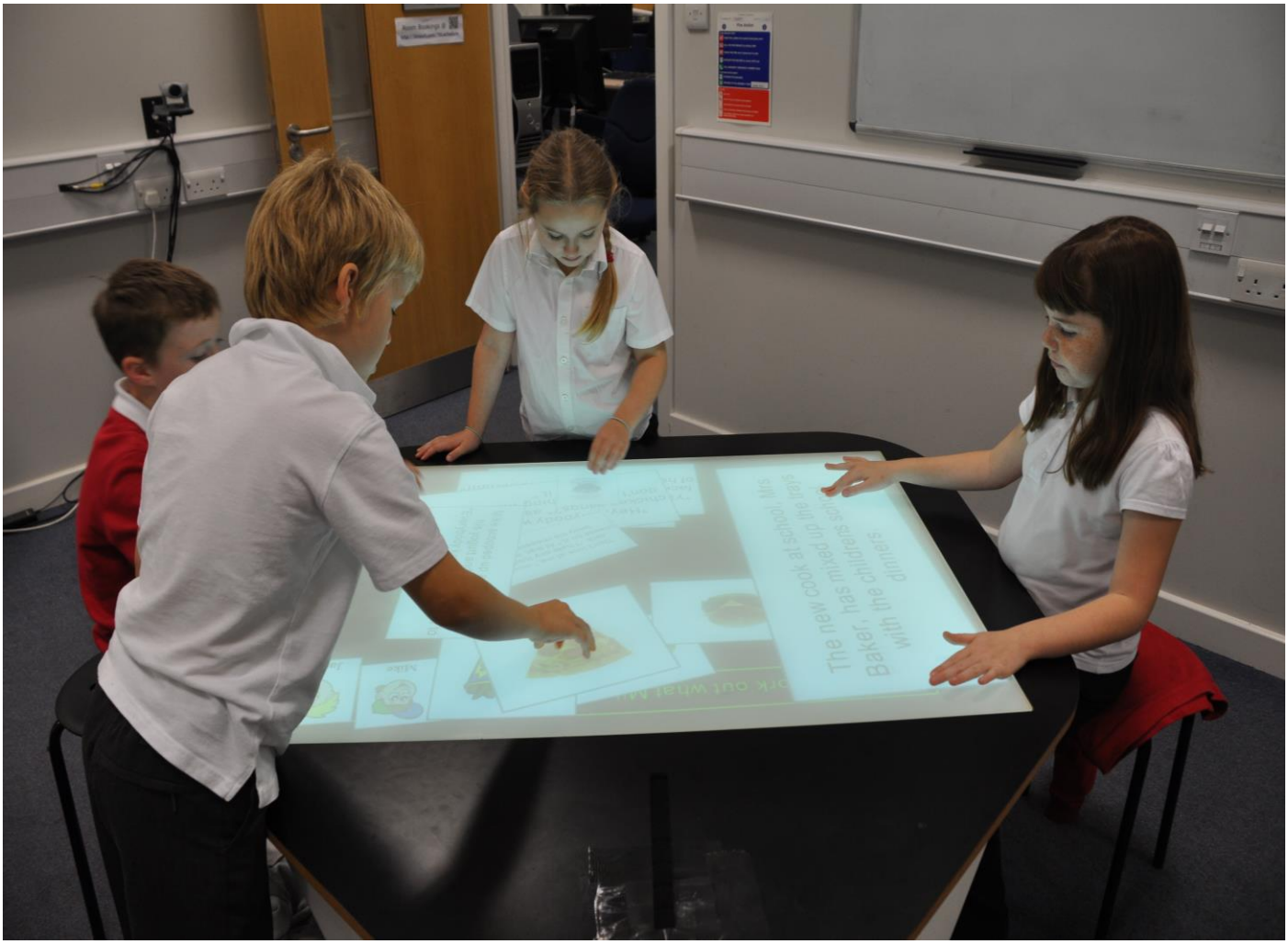
Finally, my wife Rachel has supported me through thick and thin despite her having to change countries, jobs and houses multiple times. She has been a wonderful help, guide and support through this whole journey. Thank you Warbash, I’m a lucky, lucky man.

# Contents

# 1 Introduction

The SynergyNet project pioneered the use of multi-touch tables in classrooms. These were large multi-touch surfaces, like giant iPads, around which four students could interact at once (Burd and Hatch, 2006). Figure 1.1 shows one of the tables and four students using it.

***Figure 1.1: Four students interacting using a multi-touch table in the SynergyNet Classroom***



The tables were networked to each other and to an interactive whiteboard. The teacher controlled the tables remotely using a special orchestration desk, shown in Figure 1.2, or later in the project, a tablet computer.

***Figure 1.2: The SynergyNet classroom with 4 linked multi-touch tables and the teacher orchestration desk (back right hand corner of the classroom)***

This study describes one part of the SynergyNet project, how the interactions which took place in this classroom between the teacher and the students were captured and analysed. It considers what this can tell us about the ways teachers orchestrate lessons in such an environment to support collaborative learning whether they are successful in this aim or not.

## 1.1 Research Aims

This study was part of the SynergyNet project, an interdisciplinary research project lasting four years led by Durham University's Technology Enhanced Learning group and involving the departments of Education, Computer Science and Psychology. SynergyNet was

an attempt to integrate ICT into the fabric of the classroom in such a way as the technology does not intrude on the main focus of the activity (Smith and Harrison, 2001). The multi-touch hardware and software developed by the project is still in use today in research labs around the world including Sydney and Newcastle in Australia, Oslo in Norway and Toronto in Canada.

The multi-touch tables were expected to support two main pedagogical aims. Firstly they were to enable better transitions between different levels of discussion, from the class to the group and vice versa. A process which minimised the time taken to shift between these allowed less opportunity for off –topic talk or other distraction to unsettle the students and thus maintain the flow of the lesson. Secondly, participation in group activity would be encouraged if the barriers to group participation surrounding the use of the mouse and control of digital resources were removed (Higgins, Mercier, Burd and Joyce-Gibbons, 2012).

The SynergyNet project had four aims:

1. To create a radically new technology-rich learning environment that integrated with traditional classroom layouts and collective activities.
2. To design and implement a new form of user interface for educational multi-touch systems.
3. To formulate a new pedagogy that eased transition and movement between teacher-centric and pupil-centric interaction.
4. To analyse pupils' learning strategies to inform fundamental research by capturing data as pupils use the SynergyNet environment.

The research aim of this study is to focus on the third of these: the formulation of a new pedagogy. Specifically, the study will look at the interaction between the teacher and the student, looking in detail at how such interactions may relate to the collaborative experience of students working in a group and how successful the group may be at completing the task

given. It will look at relationship between these interactions and the success of the group in completing three Mathematics tasks.

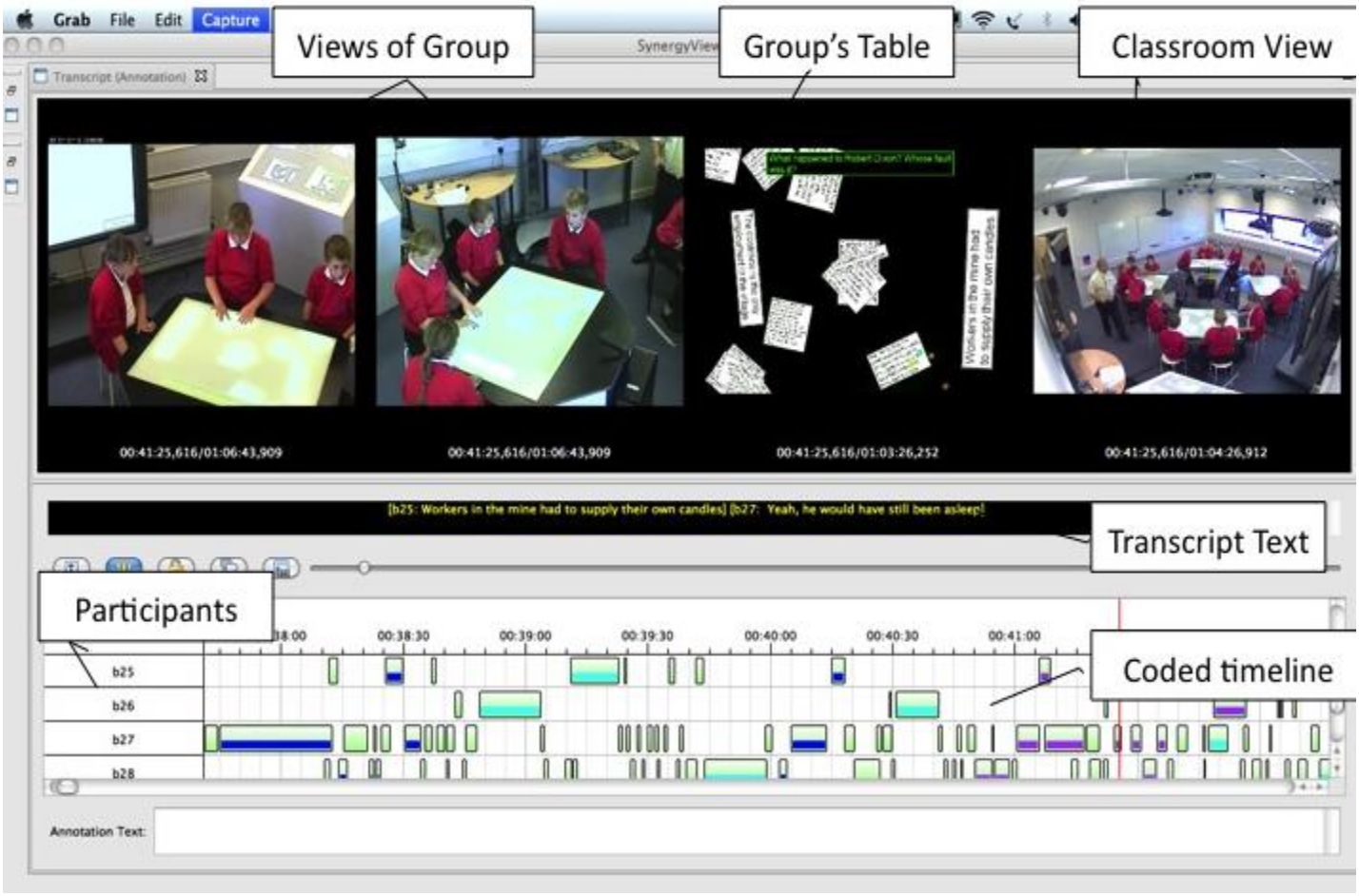
However, the study also employed a new tool developed to meet the fourth aim of the project: the capturing and analysis of data. The SynergyNet classroom was designed to allow data capture at group and class level simultaneously. Each of the four tables had a microphone and two video cameras aligned with it to capture the actions and words spoken by the students. Figure 1.3 shows the array of cameras on the ceiling of the classroom.

***Figure 1.3: The array of cameras to capture data from each of the four tables in the SynergyNet classroom***

In order that the data could be analysed in a manner which made sense of so many multiple streams, SynergyView was designed. This was a piece of temporal video analysis software which enables the combination of multiple audio and visual streams of data with transcript data using a timeline format. Figure 1.4 shows the SynergyView tool and the

multiple audio, visual and transcript streams of data which it contains. Using this software, it was possible to look at the ways in which the teacher interacted with each group in the class as well as with the class as a whole.

***Figure 1.4: The SynergyView tool containing multiple audio and visual streams of data arranged along a timeline***




This was the first time a classroom had been designed in this format with the multi-touch tables and the SynergyView tool (both experimental elements themselves within the SynergyView project). As such the nature of this study is primarily an exploratory one. It does not seek to test a hypothesis, rather to explore the rich data which was collected by the project and identify potential future avenues of enquiry once such detailed data collection and analysis tools have become available, as well as further study into the growing potential use of multi-touch tables in the classroom environment.

## 1.2 Previous Research

The study builds on the emerging research on the use of multi-touch tables in educational settings. Early studies were carried out in the field of Human Computer Interaction (HCI), looking primarily at the design and development of the tables themselves. Gradually the emphasis has shifted to their educational potential. This study arises from that shift in perspective identified in the synthetic review of the literature which was the first published research of the SynergyNet project (Higgins, Mercier, Burd and Hatch, 2011).

Prior to this study the project focused on the interactions of the students around the table, looking at the time taken for a group to involve themselves in a task the quality of the reasoning which took place during their problem-focused interaction. This was completed through a detailed analysis of the talk of each group during the task. It was shown that the groups using the multi-touch tables experienced less process related talk and more problem related talk than groups using paper based versions of collaborative mystery tasks. The problem based talk of groups working on the tables also contained evidence of higher levels of reasoning based on the analysis using the SOLO taxonomy (Biggs & Collis, 1982)

This study builds on the previous research by the SynergyNet project in three ways. Firstly, it focuses purely on the educational context and does not look at the HCI – design characteristics of the tables. Secondly, it focuses on groups of students using the tables exclusively, not using any paper-based tasks at all. Finally, whilst still looking at the interactions which take place during problem solving activities, it shifts emphasis from the interactions between the groups of students to the interactions between the teachers and the groups within the context of a class.

This shift in emphasis is possible because of the developments made during the early stages of the project in the sophistication of the SynergyView data recording system. This allowed for the collection of data in great detail. The focus of this study on the interaction

between the teacher and the groups, nested within the context of a classroom. It is just one example of the possibilities which are offered by the developing technology of data capture and analysis. The study will have implications for both the future understanding of teacher interaction with groups during collaborative activity. It will also have implications for methods and methodologies of the study of classroom interaction when using detailed data capture and analysis systems.

Early research on tables focused on researching the use of the tables by single groups, rather than whole classes as the present study does. Dillenbourg and Evans (2011) cite four reasons why multi-touch tables might present potential opportunities for technology enhanced learning in ways which differ from other technologies, such as handheld learning (Zurita & Nussbaum, 2007). Firstly working round multi-touch tables involves co-location of the group. The tables are designed for multiple users (as opposed to PCs, for example, which have been adapted poorly to the purpose). They require hands-on participation and manipulation of physical or digital objects. Lastly, they facilitate multiple modes of communication, including gaze, gesture, talk, posture and action. The SynergyView tool has been designed to capture these dimensions of interaction.

The growing volume of data available for capture in classroom environments is outstripping the methods researchers are employing to analyse these. Previous methods have fallen into quantitative and qualitative camps (Mercer & Wegerif, 1999; Mercer, Littleton & Wegerif, 2004; Mercer, 2010). Quantitative methods examine features in the behaviour or words of learners numerically. They are able to handle large quantities of audio-visual data but at the expense of the meaning which might be being made by the learners. Qualitative methods look at the utterances of the students and the implied meanings of these. These are more sensitive to changes in meaning of key concepts and they are able to look at meaning at different levels (and not just of words spoken). However, this process is time consuming and

it is difficult to look at a large body of data in detail. It is also difficult to compare samples due to the context specific nature of the analysis.

The analysis in this study employs both quantitative and qualitative methods. The SynergyView tool enables researchers to vary the granularity of their analysis over time. The shorter the time period, the greater the level of detail which can be examined (Mercer, 2008). The study will explore the interactions between the students and the teachers quantitatively, looking at the success of groups in relation to the duration and number of interactions they had with the teacher whilst completing a task. Then the utterances made by the teacher within each interaction will also be examined in relation to group success. Finally, any significant features which are highlighted by the statistical exploration will be examined in greater detail, being related to the theory and research literature as well as to the quantitative results.

The role of the teacher in facilitating learning can be thought of as a process of orchestration (Kennewell, Tanner, Jones & Beauchamp, 2008; Dillenbourg & Jermann, 2010). They must manage the affordances and constraints of the factors available in classroom environment (as they perceive them) to create the optimal learning environment (Bonderup-Dohn, 2009). The perceived affordances and constraints of the tools that lie at the teacher's disposal are dependent on their abilities to blend and adapt their pedagogical knowledge, their content knowledge and their technological knowledge (Shulman, 1986, Mishra & Koehler, 2006).

This orchestration is based upon the teacher's interpretation of the learners' actions and the passing theories they create based upon these interpretations (see section 2.2). It is these passing theories they put to the test as they orchestrate the classroom through their interactions with the students. These interactions take place in an Intermental Development Zone (IDZ) (Mercer & Littleton, 2007). The IDZ is an adaption of Vygotsky's Zone of

Proximal Development (Wood, 1988). The teachers have to create their own meaning through dialogue just as students do. However, it is an internal rather than external dialogue.

It is the internal interplay of these issues within the teacher and their interactions with the groups and classes they teach that this study will explore and it is to the understanding of the process of orchestration that this study aims to contribute.

## 1.3 Data Collection and analysis

The data was collected from 96 participants from six schools. Each school sent sixteen Year 6 students to the Technology Enhanced Learning lab. These students were between 10 and 11 years old and there were equal numbers of boys and girls. There were a number of familiarisation and data collection activities in which they all took part (see section 3.4 for a more detailed outline of the data collection procedure).

This study focuses on their use of the tables to complete a series of three Mathematics tasks, each one looking at a different set of mathematical skills; reasoning, arithmetic and logic. They were taught by one of two teachers; Michael or David. They were seated either in single or mixed gender groups. The tables were arranged either facing the centre of the room or facing the whiteboard in a more traditional arrangement. The data collection for this study lasted for roughly 45 minutes.

The data, once recorded was compiled into the SynergyView tool. The audio data was then transcribed and checked. The writer was responsible for transcription of 50% of the primary data and the checking of the transcriptions of other researchers in the team due to his familiarity with the local dialect.

The transcripts were added to the SynergyView tool and were able to be viewed synchronised with the audio-visual streams. This enriched transcript was then coded using an adapted form of the Engle and Conant (2002) framework. This framework looks at teacher interactions with groups of students engaged in collaborative activities. Although originally

designed for a class engaged in a science inquiry project, the framework is here applied to mathematics activities.

There are four categories of utterance in the Engle and Conant framework:

1. Problematizing the subject matter
2. Give students authority
3. Holding students accountable to others and to shared disciplinary norms
4. Provide students with relevant resources

Each of these relate to different aspects of teacher orchestration and the TPACK model. The framework is a comprehensive one which is able to encompass a wide range of teacher utterances. However, for this study one of the categories has been modified. Instead of the teacher holding students accountable to disciplinary norms, they are regarded as holding them accountable to the norms of classroom behaviour. This is because it is argued that the students are never able to leave the discourse of the classroom learner. If they are to be encouraged to think in a disciplinary manner, to take on aspects of a disciplinary discourse, this is as a role play within their existing classroom norms. Fuller reasoning behind this modification is given in section 1.5.1 with the wider implications discussed in section 7.3.

## 1.4 Structure of thesis

The Literature Review begins with the socio-cognitive learning processes which take place for the individual student during classroom learning experiences. These include the creation of knowledge through dialogic interaction and the dialogic space as well as the role of the zone of proximal development and it's reformulation as the IDZ. The role of power in dialogic interaction is also considered. The chapter then moves on to look at the literature concerning collaborative learning in small groups in the classroom and the role the teacher plays in orchestrating this. The ideas of teacher orchestration put forward by Dillenbourg &

Jermann (2010) and by Kennewell, Tanner, Jones & Beauchamp (2008) are explored. The TPACK model is also introduced as framework of teacher activity through which orchestration is implemented. Finally the chapter looks at some of the different frameworks of teacher-focused interaction, including the work of Gillies (2006) and Griffenhagen (2011).

The Methods chapter surveys the SynergyNet project, situating the present study within the aims and parallel research strands to which it has given rise. It describes the data collection and construction processes. The role of transcripts in the interpretive process is considered and the affordances of temporal analysis software. The operationalization of the framework of analysis is detailed as well as the degree to which group success was classified for a given task.

There are two quantitative results chapters; the first examines the number and duration of interactions between the teacher and the groups of students. It explores whether these interactions are statistically significantly associated in some way with the level of success a group reached the task in which they took place. Success in this case being defined as progress made towards task completion. Also explored is whether any categories of interactions were statistically significantly related to the conditions under which the study took place. There were five such conditions; the *school* from which the students came, the *task* which the students were asked to complete, the *room orientation* in which they sat, the *gender arrangement* of their group and the *teacher* who worked with them.

The second quantitative chapter examines the utterances which the teachers made during their interaction with the students. These utterances have been categorised according to Engle and Conant's (2002) framework. Whether there is a statistically significant association between the categories of utterance which the teacher uses when talking to a group of students and their success at completing a task is explored. Then, whether there is a

statistically significant association between the categories of utterance and the conditions under which the study was run will also be explored.

Building on the quantitative analysis there is one qualitative chapter which looks at the main findings to arise from the quantitative analysis. The relationship between certain categories of utterance and the characteristics of more and less successful groups will be considered in relation to the individual tasks and the three tasks taken as a single process.

A second qualitative chapter will examine another feature of the teacher's practice which became apparent from the quantitative analysis. The nature and characteristics of this behaviour will be discussed. The chapter will also explore possible reasons for the behaviour in relation to successful task completion.

The discussion of the results will relate the conclusions of the four results chapters to the literature. It will then build a picture of the teacher's role in the orchestration of the collaboration and learning which is taking place in the three Mathematics tasks.

# 2 Literature Review

## 2.1 Introduction

In his 2009 retrospective over the work of the Centre for Research on Networked Learning and Knowledge Building, Kai Hakkarainen described three generations of technology enhanced learning. These he called the monological, the dialogical and the trialogical generations. The first of these concerns the learner, seen in isolation as an independent recipient of transmitted knowledge. The dialogical model referred to the learner in their interactions as a constructor of understanding through the interaction between themselves and others, particularly the teacher or a more knowledgeable other. Finally the trialogical model added to its predecessor by thinking of the learning which took place between the learner and others and how this process was mediated by tools (Hakkarainen, 2009).

This chapter will take this three-generational structure as its model for an exploration of the literature relevant to classroom interaction and the processes of learning. The section 2 of the chapter examines the theories of learning which have been put forward as to the processes in which the individual learner is involved during their learning experiences. It briefly touches on the underpinning sociological ideas which led to the widespread adoption of monological approaches. These focused on the transfer of a canon of knowledge from society to the individual, from the teacher to the student (Rogoff, 1994).

The following section, section 3, contrasts the idea of a monological education with a dialogical one. However, this field is a problematic and complex one. For proof of this look no further than the difficulty posed by the words monological and dialogical. The two have been contrasted as opposites when in reality their origins are different and so strictly are the meanings. Whilst monological may mean one voice or one thought, dialogical does not mean

two voices. That would be duological. The contrast between monological and dialogical comes from the dia- meaning ‘through’ and ‘logos’ meaning word. Thus dialogue equates to communication and not just two speakers (Howe & Abedin, 2013). Nevertheless, the dialogue does contrast with the monologue because there is a greater equity to the participation and a need for exchange, a shared experience of the creation of knowledge rather than a transfer of a corpus of information from one repository to another. It is the nature of this exchange which will be explored in section 3.

The role of the teacher is a problematic one. Section 4 argues that they are outside the dialogue in many ways and cannot participate meaningfully with the students in knowledge creating exchanges because of the issues of power which surround their place in the classroom. This is a special environment in which learners and teachers come together, accepting jointly rules and conventions of behaviour. This chapter argues that the teacher is better perceived as one of the mediating tools which are available to students during collaborative activities. The power of the teacher is best seen as ceded temporarily rather than given away. So even during the interactions with the students the power imbalances are present (Skidmore, 2006).

Taking the learning processes of the individual and the group into account; the final section puts forward the framework of classroom interaction developed by Engle and Conant as a comprehensive and realistic means of understanding the interactions taking place within classrooms between teachers and students during collaborative small group and whole class teaching (Engle & Conant, 2002). However, the version to be used will be modified in one important regard. One of the teacher’s functions in the framework was to hold students accountable to the disciplinary norms of science (or other disciplines as applicable, their study was focused on science lessons). However, given the discussion of ever present power relationships and the role of the teacher as a mediator of learning rather than as a dialogic

partner; this study will modify the framework. Instead of regarding the teacher as holding the students accountable to the disciplinary norms of a specific subject, it is argued that they hold students accountable to the disciplinary norms of being a student (a student who might be roleplaying some of the features of a particular discipline but a student nonetheless).

## 2.2 Learning processes within the individual

There has always been interplay between normative ideals of what a school and learning should be and the positive reality of the society within which the learning takes place. For many, an important utility of education is the cultural transmission of values or information necessary for the successful functioning of society. In the context within which this study took place, that was the functioning of a liberal democratic system (Levinson, 1999).

It is accepted that education can influence students significantly and it is a normative ideal of education that they are not fixed in their ability or potential. In the early twentieth century social eugenicists argued that 'the wrong sorts of people were reproducing'. This was countered by the 'political arithmetic' movement, they argued that through education children could be elevated in their social condition. Later the New Sociology of Education movement took this one stage further, arguing that education did not need to change children to fit in better in society, education could change society itself, breaking down old hierarchies and taboos (Ball, 2008, p654).

These ideals led to a focus on the improvement of learners, by the mid -twentieth century there was an emphasis on developing individual's thinking skills. Learning at the time was at individual desks and involved students completing tasks independently, simultaneously and, frequently, silently. Society's focus on the individual learner engendered an education system which viewed knowledge creation as a process happening purely within the individual, if they were taught to think better they would become better learners in

general. For Hakkarainen this was a monological model of teaching and learning. Or rather, this was a model of 'the teacher and the learner'. These were entities which functioned independently, the teacher taught, transmitting knowledge, the learner assimilated it.

Interaction in this model was characterised by the three-step process of initiation, response and feedback (IRF), first defined by Sinclair and Coulthard (1975). This form of exchange remains a common feature of classroom interaction to this day (Wells, 1999, Beauchamp & Kennewell, 2010). However, this exchange is more a tool of classroom control and management rather than of the encouragement of thinking. Regarding individuals as wholly independent of each other and interacting with them as such does not make for better all-round thinkers; the thinking skills learned in one area did not easily transfer to others (Wegerif, 2006).

This is not to suggest that all thinkers in the interwar years regarded learning as a mug-and-jug process of filling the empty individual head. The key ideas of Jean Piaget (1896-1980), Lev Vygotsky (1896-1934), John Dewey (1859-1952) and Jerome Bruner (b.1915) were all formulated during the interwar years or in the years shortly after the Second World War. All these theorists emphasised the centrality of interaction to the development of the individual. Viewing the teacher and the learner as separate entities, or regarding the individual in isolation from their peer group, was inadequate if one was seeking to understand the processes of learning. Each writer produced a range of evidence, some experimental and some theoretical, work to substantiate their views. These in turn have inspired countless others with an interest in the pedagogy, psychology or sociology of teaching and learning - (see, for example, Daniels, Cole & Wertsch, 2007; Müller, Carpendale & Smith, 2009, Cochrane, 2010 and Wood, 1988).

Thanks to the work of these thinkers there has been an acknowledgement of the role of interaction with others and the environment in the education of an individual. Piaget

argued that individuals construct knowledge within themselves when they come into contact with others and the world around them. New experiences are assimilated into pre-existing schemes where meaning is made from the familiar elements within the individual. These schemes are modified in a simultaneous process of accommodation or assimilation to take account of the novel elements within that experience (Müller, Carpendale & Smith, 2009).

Vygotsky argued that knowledge was not constructed within the individual but within the society in which the individual was learning. Learning took place through social interactions, themselves the products of cultural practices. Every learning experience was one in which the individual made sense for themselves of these cultural norms and the people around them. There is interplay between the social and the cognitive for every learner. Vygotsky formulated a general genetic law of cultural development which stated that higher mental functioning is visible on two planes, the intermental and the intramental. The first of these refers to the interaction between the learner and others with whom they are interacting. Higher mental functioning will appear here first Vygotsky argues. It will then appear on the intramental level, as an internalised ability within the learner who is able to display this independently. The differences in potential levels intermental and intramental functioning are described as the Zone of Proximal Development (Del Rio & Alvarez, 2007).

Learning through the Zone of Proximal Development (ZPD) takes place in a recursive four stage process. The individual learner is assisted in an activity by a more knowledgeable other. They are then able to assist themselves in the completion of the activity. Through a period of repetition and practice the processes needed to complete the activity are internalised, automised and fossilised within the internal schema of the individual learner. Finally the process can be de-automised and revisited at a more advanced level of challenge requiring the assistance of a more knowledgeable other and the cycle starts once more (Bruner, 1985; Wells, 1999; Skidmore, 2006; Mercer & Littleton, 2007).

Exactly how to specify ways in which a child can perform under adult guidance or in collaboration with more capable peers is not exhaustively dealt with in Vygotsky's work (Wertsch, 1985). Among the first researchers to attempt to operationalise this question were Wood, Ross & Bruner (1976). They concluded that the role of the tutor was to scaffold a particular task for the learner. By scaffolding, the adult controls the elements of a task which are beyond the learner's capacity. Thus the learner is free to achieve the tasks which are in their range of competence. The tutor is able to think (almost) for and (almost) with the learner, moving with them by building up a hypothetical model of their changing understanding of the task;

*"Where the human tutor excels or errs, of course, it in being able to generate hypotheses about learner's hypotheses and often to converge on the learner's interpretation."*(Wood, Ross & Bruner, 1976, p.97)

Tutors must hold two theories in their head simultaneously. Firstly they must have a theory of how the task should be completed. Secondly they must have a theory of the performance characteristics of the tutee. There have been many other ideas and theories which have attempted to describe the means by which teachers mediate the learning of a student. However, this one has many of the key characteristics. There is interaction between the teacher and the learner, yet both must work with hypothetical understandings of the other's needs. The tutor must hypothesise as to the capabilities of the learner; the student must hypothesise as to the skills they need to employ to complete the task. There is always an unknowable, unbreachable distance between them where concepts or facts are not shared but at best taken as shared (Cobb, Yackel & Wood, 1992). Ultimately the learner must construct their own understanding, their own knowledge within themselves. Intermental interaction stimulates intramental development. Encouraging students to focus on their own thinking, or their meta-cognitive behaviour, can be one way in which students are encouraged to develop

by teachers. This enables them to construct knowledge in a pro-active and conscious way (Jager, Johnson, Johnson & Snider, 1982). The teacher or more knowledgeable adult is still a problematic issue in research into classroom or other forms of interaction. The precise amount and nature of the necessary interaction is the subject of considerable discussion. For example, Blatchford, Baines, Rubie-Davis, Bassett and Chowne (2006) argue for a minimum amount of interaction between the teacher and groups of students whom they argue gain a greater sense of satisfaction and accomplishment if they are given the greatest amount of independence. On the other hand, Tolmie, Thompson, Foot, Whelan, Morrison and McLaren (2005) argue that without the close attention of a teacher, groups' productivity declines as learners began to disagree without explanation and became uncoordinated. Therefore the content and the delivery of the interaction which scaffolds tasks for learners still remain unclear.

Mercer & Littleton (2007) accept the principle of socio-constructivist learning as brought about by collaborative interaction between the learner and a more competent other. However, scaffolding and the ZPD are both metaphors centred on the development of the individual. However, teaching and learning in formal education is situated in the context of the classroom where interaction with the teacher is at group or class level rather than group level. It is not possible to address the needs of the teacher with a metaphor based on an expert-apprentice model or parental tutoring model.

Rather they argue that for an Intermental Development Zone (IDZ). This refers not to the learner alone but rather to the space between learner and teacher. It is the attunement of each to the others changing states of knowledge and understanding of the activity (Mercer & Littleton, 2007, p.68). The IDZ is a continually reconstituted, contextualised point of activity which requires both parties to make meaning through dialogue. It draws upon the ideas of both Vygotsky and Mikhail Bakhtin.

As with Vygotsky, Bakhtin has stimulated a considerable body of writing (see for example Holquist, 2002). Bakthtin's thought about meaning making were earlier echoes of Derrida's postmodern deconstructionism. He emphasised the process of talk rather than the product of it. The construction of meaning was a never ending process which was contingent upon the time and culture in which it took place (Wegerif, 2006; 2008). The principle vehicle for this construction of understanding (which has more fluid connotations than knowledge) was through talking. However, to distinguish Bakhtin's meaning of talk from actual dialogue (which could be interpreted as merely a conversation with a purpose) the idea of dialogic interaction is introduced (Alexander, 2000).

Dialogic interaction and dialogism has gained currency among educational theorists as it expresses a temporality and fluidity which is familiar in the classroom. In dialogic interaction the purpose is not to transmit information but to discover for ones' self through responsiveness to the words heard or signs experienced. This is more common according to Alexander (2003) in other teaching cultures. He uses the examples of France and Russia which both accept open-ended, even protracted, discussion as part of the normal discourse of classroom life. In these education cultures Alexander argues that questions are prized more highly than answers. This reflects Bakhtin's view that questioning is the principle reason for the existence of a concept. If one no longer generates questions then it falls out of the dialogue (Alexander, 2003).

The ideas of Bakhtin and Vygotsky are convergent in their notions of dialogue. Both emphasise the potential for development through interaction. Both situate the creation of understanding within a process that takes place within a social and historical context (see Alexander, 2000 and Mercer & Littleton, 2007). However, one aspect of interaction and classroom collaboration frequently not dealt with by researchers discussing dialogic is the issue of power.

There is a paradoxical nature to the interaction in the classroom setting. It is not possible to divorce the imbalance in power relations from the interactions which take place. The teacher may cede authority to the student but they are ready to take it back at any time should they see fit, a fact that students do not forget. This is acknowledged by Wells. There can never be a "dialogue between equals" (1999, p.242). This is due to the difference between teachers and students in their status as an employed representative of the community as well as their own personal experience and education. Wells argues that teachers play a different role but the dialogue takes place within a classroom community.

Cheyne and Tarulli (2005) argue that this is because people naturally assume that dialogic interaction is along the lines of a Socratic dialogue. However, many asymmetries are present between the interlocutors in classroom dialogues. The interaction is therefore not Socratic but magisterial. This is a dialogue of at least three voices; the superior or Magisterial voice, the inferior, or novitiate voice and finally the institutional voice upon which the first voice draws power. This voice is the school, the curriculum, the social norms into which the teacher is fully embedded and the student is not.

Scott, Mortimer and Aguiar (2005) argue that there are *dialogic* and *authoritative* voices within classroom discourse. Their argument dealt specifically with science education and they argue that at times the teacher interacts with students in a dialogic way, one in which they are open to different points of view, one which explains new directions and is without content boundaries. However, on other occasions the teacher speaks with an authoritative voice where they focus on a single perspective, making their authority clear and with the explicit intention to constrain the direction of the discourse (2005, p.628).

Scott, Mortimer and Aguiar argue that the authoritative voice is a necessary and inevitable part of the discourse. The teacher swaps between the two based on 'passing

theories'. These are taken from the work of Donald Davidson (2006). These are distinguished from the prior theories of the speaker and listener:

"For the hearer, the prior theory expresses how he is prepared in advance to interpret an utterance of the speaker, while the passing theory is how he does interpret the utterance. For the speaker, the prior theory is what he believes the interpreter's prior theory to be, while his passing theory is the theory he intends the interpreter to use." (Davidson, 2006, p260-261)

The prior and passing theories may also be related to the *perlocutionary* force and *illocutionary* force of words outlined by Austin (1962). The speaker's words have one force of meaning for them but a different force of meaning for the listener. The teacher must form a passing understanding of the students' interactions before they initiate an interaction according to Scott Mortimer and Aguiar (2005). It is this passing theory which will dictate whether the register employed by the teacher is authoritative or dialogic. Roth goes further. He argues that;

"Such a theory has to arrive from a teacher's situate practice; he adjusts them to the contingencies of the on-going conversation. The teacher thereby becomes a situated analyst of situated talk rather than a user of general theory of cognitive frameworks."(Roth, 2005, p.158-159)

Both Roth (2005) and Scott Mortimer and Aguiar (2005) view the passing theory as being formed within the conversation, in the dialogic space. They view the teacher being able to switch between dialogic and authoritative talk easily. However, this still ignores the power imbalance which is inherent in the classroom and which can only ever be temporarily mitigated or ceded by the teacher. As their passing theories alter their tolerance for dialogic interaction will change depending on their teleological assumptions as to the goal of the lesson. Moreover, the perlocutionary force of the teacher's words when attempting to engage in a dialogic manner may mean that anything they say interpreted differently by the listening

student due to this power imbalance . Therefore, even though studies encourage teachers to provide non-evaluative feedback, the teacher will not necessarily know if the learner is going to receive their words that way should they intend to give this kind of feedback (Olitsky, 2007). The institution of the classroom and institutional voice is always present. Bakhtinian dialogism in the classroom presents a paradox; learning requires the fostering of dialogue, however, power imbalances mean that such dialogue can never be between equals if it is between teacher and student. This imbalance would impede meaningful construction of understanding as the student would continually hypothesise as to the meaning they believe the teacher wished them to make and act accordingly.

Learning does happen through accidental talk. It is *situated* within a context, a location and a culture. The learner builds a representation of these places and signs which are at once grounded within these but simultaneously separate from them. It is this representation which the learner then takes with them to other contexts and new learning situations (Greeno, 2006). Dialogue is distinguished from dialogic interaction because of the presence of a mediating tool or sign. For knowledge creation to take place within the individual there must be a mediating object of inquiry (Hakkarainen, 2009). Hakkarainen draws heavily on the work of Yrjö Engeström who emphasises that all interaction between individuals is related through the roles, the rules and division of labour in which the interaction takes place. Interaction, in the case of learning, dialogic interaction, takes place within the framework of these four elements. The interaction is focused around, made meaningful by, the activity through which it takes place. (Engeström, 2000, 2007).

It is this idea of situated activity in which the learner engages that represents the trialogical understanding of learning that Hakkarainen proposes. The construction of understanding is a dynamic process which occurs not within the individual but between them and the others. The dialogic space describes the possibility in which imperfect but improved

understanding begins. The ZPD describes the impact which this interaction and construction of meaning in the dialogic space may have upon the potential action of the individual. Finally the activity of meaning creation, mediated by tools and signs, gives the dynamism to the interaction, making it purposeful and temporal.

Models of learning through interaction are unclear on the role played by the interplay of interactions between peers and teachers and individuals. The learner in the classroom is faced with many differing kinds of interactions, those of different sizes, those with different power balances and those with multiple levels of competency among the participants. Where and how the dialogic space or IDZ is created by the teacher whilst they are engaged in multiple levels of interaction remains a gap in the literature which this study will attempt to explore. The next section looks at the applied theories which have emerged concerning collaborative group work in the classroom. It will discuss what makes groups more or less successful and looks studies which investigate the role of the teacher in contributing to this success.

## 2.3 Interaction through collaborative activity

For more than four decades, studies have shown that students can make strong progress in their learning, achieving a deeper and more flexible understanding of concepts in a range of subjects when they learn as part of a small group compared to the level of understanding they get when they work on their own (Johnson & Johnson, 1981, Schwartz, 1995). Even when assessed as individuals, those students who participate in group learning task tend to perform better when assessed than those who had only worked individually ( Barron, 2000a).

The meta-analysis carried out by Ginsburg-Block, Rohrbeck & Fantuzzo show that other benefits to collaborative small group learning shown include social, self-concept and

behavioural outcomes. The same analysis also showed a positive relationship between raised social and self-concept outcomes and raised student achievement. These effects were replicated across all demographic groups. However, they were significantly more effective for students from ethnic minorities, those from lower-income households, those in urban settings and those of upper primary school age (Ginsburg-Block, Rohrbeck, & Fantuzzo, 2006, p.746).

Cohen defines collaboration in small groups as "Students working together in a group small enough that everyone can participate on a collective task that has been clearly assigned." (Cohen, 1994, p.3) The groups are expected to work with each other and not rely on the direct support of the teacher to complete the task assigned.

According to Barron & Darling-Hammond (2008), there are three major challenges to developing successful collaborative small group work in the classroom:

3 major challenges for cooperative small group learning in classrooms:

1. Developing norms and structures within groups that allow individuals to work together.
2. Developing tasks that support cooperative work.
3. Developing discipline-appropriate strategies for discussion that support rich learning of content.

### 2.3.1 The first challenge - developing norms and structures

Yager, Johnson, & Johnson, (1985) attempted to address the challenge of developing norms and structures by assigning roles to group members in one condition of their study. The 'learning leader' was responsible for summarising the learning points of the lesson for the rest of the group. The 'learning listeners' were responsible for probing the information given by the learning leader, questioning their account, encouraging recall from the leader

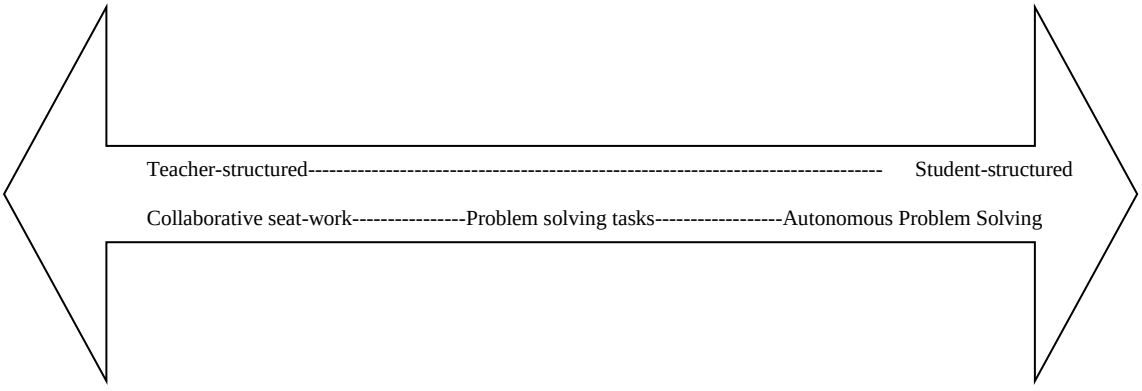
and from each other and finally, discussing the ideas which had been contained in the instruction they had been given. Groups in the unstructured condition of their research were simply told to continue working and discuss the material they had been given. All groups were of mixed ability. Two teachers participated in the study, one teaching both small group conditions and one teaching students working individually through the tasks. The outcome of the study was that those students in the structured group performed better than those in the unstructured group and the students working individually on post-intervention tests.

Students who have the opportunity to regularly collaborate develop highly socialised group working behaviour compared to students who only engage in it sporadically. Gillies, (2004) argues that performance was improved by the development of beneficial interpersonal learning skills in collaborative working such as timely positive interruption to provide help but a reduction in overall interruptions during discussions. These skills led to persistent systematic inquiry during group activities which was where "pivotal learning had occurred" (p.210).

### 2.3.2 Developing tasks that support group work

Nystrand, Gamoran & Heck (1993) looked at the variety of small group activities teachers used and found a great variety in the kinds of tasks. They offer a continuum of small group work which situates tasks according to their amount of teacher control and student autonomy:

***Figure 2.1: Nystrand, Gamoran & Heck's continuum of group work***



Teacher structured ‘collaborative’ seatwork activities might be considered an activity for a single person which has been slightly adapted to encourage some discussion. Johnson & Johnson, (1999) point out that in collaborative seatwork, or worse, a pseudo learning group, there is little incentive for individuals to share collaboratively because they are being tasked and assessed as individuals. The enduring centrality of individual assessment at the core of classroom education is perhaps the biggest barrier to the adoption of greater collaborative working methods despite the positive effect these can have on performance (Barron, 2000b, Scardamalia & Bereiter, 2006). It was this need to provide a means of assessing individuals within the setting of collaborative group work which Leat & Nichols (2000) were seeking to address through the development of the Mysteries tasks which have been adapted to form the basis of the tasks used in this study. The tasks are discussed at length in section XX and copies are included in appendix XX.

Nystrand, Gamoran & Heck (1993) found the more tightly controlled the structure of the group-work, the worse the students performed in post-intervention tests. In fact those students involved in tightly controlled group tasks did not perform as well as students who had had no group time at all. Those students who had been allowed to be highly autonomous in their group task had considerably outscored the control group. The conclusion of the researchers was that if collaborative group work appeared ineffective, this was because the groups were being used ineffectively and that further work was needed to develop effective tasks which were meaningful but less structured and which were supported by pedagogy

which was supportive but less controlling. These goals are reflected in the aims both of the SynergyNet project, outlined in section XX, and in the research aims of this study, discussed in section XX.

### 2.3.3 The third challenge - Developing discipline-appropriate strategies

It was argued in 2.2 that it is important for students to reflect upon their meta-cognitive development as collaborative learners (Yager, Johnson, Johnson, & Snider, 1986). However, this is not enough to have them develop discipline specific ways of thinking (Bennett et al., 2004). Such disciplinary specific thinking requires internally driven discussion. In scientific activities this may mean discussing different hypotheses and making predictions to arrive at group consensus. Then such internally derived consensus must be challenged in externally driven debate where they meet the ideas of other groups.

The importance of this conflict arises through a redefinition of the knowledge which we wish students to develop. This emergence and advancement process is something which can be replicated in group collaboration. Rather than a didactic transmission of skills and facts, knowledge becomes a dynamic process of being built and modified (Scardamalia & Bereiter, 2006). To refer back to section XX and the trilogical model of learning; the dialogic space in which groups are able to construct a shared understanding is one which is expanded in stages to force them to reevaluate their models in the face of a greater number of voices and ideas in the dialogue. This process replicates, it is argued, a disciplinary discourse which may have taken place across centuries and over continents. However, such suggestions of replication of the discourse of one ‘situation’ ignore the other in which the collaborative group work is taking place. It is always necessary to bear in mind that such interaction takes place in the classroom and therefore it is within the situation, signs, language and power relations of the classroom that learners are able to model such disciplinary inquiry. Ultimately

they are to be held accountable not to the discipline they are exploring but to the norms of their classroom environment and to the norms of being a learner. This is a process managed by the teacher. It is the teacher who must manage these discussions and hold students accountable to the spirit of inquiry relevant to the discipline they are working in (Engle & Conant, 2002). The teacher must mediate the internal and external discussion to create a situation in which knowledge emerges and is explored.

### 2.3.4 Characteristics of collaborative activity

Johnson & Johnson, (1999, pp70) have identified five elements which they claim are essential if an activity is to be collaborative.

***Figure 2.2: 5 Elements of collaborative activity (Johnson & Johnson, 1999)***

| | |
|---|---|
| *Positive interdependence:* | *Group members realise that they cannot succeed if the rest of the group does not succeed.* |
| *Individual accountability:* | *The group is only as good as its weakest link and any group member might be called to represent the achievement of that group.* |
| *Face to face promotive interaction:* | *This can take the form of supportive acceptance of the ideas of others in the group. It can also be a sense of accountability to others in the group to contribute to the group task.* |
| *Group processing:* | *An awareness of the meta-group interactions by members of the group who are able to reflect upon the relative success of group dynamics, identify strengths and weaknesses and act to address any of these.* |

The final essential element they identify is "social skills"(p.71) which as they characterise them are not an observable set of characteristics but rather an acknowledgement that students must be trained to work collaboratively over a period of time. This will not happen without instruction and help. A similar point is made by Slavin (1996), that it is not enough to give students a task and expect then to get on with it. They must be given a sufficiently good reason to want to collaborate together. The responsibility for this and for training students to work collaboratively together is placed firmly on the shoulders of the

teachers ( Cohen, 1994). Teachers have to employ 'group-worthy' tasks which are open-ended and multifaceted. They also have to support more equal participation by bolstering the status of infrequent contributors. Here the idea of equality is not about equal quantitative participation but creating and sustaining a sense of fairness in the group.

Within collaborative groups there are learning leaders and learning listeners (Yager, Johnson & Johnson 1985). The learning leader needs to share their original insights with the group. They need to explain their thinking about a phenomenon, possibly with an element of performance. The learning listeners need to critique the information they have been given rather than to simply accept it. For this process to be successful the teacher needs to refrain from passing judgement on the group's discussion whilst it is still taking place (Bos, 1937; Sohmer, Michaels, O'Connor & Resnick, 2009; Webb, Troper & Fall, 1995). Rather the learning listeners have to resolve differing perspectives through argument (Amigues, 1988), observe the strategies of others (Azmitia, 1988) and listen (actively) to the explanations of others (Schwartz, 1995). Within these roles there is a place for some flexibility, not all learning leaders lead in the same way, nor lead to the same degree.

### 2.3.5 What makes some groups more collaborative or successful than others?

Teachers are faced with the issue of recognising which groups may be collaborating successfully in their classroom and which groups are not. It may not be possible to look for all the above characteristics, some are only detectable in post-hoc analysis of data collected, such as the observation of the strategies of others in the group. Barron ( 2000a) has described three markers indicating collaborative activity:

1. Mutuality: highly collaborative groups take turn, respecting others' right to speak even during conflicts.

2. Shared task alignment: highly collaborative groups arrive at a solution by referencing each other's ideas.
3. Joint attention is exhibited by highly collaborative groups. These share resources and use them as tools around which to collaborate rather than appropriate or share them out.

Joint attention around the artefacts in the history mysteries in the SynergyNet project was seen to be created more quickly and more easily whilst using the multi-touch tables than it was when using paper based versions of the tasks (Mercier, Higgins, Burd & Joyce-Gibbons 2012).

However, collaboration by itself is not an indicator of success at the task set. It may be that some groups show low levels of collaboration yet are successful at task completion. There are many reasons for this, for example, this may be because of individual ability, task simplicity or the working of an inner group within the whole. To determine what if any relationship existed between the two, Barron carried out a mixed methods study, looking first quantitatively at the kinds of response students gave to each other and how connected these were to the utterances which had previously gone before it (Barron, 2003). There were significant differences in the performance of groups that could not be accounted for by either pre-existing variables nor by interaction variables such as the number of turns taken or the number of correct responses brought to the group. What differed was how students responded to ideas of other group members.

More successful groups responded to correct proposals by discussing them or accepting them. Less successful groups responded with silence or rejected them without giving an explanation. Conversation in less successful groups was more off topic and even when it was on topic, it was not as tightly focused as in successful groups. When someone generated a correct proposal, the ensuing conversation was not closely related to that

proposal. Barron concluded that this made it harder for the group to recognise the significance of that proposal. This issue of recognition was less problematic in more successful groups. (Barron, 2003, p.349)

Qualitative analysis showed less successful groups had relational issues that stopped uptake of good ideas by group members. These difficulties appear to stem from a more individualistic approach by members of the groups whose interactions were more competitive. The efforts made by group members were more asymmetric. The approach to problem-solving, even as a group, was focused on the self.

The less successful groups went against turn-taking norms when they had been established with dominant behaviour by some group members, echoing Johnson & Johnson's idea of the learning leader and listener, Barron showed that both were important for the uptake of ideas. It was not enough for someone to be right, or partially right, they had to be accepted and their ideas elaborated upon. For less successful groups this was particularly difficult. Most difficult of all for these groups were mitigated ideas. These were often ideas or suggestions put forward in such a way as to avoid causing offence, such as rhetorical questions and thinking aloud (Linde, 1998).

## 2.4 The role of the teacher

Of the numerous studies which focus on collaborative learning, few deal explicitly with the role of the teacher in fostering collaborative practices in the classroom. In general the literature regards teachers as important but does not examine in detail with the mechanics of what they are required to do. In one study for example (Puntambekar & Kolodner, 2005), the teacher refrained from interrupting the working of the groups despite real problems being observed, such as students needing help understanding the problem, applying knowledge they had, evaluating the designs, explaining the failures and engaging in revision. Students also

neglected to use informational resources unless explicitly prompted. All areas a teacher could have helped address. The researchers noted that the teacher monitored the groups "The teacher walked from group to group to make sure students were on task and to listen in on their discussions and help them out of quandaries." (2005, p.198). However, they do not go into greater detail as to the nature of the help offered, or the impact that it may have had.

Some researchers have put forward normative guidelines as to the design of lessons which teachers have to deliver, one such (Barron et al., 1998) advises that teachers should:

- Define learning-appropriate goals that lead to deep understanding.
- Offer scaffolds to support students learning.
- Ensure multiple opportunities for formative assessment and revision of work.
- Design social organisations that promote participation and result in a sense of agency.

However, the researchers do not offer positive analysis as to the impact of these strategies, nor how they may be implemented in greater detail.

Johnson & Johnson (1999) draw a distinction between what teachers do in formal cooperative learning environments and informal ones. In formal ones, where students work together as a group for a number of sessions, the teacher has three tasks; make pre-instructional decisions as to the task, composition of the group and resources available. They explain the task, stressing both interdependence and accountability. They monitor students' learning and if necessary, intervene in a group. Intervention can be to assist with the task or to improve students' interpersonal skills (the subcategories of intervention are reminiscent of the *problematization* and *holding students accountable* categories of the Engle & Conant framework discussed in section 2.5). Finally they assess group learning. Informal cooperative learning situations are where students are grouped in temporary, ad-hoc groups which last no more than a single session. Here the teacher is responsible for ensuring that the students do

the work; “Organising material, explaining it, summarising it and integrating it into existing conceptual structures” (Johnson and Johnson, 1999, p.69).

Johnson and Johnson do not explain why there is a difference between the role of the teacher in the formal and informal learning environments. Nor do they elaborate on what kinds of intervention teachers may attempt to ensure that students are on task and working together.

Both groups of researchers argue that the teacher has a role in organizing collaboration, one relating to task focus and one assessing the students. Both argue that the teacher must hold the students accountable for their participation.

### 2.4.1 Orchestration and the Role of the Teacher

‘Orchestration’ is a metaphor for the role of the teacher within the technology enhanced classroom. It refers to the orchestration of the players by the conductor, seen as a pivotal agent in a complex system, rather than the composer, who is removed from any interpretations of his work. Dillenbourg & Jermann (2010) have taken the idea of orchestration to develop design rules aimed at achieving an authentic learning situation and activities in the technology enhanced classroom. They describe 9 factors to be considered in the design and implementation of collaborative learning activities employing technology. The first are drawn from the metaphor of the orchestra, the conductor and their joint orchestration.

1. Teachers provide leadership for all activities, even if it is by their very presence.

2. There must be flexibility in planned activities as teacher and class respond to each other and the time constraints.

3. Teachers are responsible for control, maintaining the interest and concentration of the class in the activity.

4. There must be opportunity for cross- plane integration within the activity, the integration of individual, group and whole class elements in the learning process. There must also be integration with homework and home life.

5. Activities should broadly be linear. Groups should perform sequentially similar activities at the same time.

6. There should be continuity of structure and regular reference made to the learning goal.

7. Although difficult to quantify in a research context, drama is necessary for engagement, as Dillenbourg & Jermann put it, “It is difficult to report this from a scientific stance, but the best methods are salty.” (2010, p532)

8. Time must be spent on issues in proportion to their relevance to meeting the learning objectives.

9. Careful thought must be given to physicality, that is, is it physically possible for students and the teacher to move, see and interact in a way which will al low them to meet the learning objectives.

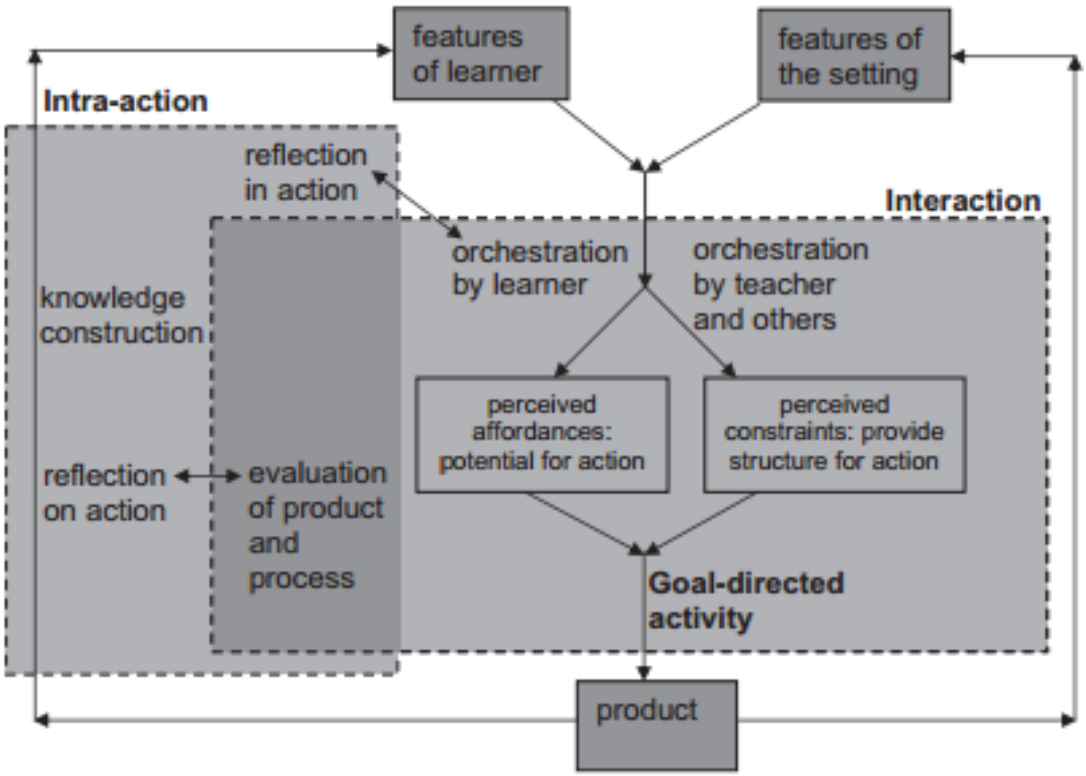
These nine factors are refreshingly free from any presumed equality between students and teachers in their interactions. Their mention of cross-plane integration is one of the few instances where the multiplicity of levels of teacher interaction within the same activity and within the same classroom is mentioned within the literature. Their concept of linearity is an important one. The literature on group research does not mention coherence between groups as a role of the teacher, yet it is an important practical consideration for teachers. The issue of drama is problematic to quantify or operationalise. However, drama and role-play is embedded within the classroom. In effect interactions where teachers may assume a dialogic role rather than an authoritative one (as discussed above in the work of Scott, Mortimer and Aguiar, 2006 and in the work of Wells, 1999) can be seen as them roleplaying at

collaboration with a group of students who are also complicit in this roleplaying, perhaps whom may be in fact roleplaying at a more involved level – they may be acting out the role of a collaborative group and then the role of a group which chooses to play along with the teacher who wishes to join them.

Kennewell, Tanner, Jones and Beauchamp (2008) present a less prescriptive and more interactional model of teacher orchestration of interaction within the classroom. Building on the work of Kennewell (2001) they initially developed to describe how to integrate new digital technologies into the classroom in a way which was pedagogically meaningful. However, they argue that the technology present in an interaction situation is only one of the features of that situation. The crucially important activity is the orchestration of the factors within the learning situation rather than the situation itself (Kennewell, Tanner, Jones & Beauchamp, 2008, p.71).

This model is intended as a cyclical process where learners interact with the setting in

***Figure 2.3: Analysing teaching and learning in activity settings framework (Kennewell, Tanner, Jones & Beauchamp, 2008, p.67)***



which they find themselves and through interaction with the teacher progress towards meeting the goal of the activity. The agency of teacher and learner remains separate within the interaction they both are able to orchestrate the situation to achieve their own ends. Kennewell, Tanner, Jones & Beauchamp use John Gibson's idea of affordances and constraints (1979), developed initially to describe experiences of visual perception but later developed by Norman (1998) to describe the features of objects and machines.

The role of the teacher is to orchestrate the affordances and constraints of situation and the interaction as they present themselves. This focuses the teacher on their role as a mediator of learning rather than a dialogic actor. They have a much wider role within the dialogue than as an actor alone. They must discern between the potential for action and the structure for action within the task (bearing in mind the outcome they desire). They must also perform a role which embodies these affordances and constraints.

Reflection in action, taking place during the interaction, and reflection on action, taking place outside of interaction are two processes which the teacher can orchestrate as well. According to Kennewell, Tanner, Jones & Beauchamp reflection in action is more likely to take place in activities where students are less constrained from dialogic interaction and are afforded more potential to interact more freely (2008). Reflection on action may be a process involving whole class discussion in plenary sessions. The teacher must orchestrate interactions which allow for the former and ensure that the latter happens by managing a transition between group and whole class discussion.

### 2.4.2 Affordances and the role of the teacher

The nature and role of the concepts of affordances and constraints in the perception and use of tools is one which has been caused a great deal of interest and debate amongst educators, philosophers and engineers in recent years. Derry (2007) criticises Gibson's use of affordances because they appear to suggest that meaning is attached to tools through a

mechanical rather than a socio-cultural process. This is a point echoed by Oliver (2005). He argued Gibson elided a distinction between subject and object.

Norman's position in his work 'The Psychology of Everyday Things' (1988) argued that affordances did convey a message of possible actions to their user; a very different position from Gibson. This opened up the possibility of seeing affordances as interpreted by the subject in a historical context.

Norman's aim was to put forward a view which helped designers to improve the usability and elegance of everyday objects. He argued that designers have a view of the function of an object (the design model), this is transmitted into what the object looks like (the system image). It is this image which then conveys meaning to the user who forms their own view of the function of the object (the user's model).

***Figure 2.4: Norman's transmission of meaning through objects***


Oliver argues that Norman is caught in a tautology. If affordances are general as Gibson argues then there can be no communication of intention by the designer because there is no communication. However, if affordances are communicated then they are interpreted in a socio-historical context and therefore subjectively by each user. As such, they are too subjective and individual a concept to be a good basis for design.

Oliver suggests that objects may be viewed in similar ways to literature, creative processes with authorial intent but divorced from original authorial meaning, interpreted through the ideologies (the beliefs, discourses and contexts which contribute to the world view) of the user. Meaning is not transmissive but rather dynamic, negotiated and dialogic.

Technology, like language, can be subverted and adopted in many ways never intended by the designer (2005, p.412).

Bonderup-Dohn (2009), attempts to deal with the muddied waters of affordances differently to Oliver. Bonderup-Dohn defines an affordance as an affordance 'for' someone. It only exists relative to an agent. Affordances are 'interaction potential' and, crucially, a bodily potential. The body has been forgotten in the theorising about affordances. The body acts according to the requirements of the situation. It plays an important part in memory and sense making.

Bonderup-Dohn argued for Merleau-Ponty's idea of the body-schema (the idea that meaning can be represented not in mental schemas but in physical ones which do not form part of conscious thought).

> *"For Merleau-Ponty, we are as bodily beings always already in the world in a pre-reflective, non-thematised (and therefore non-representational) correspondence of body and world in the concrete activity in which we are engaged. (Bonderup-Dohn, 2009, p158).*

Epistemologically in a Mearleau-Pontian view of affordances there is a distinction between perception and representation. Perception is the presentation of meaning to the agent through their actions. Representation happens only in the head. This perception is always in a figure (foreground) – background structure. This background contains the knowledge and experience of the agent. This perception by the agent is not of all the possible affordances of an artefact but only of those relevant to the task.

Ontologically, the nature of Merleau-Pontian affordances is dynamic, relational, cultural, experience- and skill-relative. What an artefact affords a person throughout their life may well change. Dohn's view seeks to resurrect Gibsonian affordances at the expense of

Norman's view. The tool and the task are inextricably linked. The action gives meaning to the tool.

> *"From a Merleau-Pontian perspective, it is in this fundamental relating of meaning-in-the-world [a Heideggarian phrase] to bodily doing-in-the-world that the Gibsonain transcendence of the subject-object dichotomy consists." (Bonderup-Dohn, 2009, p163)*

Affordance is potential, it relates to the interaction potential of a range of body-schematic possibilities of interaction (some of which take place). Interaction needs to be with objects which have some identical or similar features to a previously experienced exemplar (in the body schema). Dohn turns Norman's philosophy of design on its head. Rather than the goal of design being the making of mental representations easy to construct, it should rather be to make them unnecessary.

How the teacher should best manage the affordances and constraints present in the classroom during collaborative activity, based on the analysis of the data collected in the project will be discussed in section 8.4. However, the affordances the teacher avails themselves of the tools which they select to use, reflect the judgements they have made as to the needs of the students in their class. It is in the orchestration of the classroom through the affordances of tools that the meaning which the teacher is making can be perceived. Merleau-Ponty's emphasis on them as creating meaning when enacted automatically creates a judgement as to the quality of the experience of that action by anyone observing it. They reveal an indication of the passing theories which they have constructed

### 2.4.3 TPACK and the role of the teacher

The TPACK framework, articulated by Mishra and Koehler (2006) is a means to describe the various kinds of beliefs a teacher may hold about the best way in which to teach a given lesson whilst employing new technologies in their lessons. Although the present

study is concerned primarily with interactions between teachers and students in collaborative small group Mathematics tasks, it is part of the SynergyNet project and as such is taking place within the context of a Technology Enhanced Learning lab and using the multi-touch tables and orchestration system developed by the SynergyNet team. The TPACK model and Shulman's earlier work describe the interplay of forces which act upon teachers as they orchestrate classroom situations as well as providing a framework for thinking about the iterative design process of collaborative tasks, particularly those enhanced by technology.

TPACK models the interplay between various areas of knowledge within the individual teacher; their knowledge of technology available, the content which they have to teach and the pedagogical practices or constraints which are necessary. It has quickly become seen as a good framework for describing what teachers do and what they know (Polly & Brantley, 2009).The roots of TPACK lie in teacher education and the work of Lee Shulman who first described a unique Pedagogical Content Knowledge which was separate from either of its constituents (1986). Subsequent research also focuses on teacher formation (Archambault & Barnes, 2010; Mishra & Koehler, 2009; Chai *et al.*, 2011; Angeli & Valanides, 2005 & 2009). However, the framework raises important issues for the present study. By locating the employment of technology by a teacher in a given lesson within a contingent set of ideas that are negotiated rather than fixed it is an important way to view and perhaps shed light on teacher behaviour. However, the research arising from the TPACK framework largely relates to teacher education rather than classroom practice. Vagueness and confusion exist among researchers as to the definitions of the various categories within the TPACK framework.

#### *2.4.3.1 Origin of TPACK: Pedagogical Content Knowledge*

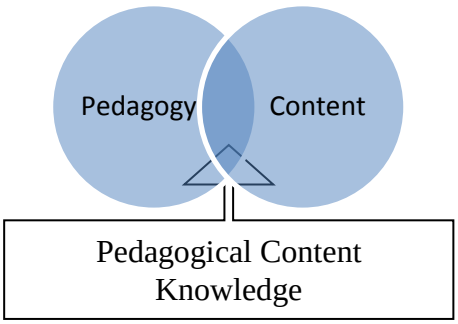
Writing in 1986, Shulman described various kinds of knowledge which the teacher was expected to possess. Hither to this there had been a dichotomy in teacher training

programmes between teaching subject knowledge and pedagogical knowledge. This, he argued, was insufficient. Paraphrasing Aristotle and Bernard-Shaw, he argued that it was not enough to be able to do something. If you wanted to teach it, a greater level of understanding was called for. To be in a position to teach a given subject or skill, the teacher needs to be both competent in that area and have another kind of understanding, how to articulate the necessary steps to arriving at competency in that particular subject or skill.

> *"Teachers must not only be capable of defining for students the accepted truths in a domain. They must also be in a position to explain why a particular position is deemed warranted, why it is worth knowing and how it relates to the other propositions, both within the discipline and without, both in theory and in practice."(Shulman, p.9, 1986)*

Clearly the actions described here; defining, explaining, knowing and relating; require knowledge greater than that required to perform a function relating to that domain. They require pedagogical knowledge as well. For Shulman, pedagogic knowledge contains a range of teaching techniques such as analogy, illustration, exemplification, explanation and demonstration. When these are employed in the service of teaching a particular knowledge domain to learners, it is this interplay between the teacher's understanding of the content and the teacher's understanding of the pedagogical tools at their disposal which is what is understood as Pedagogical Content Knowledge (PCK).

***Figure 2.5: Pedagogical content knowledge: the first stage of TPACK***



For Shulman, PCK goes beyond knowledge of the subject matter. It describes the content knowledge *"That embodies the aspects of content most germane to its teachability."* (Shulman, 1986, p.9) The construction of PCK as the interplay between various forms of knowledge possessed by the teacher and their perception of what learning must take place. It is not static, nor the same for each lesson or subject. Shulman says teachers must maintain a "veritable armamentarium" of ways to represent concepts deriving from both research and practice. However, he makes no mention of the use of new technologies, or indeed any particular equipment in achieving learning goals, seeing teaching in the abstract as imparting a body of knowledge and a familiarity with the syntax of thought pertaining to a particular discipline.

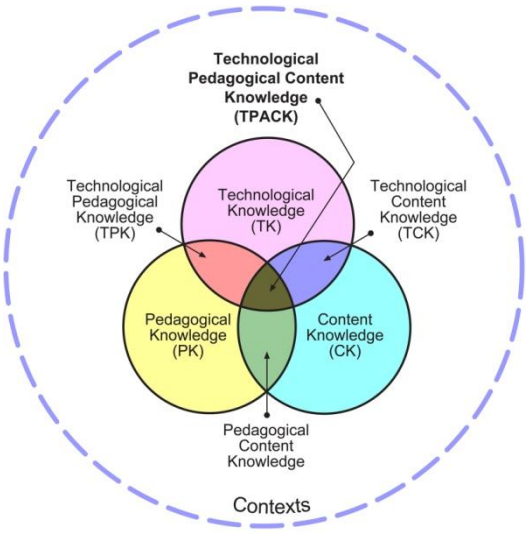
Shulman's definition has been criticised for a lack of clarity which in turn has made it hard to measure (Cox, 2011). However, it is a construct which has attracted a lot of attention because it attempts to describe the interplay of important factors in the development of teachers' perceptions of their own role and their effectiveness in teaching particular concepts. The TPACK framework develops this two dimensional interplay of pedagogy and content into a three dimensional one incorporating the teacher's ideas about the use technology, both in the subject area, the pedagogical armamentarium and most importantly, in the interplay between these three.

#### *2.4.3.2 Description and uses of TPACK*

Mishra & Koehler, writing in 2006 argued that the tools a teacher should use were part of the consideration when it came to delivering lessons. However, that this was not something considered by Shulman because in 1986 tools, or technology, in the classroom was largely transparent. The tools the individual teacher used were well established and it was widely accepted and expected as to how they would be employed. There were times, however, in the past when this was not the case. The book was new technology when it

replaced the scroll the jotter when it took over from the slate. At such times teachers would have to give explicit consideration to the use of such tools; to what they with advanced pedagogical and content knowledge perceived as the tool's affordances and constraints as well as to how their students with less developed understanding could perceive in their uses. The advent of new technologies and their proper use in a given learning situation is an important factor that teachers must balance with existing content and pedagogical considerations until such time as each new technology become embedded in classroom practice and a consensus forms as to its usefulness in given situations (Cox, 2009).

***Figure 2.6: Mishra & Koehler's TPACK model***




The TPACK model (http://tpack.org) builds upon PCK, developing it from a three to a seven strand model. Mishra and Koehler argue that TK is the teacher's knowledge of a given technology. How this is employed in the domain to be taught is the TCK. TPK is a teacher's understanding of how technology behaves in teaching and learning settings, understanding the tools that exist and their potential applications. Although this, arguably, is not possible without some reference to the content which the tool has been designed to support, there are some technologies so broad that they are applicable to almost anything, particularly hardware such as handheld or desktop computers. Also general software

applications such as virtual learning environments encompass a broad range of tools that can be applied to more than one learning domain; such as wiki or chat tools. There are also pedagogical technologies which support learning but are not designed to interface with learners at all, such as online registration or assessment tools, even photocopiers. Yet an understanding of their place in the life of a teacher is a necessary condition to successful teaching and learning.

It is insufficient for a teacher to simply use technology in schools because it is there:

> *"[TPACK] Represents a class of knowledge that is central to teachers' work with technology. This knowledge would not typically be held by technology proficient subject matter experts, or by technologists who know little of the subject or of pedagogy, or by teachers who know little of that subject or about technology." (Mishra & Koehler, 2006, p.1029)*

Many software tools, for example, are designed for business and are then transplanted into the school environment without thought given by the designers for the needs pedagogic or content needs of the user. Teachers must employ TPACK to judge when and how to use these in their lessons to best deliver the desired domain knowledge to learners.

TPACK then is a unique class of knowledge and describes the process by which teachers orchestrate their use of technology within the context of a given learning situation. Whilst it is distinct, it is also not fixed. Rather it is a nuanced class of knowledge, dependent on the context in which the learning is to take place. The teacher must balance their pedagogical devices, the demands of the content to be taught and the perceived usefulness of the technology available to create the most meaningful experience for their students possible.

The perceived affordances and constraints of a technology can impact upon the pedagogical method and content to be taught. Likewise some specific content may require both specific pedagogy and the utilisation of specific affordances and constraints present in

the perception of a technology. Finally, specific pedagogies, for example collaboration in small groups, may require specific subject materials and specific affordances and constraints in the use of a specific technology to support the desired pedagogy.

The TPACK framework is the product of research which follows the design based research methodology. This is an iterative process of research within classroom contexts wherein interventions are developed, study and refined (Angeli & Valanides, 2005). Researchers and teachers work closely together to redesign resources, data collection and classroom processes depending on the feedback they continually receive. It is regarded by some as a more pragmatic approach to classroom research which addresses some of the criticisms of traditional methodologies which derive one set of results in a controlled environment but then struggle to replicate them when the intervention is transplanted to the everyday classroom (Brown, 1992).

The design based view of research implies a view of knowledge which is constructed over time and in a variety of ways. This is mirrored in the TPACK framework; teachers are not able to have fixed ideas as to what constitutes the right way to use a particular technology if they must also address the demands placed upon them by the content the pedagogy. All this is also dependent on the context in which they find themselves at a particular time. Like the design based research methodology, teacher's knowledge in TPACK is constructed within the dynamic constraints of the context and requirements of technology, pedagogy and content.

#### *2.4.3.3 Issues with TPACK*

The favourable way in which TPACK has been received into the under-theorised of the teacher's role in technology enhanced learning has led to it being put under a great deal of scrutiny. This in turn gives rise to a number of criticisms which need to be addressed. It is not clear in Mishra & Koehler's original work whether the TPACK element of the framework was to be seen as a transformative or integrative form of knowledge. If transformative then it

would be different from other forms of knowledge, such as TPK or TCK. This is suggested by the way the framework is set out and how TPACK is described. However, the emphasis on context and on the interaction of the three core elements and how they 'dynamically constrain' each other suggests that it is a more transient concept which is integrated 'on the spot' by teachers.

Angeli & Valanides (2009) found in computer mediated lessons that experienced teachers did not perform better than less experienced teachers who were more technically proficient until they were given instruction on how to teach with computers; note, not that they were given instruction on how to use them, but how to teach with them. This leads them to conclude that TPACK is a transformative knowledge which cannot be explained by a growth in a contributory knowledge alone. However, they do caution that the researcher's view of TPACK may influence their choice of methodology and research design. Those who view it as transformative may find it so whereas those who view it as integrative may not.

Another criticism of the original formulation of TPACK is that it does not include any consideration of teacher beliefs about the context, purpose or process of learning which might lead them to be prejudiced for or against a particular technology or pedagogical tool (Angeli & Valanides, 2009). That this means that TPACK research gives an incomplete picture of teachers' reasoning about their ability and the strategies they employ.

Archambault & Barnes (2010) have argued that identifying the intersections of technology with pedagogy and content is more straight forward than trying to identify the intersections between pedagogy and content knowledge as proposed in Shulman's original idea. They argue that one major obstacle is that many teachers do not separate pedagogy from content; another is that what teachers and researchers view as pedagogy or content can be very different. Some work towards a coherent definition was carried out by Cox & Graham (2009) but weaknesses still remain (Graham, 2011).

The importance placed on the context of the context of the learning situation has meant that it is difficult to develop coding schemes or questionnaires which are generalisable outside the context of a given study, even if they were internally coherent categories in the first place. Although work is ongoing with, among others, Chai *et al*. (2011) attempting to adapt the questionnaire used by Schmidt *et al.* (2009) to explore the TPACK of pre-service teachers in Singapore. Their conclusion was that TPACK was a useful framework with groups that can be discernibly identified from surveys by factor analysis (as did Archambault & Barnett, 2010), but admit that more work is needed in this area. They also tend towards a dynamic and contingent, integrative view of TPACK.

Graham (2011) argues that whilst TPACK is built on an unsure foundation, it has led to interesting directions for research. It is immediately understood by teachers and researchers on a surface level. Inevitably, he argues, there is a tension in any framework between economy and comprehensiveness. The very economy which makes TPACK readily accessible also makes it vague in some areas or to ignore others.

When considering whether TPACK is integrative or transformational knowledge in character, Graham suggests that whilst it is talked about by Mishra and Koehler (2006) in transformational terms, it is paradoxically represented by a diagram that suggests an integrative nature. Clearly there are still many issues to be resolved with the TPACK framework. However, in an under-theorised area of educational research it presents a useful and widely accessible model of what teachers do and how they do it. Therefore it is necessary to consider its implications for the role of the teacher in the SynergyNet project even if the methodology and analysis do not take explicit account of it.

## 2.5 Frameworks for analysing collaborative classroom interaction

Engle & Conant, (2002) looked at how students in a 5th Grade class (10-11 years old, same age as the students in this study) worked together and interacted with their teacher and other adults whilst working on an extended project on endangered species, specifically the Orca. The class was following a programme designed on collaborative learning principles called Fostering Communities of Learning. One group in particular engaged in strenuous debate of the classification of an Orca, whether they were more properly called whales or dolphins. It was the interactions of this group particularly amongst themselves and with their teacher, from which the Engle & Conant derived their insights.

To be meaningful, they argue, collaborative activity must be engaged and productive, not just judged by the norms of the classroom behaviour, as Johnson and Johnson suggest with their vague descriptions of monitoring, and ensuring students are on task. Rather the activity must be held accountable to the ideas "of what constitutes productive discourse in a content domain." (Engle & Conant, p.400).

They describe four 4 principles which teachers can follow to foster productive disciplinary engagement in collaborative groups in the classroom:

1. Problematising the subject matter: Teachers encourage students to define problems for themselves and to treat the claims and explanations of others as needing evidence to support them.
2. Give students authority: The teacher encourages students to become stakeholders in the investigation, taking authorship for their explanations by critically engaging with the evidence at hand. They encourage students to be producers of knowledge rather than consumers of it.
3. Holding students accountable to others and to shared disciplinary norms: Teachers must also hold them accountable to external the standards of the discipline which is understudy.

4. Provide students with relevant resources: The teacher must provide access to relevant resources for the students to be able to explore the problem they have been given.

Engle and Conant (p.401) acknowledge their debt to Brown's design principles for creating favourable conditions for classroom interaction (Brown, 1992). However they make the crucial methodological distinction that their principles have not been reached through an iterative process of design and redesign. Rather their work has been to try and explain a complex yet everyday phenomenon after the fact through post-hoc interpretation of the video data.

Engle and Conant argue that teachers should try to create a synergy between these four elements in groups, if the learners are aware of all four elements and their importance they are less likely to become disengaged and off topic. Students are bound together by a principle of mutual respect as co-learners and derive authority not from the teacher but from developing their own learner through the opportunity the teacher gives them. They are accountable to during discussion and feedback sessions but also to the standards of the discipline they are studying (in their case, science) to provide satisfactory reasoning and evidence. It is not only the teacher but the other students who hold group members accountable to these standards (2002, p.450).

## 2.6 Studying teacher mediated learning

There is a paucity of research which focuses exclusively on teacher discourse during collaborative learning (Gillies & Boyle, 2008). There are studies back as far as 1990 that found that when engaged in whole class discussion with students, teachers were on the whole very formal, giving instructions, collective praise and collective discipline (Hertz-Lazarowitz & Shachar, 1990 cited in Sharan & Sharan, 1992). When interacting with small groups of students the teachers were more encouraging, more helpful and gave more specific feedback

to students. Building off the work of Hertz-Lazarowitz & Shachar, Gillies (2006) identified six teacher behaviours when dealing with collaborative groups:

1. Teacher control: Instructing, lecturing, providing mechanical reinforcement to students, and reinforcement expressing comparisons between the children's performances, initiative, or behaviours)
2. Questions: Short questions and open questions designed to elicit expected information
3. Discipline: discipline comments directed at individual students, groups, or the whole class
4. Mediation: paraphrases to assist understanding, prompts, uses open questions in a tentative manner to promote thought about an issue the student is focused on, mediates learning between students to encourage engagement about an issue.
5. Encouragement: praises student's, group's, and class efforts, encourages interactions among students and expresses spontaneous emotion
6. Maintenance interactions: helps the student during learning, refers to the problem task without punishing, refers to technical problems in carrying out the task, and language needed to maintain the activity

Gillies found that when compared to teachers teaching in a traditionally structured class with periods of whole class teaching and individual work, teachers employing collaborative learning structures were more likely to engage in questioning, mediated learning behaviours and make fewer disciplinary remarks (2006, p285).

In subsequent work the concept of teacher mediating learning was explored further and five subcategories of mediated learning were identified (Gillies & Boyle, 2008):

- Challenging basic information
- Using cognitive and meta-cognitive reasoning
- Prompting
- Focusing on issues

- Asking open questions
- Validating and acknowledging students efforts.

The major difficulty with the work of Gillies and Boyle is the role ascribed to questions. To treat questions as an end rather than a means underestimates their versatility and ultimately their potential use in teacher student interactions. Questions can take on so many forms and be used for a multiplicity of purposes from classroom management to abstract reasoning (Smith & Higgins, 2006; Beauchamp & Kennewell, 2010). The advantages of the Engle and Conant four category scheme is that it is inclusive of questioning in each of its categories, it also can apply to both mediated and unmediated utterances, situating them in the teachers' efforts to structure class learning.

A very different approach to understanding teacher interaction with students in a collaborative activity was taken by Greiffenhagen (2011). He argued that an ethnomethodological study could help tackle the lack of understanding about this area of teacher pedagogy because an ethnomethodological exploration significantly differed from discourse analysis in its approach. Rather than look for hidden meaning and underlying patterns it just dealt with what was discernible on the surface. Griffenhagen's analysis of a secondary school teacher's ICT lessons in a computer suite grouped the behaviours of the teacher he observed into the following five areas:

| | |
|---|---|
| *Ratifying:* | Students expect that teacher will stop and look at work as part of their rounds. One function was to keep students focused on the teacher's educational aims, not just on what they found interesting. |
| *Making suggestions:* | Teacher tried not to impose their authority and will but to stretch students, making the task more complicated and challenging. |
| *Maintain classroom control:* | The teacher equated classroom discipline with students sitting at their desk, not talking too loudly and appearing to be working. |

| | |
|---|---|
| *Making whole class announcements:* | The teacher's reason for sharing was that it was likely that other students would encounter the same problem; sharing solution would save time and effort. |
| Linking the activity to the exams: | Activities may have been seen as worthwhile standalone exercises, but most are embedded in the larger programme of work of preparing students for an exam. |

The behaviours observed by Grieffenhagen are similar in many respects to those already noted by Engle & Conant and Gillies and her collaborators. Unlike Gillies, both Griffenhagen and Engle & Conant make explicit reference to whole class interventions during the session. Neither treats group work and whole classwork as separate entities but see links between them. This is not something which is explicitly covered in much of the teacher interaction literature.

Griffenhagen also links the interactions to the wider context of exams which frame activity and add a meaning and context that give them a dual relevance. Students are not just working to improve their skills. They are preparing themselves for external high-stakes assessment in the future. Such reminders are another form of accountability which students are familiar with and one which it is not possible for them to forget even when trying to apply other disciplinary norms to their work. This reinforces the reality that the voice of the teacher and the learner in classroom dialogic interactions are not the voices of equals but the voices of Magisterial and Novice (see section 1.2).

Engle and Conant focus on the process of interaction rather than its wider context, regarding the teacher as responsible for class management and reporting that teachers and students responded accordingly to this. For them the teacher is supposed to have a visible and uniquely different role. Their stance is a pragmatic one. Where difficulties arise however, is their assertion that the teacher holds the students accountable to the norms of the discipline under investigation (Engle & Conant, p.400). However, the notion of disciplinary norms is

problematic because the students are already immersed within the norms of their own discipline. They are unable to free themselves of the roles of students within a formal learning context to fully become investigators within a scientific context. This is a conceit of the classroom, their disciplinary norm can require them to role-play using the norms of other disciplines but it does not allow them to completely immerse themselves in these. The teacher's role is to hold students accountable to their own disciplinary norm, that of learner in the classroom. This role can encompass a degree of adoption of the norms of other disciplines but it can never be substituted by them.

## 2.7 Conclusion

Theories of collaborative learning both at the level of knowledge creation within the learner and at the level of collaborative classroom interaction have been well studied for many years. Nevertheless there remain some important areas still to explore. Firstly, the role of the teacher within the interactions with pupils remains a problematic one. The issues surrounding the perceived role of the teacher themselves and how their perception by learners may be distorted by the power relations present within the classroom need to be explore further. Related to this, the role the teacher plays as an interactor, be it as orchestrator or within an intermental development zone, needs to be further explored. They are an inter-actor with learners but not necessarily a collaborator.

A second issue which is not widely considered in the literature is that of transition. The teacher orchestrates transitions between group and class activities. However, these do not always follow a set format, class discussions are not always book ends for collaborative activities. There are mini-plenaries within lessons which are never mentioned within the literature but are certainly part of lessons observed within this study (for a full exploration see Chapter 7). These differ from the whole class announcements mentioned by Griffenhagen (2011).

Thirdly, the study will contribute to the practical and theoretical characterisation of the teacher's role in orchestrating the classroom. Dillenbourg & Jermann (2010) present educators with a checklist of qualities, Kennewell, Tanner, Jones and Beauchamp (2008) with a model of managed affordance and constraint. This study will consider how these might be brought into practice within collaborative activity and how they may be related to the successful completion of collaborative tasks within the group and within the class.

Finally, the teacher and the student always interact with their location and this location conditions their perceptions of the roles they have and the roles they expect. The study has adopted the framework described by Engle and Conant as a viable means of exploring the nature of teacher student-interaction. However, the idea of a disciplinary norm or disciplinary practice outside the bounds of the classroom is not one which is felt to be practical particularly in the context of the primary classroom, where students are used to the same teacher for all lessons, who stays with them for a whole year. The teacher and the student are unique in their relationship which encompasses the adoption of other roles within it. However, the one they must always return to and which frames all their interactions is that of the actors in the classroom. Therefore when the framework is applied to the data collected in the study it will be within this context. The teacher will be regarded as seeking to foster disciplinary engagement but it will be engagement with the 'discipline' of the classroom learner. That is, with the culture and mindset in which the students are automatically engaged in during their time in school. They will also be regarded as holding students accountable to disciplinary norms. However, these norms shall be those of the classroom learner, adhering to the rules and behaviours which are already very familiar to them from their previous years of schooling. For a description of how this framework is operationalised in the study please see section XX.

The present study was part of the wider SynergyNet project. This was a major interdisciplinary project which looked at the evolution of teaching and learning in the classroom from multiple perspectives. It also looked at the changing needs and opportunities for research in this environment. The contributions of this study will not only be theoretical. It is hoped that they will also provide a platform for the discussion of innovative tools and methodologies with which to better understand classroom interaction. The following chapter begins with an overview of the SynergyNet project, the research it has already published and the niche into which this study fits. It will then go onto look at the implications for the future of classroom research of multi-level simultaneous audio-visual data collection and how this study has gone about operationalizing techniques to best qualitatively and quantitatively analyse the large quantities of data available.

# 3 Methodology

## 3.1 Introduction

This study formed part of the wider SynergyNet project. SynergyNet was a four year interdisciplinary research project funded by ESRC and EPSRC through the Teaching and Learning Research Programme Technology Enhanced Learning phase (TLRP-TEL). SynergyNet investigated the use of multi-touch technology in a classroom situation from the perspectives of computer scientists, educational researchers and psychologists. The study was therefore made possible due to the unique design of the SynergyNet classroom environment. Ten cameras and six microphones were used to record audio-visual data, giving a rich detail which allowed the study of interaction at individual, group and class level, often simultaneously. Part of the computer science contribution to the project was new software which enabled the temporal analysis of audio-visual data coupled with the transcription of what was said. This allowed detailed analysis of the teacher's words and movements in relation to those of the groups of students around the table.

The aim of the study is exploratory. This was the first time that it had been possible to study groups working nested within the context of a classroom environment in this level of detail. Although the study was run under a number of different conditions, and the main purpose was not specifically to compare one with another. Comparative studies had been run earlier in the project (Higgins, Mercier, Burd & Joyce-Gibbons, 2012). Rather the study was exploratory: to explore the pedagogic interaction between the teacher and students at the group and class levels.

This chapter shall outline how the study fits in with the broader educational research aims of the SynergyNet Study. The research questions this study will pose will be discussed in the context of the wider project. The chapter will then describe how the study was run,

coded and analysed. Finally some of the constraints placed upon the data collection will be discussed and how these may limit the study's findings.

## 3.2 An overview of the SynergyNet project

The SynergyNet project was a four-year study by Durham University's Technology-Enhanced Learning Research group which had a long standing interest in developing innovative learning spaces (Hatch & Burd, 2006). The group brought together a multi-disciplinary team of computer scientists, education researchers and psychologists, each participating with different research methodologies and research priorities. The drive behind the project was a concern that the 'move to use' requirement inherent in much educational technology hardware present in classrooms detracted from the educational impact of that technology. SynergyNet was an attempt to integrate ICT into the fabric of the classroom in such a way as the technology does not intrude on the main focus of the activity (Smith and Harrison, 2001).

The project focused on the development of multi-touch technology, both hardware and software, which was designed to facilitate classroom dialogue by providing unobtrusive and instantaneous transitions between group working and whole class discussion by enabling the teacher to control the distribution and operation of programmes and information on all the multi-touch tables in the classroom. It was also thought that as the multi-touch technology also obviated the need for a mouse it may have increased participation, allowing members to simultaneously interact with the technology and each other.

The SynergyNet project had four aims:

5. To create a radically new technology-rich learning environment that integrated with traditional classroom layouts and collective activities.
6. To design and implement a new form of user interface for educational multi-touch systems.

7. To formulate a new pedagogy that eased transition and movement between teacher-centric and pupil-centric interaction.
8. To analyse pupils' learning strategies to inform fundamental research by capturing data as pupils use the SynergyNet environment.

The SynergyNet project began with studies comparing the behaviour of students completing comparable tasks on paper and on the multi-touch tables. It was found that the students working on the multi-touch tables were able to create a shared understanding of the task more quickly than those doing so using paper based tasks (Higgins, Mercier, Burd & Joyce-Gibbons 2012). Those using the multi-touch tables used them to externalise their thinking in ways which indicated joint cognition more frequently and were more frequently successful at tasks than groups attempting paper-based versions of these (Mercier, Higgins, Burd & McNaughton, 2011). Such studies were a means of beginning to evaluate the first aim of the project.

The second aim, to design and implement new forms of interface, was one which evolved throughout the project. The classroom as setup during the data collection for the present study is described in section 2.2.4. However, it is important to note that this arrangement was part of a narrative of computer science development which began with the task being loaded individually by computer scientists. The next stage in the evolution was an orchestration desk, a multi-touch computer used by the teacher to control all the tables simultaneously (the study was carried out using this desk). The desk was replaced by an iPad with an app which replicated the same functionality but which allowed the teacher free range of movement within the class. Finally, the teacher controlled the students' boards using a series of contactless gestures, interacting with the tables using gestures which were picked up by an Xbox Kinect sensor system (Mercier, Higgins, Burd & McNaughton, 2012).

The fourth and final aim of the study resulted in the SynergyView data analysis tool (for a screen shot of this tool and the features it contains, please see section 2.2.8). This program allowed researchers to synchronise audio, video and transcript data into one feed which they could explore in detail. Data can be played forwards or backwards. It is possible to go to a specific time point if required. The transcription data can be assigned to speakers and the granularity of the playback varied to show either an overview of the transcript whilst video is playing or the individual utterances. This transcription tool played an integral role in the analysis of the data collected for this study.

It is the third aim of the SynergyNet project which this study seeks to address. It looks at the kinds of interaction between the teacher and the student in a classroom setting. In this setting the teacher speaks to various groups at various times. They may speak to the individual; however, they do so because that individual is the member of a class or the member of a group which is focused on the completion of a set task. The arrangement of the data recording and analysis capabilities of the SynergyNet project allows the researcher the equivalent of a varifocal lens. They are able to look at interaction within groups, look at interactions between the teacher and groups and they are able to look at the interaction between the teacher and the whole of the class. Whilst the pedagogy used (discussed below in section XX) is not self-consciously designed to be different in any way to that which might be reasonably employed by a teacher in a normal classroom, in examining the interactions of teachers with students, it is hoped that insight will be gained in to the strengths and weaknesses of the teachers' craft. These insights will inform future thinking about teaching and learning during collaborative activities; not only those where multi-touch tables are being used.

## 3.3 Research Questions

The SynergyNet data collection facilities and the SynergyView tool afforded researchers the opportunity to collect and analyse extremely detailed data on the interactions between the students and the teachers. The general aim of the data collection in this study was to inform the development of new pedagogical techniques by exploring the interactions which occurred in great detail. These took place in a variety of conditions and at a variety of levels (teacher to group, teacher to class).

The overall question which this study seeks to explore:

*How does teacher orchestration of collaborative Mathematics tasks relate to the learning and interaction which takes place?*

There are four more specific questions which were asked which defined the data collection and analysis which support these questions. In general teachers are tasked with helping students achieve their goals. In the case of this study, the first question to be asked was whether teacher interactions with groups of students was in some way related to the subsequent success of that group.

However, task success may not be the only factor which prompts teachers (explicitly or implicitly) to interact with their students. These interactions may be prompted by the conditions in which the lesson is being held. The gender of groups or the arrangement of the tables may influence interactions. Therefore a second question is whether the teacher's interactions with the students are associated in some way with the conditions under which the study was run.

No two interactions, nor the utterances which comprise these, are the same. They are made to different people with different needs at different times. However, past studies have attempted to categories these and look at how or why they have influenced students. Engle and Conant (2002) describe four categories of teacher utterances, discussed in section 2.5.

The study will explore whether these four categories are applicable to the data collected and analysed using the SynergyView tool (which also has the capability of assigning categories to specific utterances). If they are applicable, how are they related to the success of groups which receive them or to the conditions in which the study took place?

Finally, the idea of a mini-plenary, though common in classroom practice, is a little studied phenomenon in the research. Mini-plenaries take place when the teacher decides to stop the groups from working and refocus them together as one class. They then address the class together, either to tell or to discuss something, before asking the groups to return to working by themselves once again. There is some evidence, also studied in the SynergyNet project, to suggest that they are influential in moving group reasoning forward and promoting joint attention (Mercier, Higgins, Burd & Joyce-Gibbons 2012). However, much remains to be explored in this area. This study will look at how the mini-plenary relates to the interactions between the teacher and the groups which make up the class.

*Table 1: The research questions of this study*

| | |
|---|---|
| *1* | *Are teacher interactions related to group success?* |
| *2* | *Are teacher interactions related to the conditions under which the study is carried out?* |
| *3* | *Are the categories of utterances which comprise teacher interactions related to the success of the groups to whom they are made?* |
| *4* | *Are the categories of utterances which comprise teacher interactions related to the conditions under which the study was run?* |

## 3.4 Data collection

Before the data collection sessions for this study, teachers and researchers in the SynergyNet team visited each school to work with a whole class of Year 6 students. This session involved introducing the students to strategies of working collaboratively to solve Mathematics problems. It also introduced students to the format of problems used and told

them about the SynergyNet project. At the end of the session participation was invited and parental consent forms were given out.

The data for this study was collected over six sessions. Six schools participated. To preserve, as far as possible an ecological validity of class cohesion, the students for each session came from the same class. They were seated in four groups of four students, each around a multi-touch table. Apart from gender balances for the tables (two schools sat in mixed groups, four sat in single gender groups), the students were not assigned seating and were able to choose who to sit with.

Two teachers, who were also researchers in the SynergyNet team, also participated. They fulfilled the role of the teacher in each session. Each teacher took one entire session which lasted for two hours and consisted of tasks and introductory activities. These introduced students to the working of the tables and reminded them of their previous experiences of working in groups to solve mystery problems as they had done in their ordinary classes.

The first introductory games calibrated the tables to ensure that the students' touches were registered by the tables. At the same time they introduced them to the affordances and constraints the tables offered. After they had completed these they were asked to attempt a history mystery task. They were asked to use the clues presented on the table to discuss why 16 people died in the Great Fire of London. This was one which they had attempted previously in the session the researchers ran in the classrooms prior to each visit. The purpose of repeating this activity was to get the students to make a transition from using paper based clues to those on the table and to become familiar with the actions associated with the clues, rotation and resizing.

## 3.5 The Mathematics tasks

Mystery tasks, such as the Great Fire of London task have been used for a number of years in research projects looking at the thinking skills (Leat & Nichols, 2000). They were developed in response to a perceived need for students to focus on the process of constructing understanding through an explicit thinking process and recognition that teachers needed a structure they could use and develop to support this. The process called for knowledge to be regarded as a fluid rather than a fixed concept, one which students arrived at through questioning, reasoning and discussion (Mcguinness, 1999).

The rationale behind using the mysteries at all was that they were a pedagogical tool to help the students focus on a shared artefact and thereby have to discuss its significance. The mysteries were a 'powerful pedagogy', one which exhibited all the characteristics of an activity which could change learning dramatically (Leat & Higgins, 2002). They were flexible, transferrable, encouraged talk, brought about a change of thinking and did not lead to one explicitly right answer.

Their development drew on the work of Wood who had tried to operationalize Vygotsky's concept of a Zone of Proximal Development. This zone describes the gap between what a learner is able to achieve on their own and what they are able to achieve with the help of either an adult or the help of more competent peers (Daneils, Cole & Wertsch, 2007). Wood identified several tutoring functions which adults performed when working with learners: recruiting the learner's interest, establishing and maintaining an orientation to task-related goals, highlighting critical features, demonstrating how to achieve goals and helping to control frustration (Wood, Brunner & Ross, 1976).

The Mathematics tasks were not, strictly speaking, 'mysteries' as they did lead students towards a specific right answer. Rather, they were tasks which adopted the delivery mechanism of mystery tasks to deliver segmented Mathematics word problems. However, given they exhibited most, if not all, of the characteristics identified by Leat & Higgins

(2002, p74); they can be considered as ‘powerful pedagogic strategies’. Some pieces of information were included which were not relevant (referred to by the researchers and students as “red herrings”. The clues used in each of the three mysteries are detailed in appendix 1. On the continuum described by Nystrand, Gamoran & Heck (1993) in Section 2.3.2 the Mathematics tasks are problem solving tasks, explicitly designed for groups rather than adapted individual exercises.

The mysteries used in this study were not designed to specifically elicit these behaviours from the teacher; rather to elicit from the students situations where they were able to be explicit about their reasoning when in search of a solution for each task. As part of that process of striving for a solution, they would find it necessary to articulate their thoughts about the clues they read, sharing these with other group members thereby creating a joint cognition of the nature of the task and the nature of the solution necessary to complete it (Higgins, Mercier, Burd & Joyce-Gibbons 2012). Whilst this was taking place, the mysteries would provide the opportunity for the teacher to display behaviours similar to those described by Wood *et al.* (1976) in the course of their interaction with the groups.

The convergent nature of the Mathematics tasks may be reasonably supposed to lead to different collaborative behaviours among the students, however, there is no reason to suppose that this would be ‘less’ or ‘more’ so. Rather they were included in the study to provide a contrast to the more open History tasks. Red herrings were included to avoid giving students the impression that all the clues were equally relevant or valid (this was also the case in the History task).

The three tasks each focused on a different area of mathematical skill; reasoning with numbers, arithmetic and logic. Each task related to the ‘Ma2: Number and Algebra’ section of the National Curriculum for Mathematics; specifically sections 1a, 1b, 1d, 1h, 1i, 3h, 4a

and 4b (these references refer to the National Curriculum as it was when the tasks were designed in 2009).

The conditions of the study are summarized in the Figure 1: Each of the six schools is represented in the order in which they participated in the study. The students from each school were either seated in single gender or mixed gender groups. They were seated at tables which either faced the front of the room or the centre of the room and they were taught by either Teacher 1 or Teacher 2. The groups were referred to as by the coloured panel on the side of the multi-touch table, Red, Blue, Green or Yellow.

## 3.6 The Study Procedure

The data analysed is based upon observations of 24 groups of students engaged in three mathematics tasks. The groups came to the lab in classes of 16 from six different schools, Benbrook, Dunhulme, Easterburn, Seacrest, Shadbrook and Yadstone. The students were seated in four groups of four: Blue, Green, Red and Yellow. Throughout the day they were given a number of exercises to do including the three mathematics tasks. These tested different areas of mathematical ability, reasoning about number, arithmetical computation and logical thinking. Each task was designed to last between five and ten minutes, though the teachers delivering the task were allowed to let the task run for as long as they thought necessary. It is from the audio-visual transcripts of these tasks that the data is derived.

Each task followed a similar structure in its delivery. First of all the teacher would introduce the task and perhaps clarify any contextual or comprehension issues they anticipated the students may have. For example in the Arithmetic task the teacher needed to ensure that the students were familiar with a fairground waltzer and with soft-toy monkeys. The students were then given time to read and discuss the clues on the table and attempt to work out the answer. During this time the teacher would move around the groups, observing

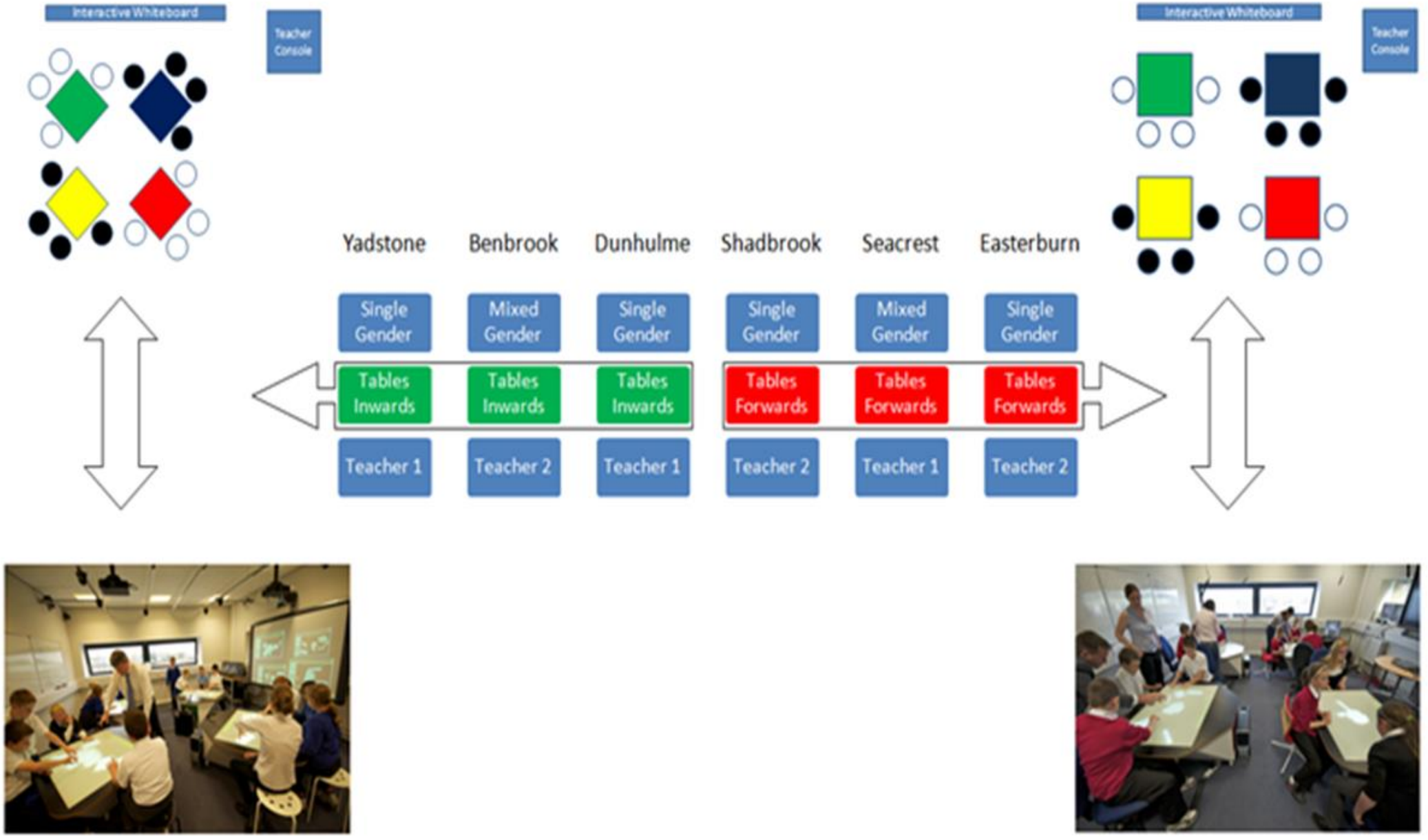
and interacting with one of the four groups. Finally they would stop the groups from working by themselves and bring them together into a whole class discussion as a plenary.

The tasks were carried out by schools in different conditions, the grouping of tables in the classroom and the seating of students in mixed or single gender groups was varied throughout the study. The various permutations of the variables are summarised in Table 2:

Table 2: Variables and conditions in the mathematics study

| ***School*** | ***Task*** | ***Room Orientation*** | ***Gender grouping*** | ***Teacher*** |
|---|---|---|---|---|
| Benbrook | Reasoning | Centred | Boys-only | Michael |
| Dunhulme | Arithmetic | Traditional | Girls-only | David |
| Easterburn | Logic | | Mixed | |
| Seacrest | | | | |
| Shadbrook | | | | |
| Yadstone | | | | |

*Figure 3.1: A summary of the conditions under which the study was carried out*



### 3.6.1 Data collection and construction

Data is constructed from observed reality. The robustness of any research findings are dependent on the validity and reliability of the methodologies employed in data collecting as much as they depend on the validity and reliability of those used to analyse this data. Indeed this section will argue that the process of data analysis in this project began with the transcription of dialogue from the video recordings (Bucholtz, 2000).

No form of data capture will ever give the researcher a true or complete picture of what took place. The debate then, is how best to achieve the most complete understanding available, whether by human, real-time observations and notation; or the post-hoc review and treatment of videos. This is between what Duranti (2006) terms the hypercontextualist position and the visual-realist position. Both, at their extremes are fallacies, "reified epistemologies" which contend on the one had that recording classroom interaction is no substitute for experiencing it and on the other that careful use of video can actually create a more accurate reality for the observer than they could ever achieve by participation in a classroom. It was decided that in this research that the data would be collected by recording for two reasons. Firstly, the researchers involved on the project were both trained teachers and the only ones familiar with using the multi-touch table control system. Secondly, the research questions require that data be collected from individual students interacting with teachers and fellow students at both a group and a whole class level. It would not be possible in the small space available to have sufficient observers to code such interactions and yet still maintain the atmosphere, as far as possible, of a working classroom.

It was this need to capture a multi-layered data set that gave rise to one of the challenges for the Computer Sciences researchers on the project. To design a tool that allowed for the integration of multiple video streams with audio and transcription data too. This section will look at the implications of the data collection methodology; from the choice

of video, to the nature of transcription as a process of analysis. Finally the tool developed for the data collection will be described and evaluated in the light of theoretical concerns raised.

### 3.6.2 Ethical considerations

The study was carried out in accordance with the ethics procedures of Durham University. The SynergyNet project had received an overall approval for its aims, objectives and proposed methods at the beginning of the project. This study received specific approval for using children as subjects.

In the first instance schools were asked for their consent to participate as a school. The SynergyNet team worked with each school to develop a detailed risk assessment covering all areas of the students' time in the TEL lab. See appendix seven for an example copy of a risk assessment.

The students participated with informed consent; researchers visited the schools prior to the data collection and gave a presentation on the study, our aims and what they could expect.

Once students had expressed an interest in participating in the study, they were given information and a consent form to take home. This gave their parents more information on what they were being asked to do. It also asked for written permission to use anonymised images of the students in research reporting and marketing which arose from the project. Only students who returned a parental consent form were eligible to participate in the data collection. See appendix eight for a sample copy of a parental consent form.

Sixteen students came from each school. The study proceeded on a maximum adult to student ratio of one to nine. To help ensure their safety and comfort, the schools sent one adult, either a teacher or teaching assistant, with the group for the whole day. This meant that one of the research team accompanied the students when travelling between the university

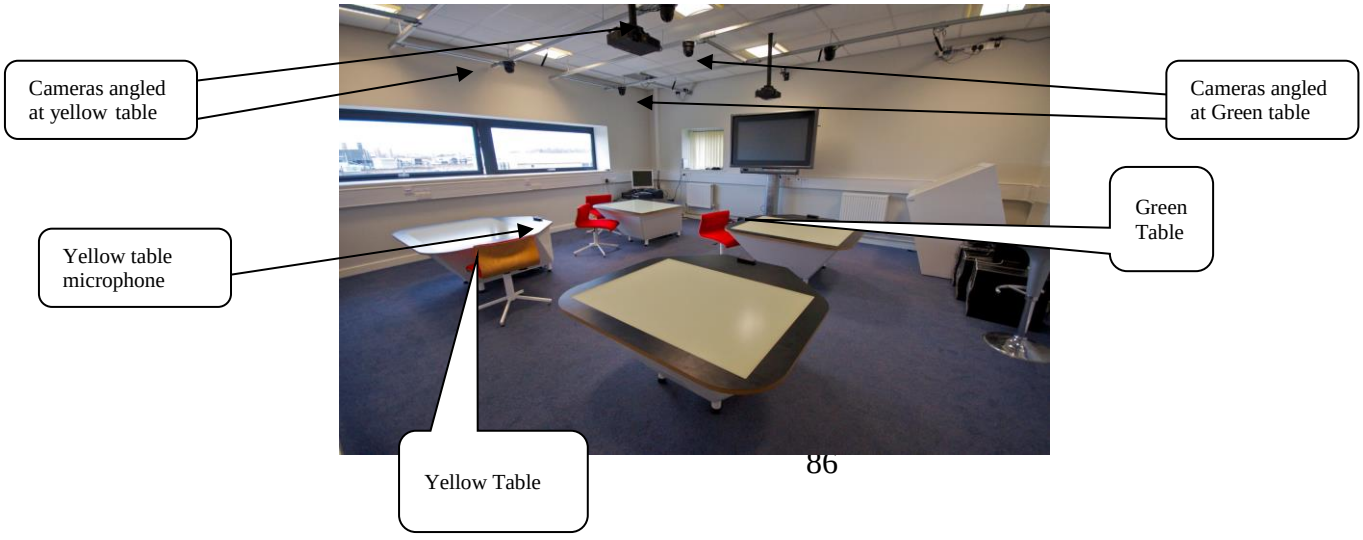
and their school at all times. The transportation company we used employed drivers who had themselves been through the enhanced Criminal Records Bureau disclosure process.

The risk assessment which was filled in covered the time spent in the lab, the transport between school and the university, the tour of the university library which all students were given and the interactions in the refreshments area when the students were having a break between sessions.

### 3.6.3 Why use video?

Studying the dialogic interaction of teachers and students in a group problem solving task requires a far richer data than can be supplied by a transcription of words spoken. Video recording rather than audio recording is essential because it captures the gestures and paralinguistic features which are lost in purely audio recording (Plowman & Stephen, 2008). Features which require careful and repeated observation to be identified accurately and therefore may be missed by live observers who may be too distracted and overloaded by classroom interaction to take note of what has actually transpired. Provided that the cameras angles are set up in a way that captures the interaction of students and teachers, then video allows a permanent record to be made of a huge number of subtle nuances which surround and qualify the utterances made by students.

***Figure 3.2: The use of video in the SynergyNet classroom***



Cameras with two angles on each table were suspended from a gantry above the tables; a microphone was placed on each table for a separate audio recording stream. The design of camera was chosen to be as unobtrusive as possible. In two opposite corners (far right and near left in the classroom as seen in this picture) were wide angle cameras which had all four tables in their field of view at once and clearly showed the movement of the teacher between groups. This was not captured well by the cameras focused on the tables.

***Figure 3.3: The camera angles available for each table in the SynergyNet classsroom***

The left and centre shots show the camera angles for the blue table group and the right shot shows one of the cameras recording the teacher's movement around the whole class.

### 3.6.4 The case for observation and against video:

Live observation has advantages over video recording data. Smith and Hardman (2003) argue that coding in real time during lessons has two advantages over using video and post hoc analysis. Firstly, the researcher is able to produce and analyse data almost immediately. This allows them to carry out analysis as the project progresses and evaluate their progress towards answering their research questions and adjust the methodology if necessary. Secondly, not spending time and resources on transcription enables researchers to devote more time to data collecting, thus creating larger data set.

There are also two disadvantages to using video recordings which are reduced by using direct observation. The first is psychological, noted by Smith and Higgins (2006) is that the presence of video cameras might render the performance of teachers and students under observation far less authentic than would be obtained by an unobtrusive observer in the classroom. Plowman and Stephen (2008) also make the point that in determining where a camera should point, the researcher is making a judgment about what may or may not be important to record prior to it happening. They also may forego being able to record interactions which happen at a distance that are common in schools, such as looks and gestures used by the teacher to control behaviour. These two concerns have been addressed by the SynergyNet data collection set up. To understand this it is important to consider the physical nature of the recording equipment in each case. Smith and Higgins (2006) referred to large video cameras set up on tripods in a classroom at the students' eye level. These were indeed extremely obtrusive and in both the field of vision and in the way of students, teachers and researchers alike. Cameras in the SynergyNet classroom are small and suspended from the ceiling, far out of the field of vision, so as to reduce their effect on the behaviour of students at the tables. Secondly, Plowman and Stephen were referring to hand held cameras, which were used to record the highly mobile play among preschool students. Due to the nature of the tasks, where students are asked to sit and work at tables, the cameras could be fixed and the angles that they captured could be planned. There were rare occasions when students moved around but they did so in such a way that at least one camera and the microphone were able to record their words and gestures.

### 3.6.5 The practical benefits of video data

Video recording of classroom interaction may not make data available to researchers immediately, or be able to capture some of the nuances of mood and interaction in the same way that an observer may be able to interpret these. However video recording, as organised

by the SynergyNet project does have a number of distinct advantages. Unlike previous video recording methods, the gantry of angled cameras is unobtrusive, which allows for more authentic interaction to be observed. It is comprehensive, with multiple cameras and audio feeds recording words, movement, gesture and para-linguistic features. All of these would be lost to live observation. Finally it is synchronised so that the each group's video can be observed in an overall timeline for the class or cross referenced with groups from different classes so their task play side by side.

The rich, voluminous data set collected of the problem solving sessions may also be potentially a disadvantage. It is easily possible to have too much information to accurately judge what is relevant. Structured observation does this by researchers agreeing a stringent coding scheme in advance, testing it and then applying it (Smith and Higgins, 2006). However, no matter how well trained the observation team, there will always be questions over validity and reliability as there is no means of independently verifying the interaction made in classrooms (unless video is used). These threats are reduced by making video available to a wide range of researchers who can use and discuss the evidence, making use of different aspects of what was recorded or verifying the observations of others. This is particularly important in the context of working in an interdisciplinary team and with an iterative methodological process where the video record will be viewed and analysed multiple times by team members who have very different research interests (Engle, Conant & Greeno, 2007). The vast amount of data collected, the ability to reuse data to answer a variety of questions, the ability to have observations independently verified are all important reasons why video provides the best possible record of the investigations for the multiple uses it was be put to by the SynergyNet team.

### 3.6.6 Why use transcription?

The transcription process is not a mechanical one. Nor is it one which will ever be free of either subjective judgment or theoretical concerns of the transcriber and interpreter (Barron & Engle, 2007). However if such realities are accepted and explicitly accounted for, it is possible to create a record which is robust and can withstand interrogation on multiple occasions by one or more researchers with numerous research questions.

Transcription requires some degree of personal judgement by the transcriber. If carried out well it can lead to a document which as far as possible accurately represents what was said by subjects. A rigorous transcription process produces a document which can be analysed and disseminated by large numbers of researchers over a long period of time and great distances. If, however, transcription is not carried out in a rigorous manner, the transcript can be inconsistent in its coverage of the data and biased in its representation of what and how the subjects spoke. This section will make the case for transcription and then outline how this was carried out using the SynergyNet transcription tool, specifically designed for our project to situate the transcripts in the most data-rich context possible.

Written language cannot contain or convey the diversity and nuance of spoken interactions. The transcriber therefore makes a determination in their words as to how to represent this reality, based upon their 'scholarly disposition' (Bucholtz, 2000). This is their mindset, in the light of experience, knowledge of the subjects, the research questions and the idiosyncrasies of the language used by the subjects.

The process of constructing a transcription and the role of the transcriber, though oft forgotten in most considerations of validity and reliability of data, are in fact central to the quality any subsequent data analysis. It is not sufficient to regard them as agency free. The act of transcribing requires considerable creative activity which Jenks likens it to painting,

> "A transcript is not only a representation of communication data, but also a reflection of the person who created it, what features of talk and interaction he

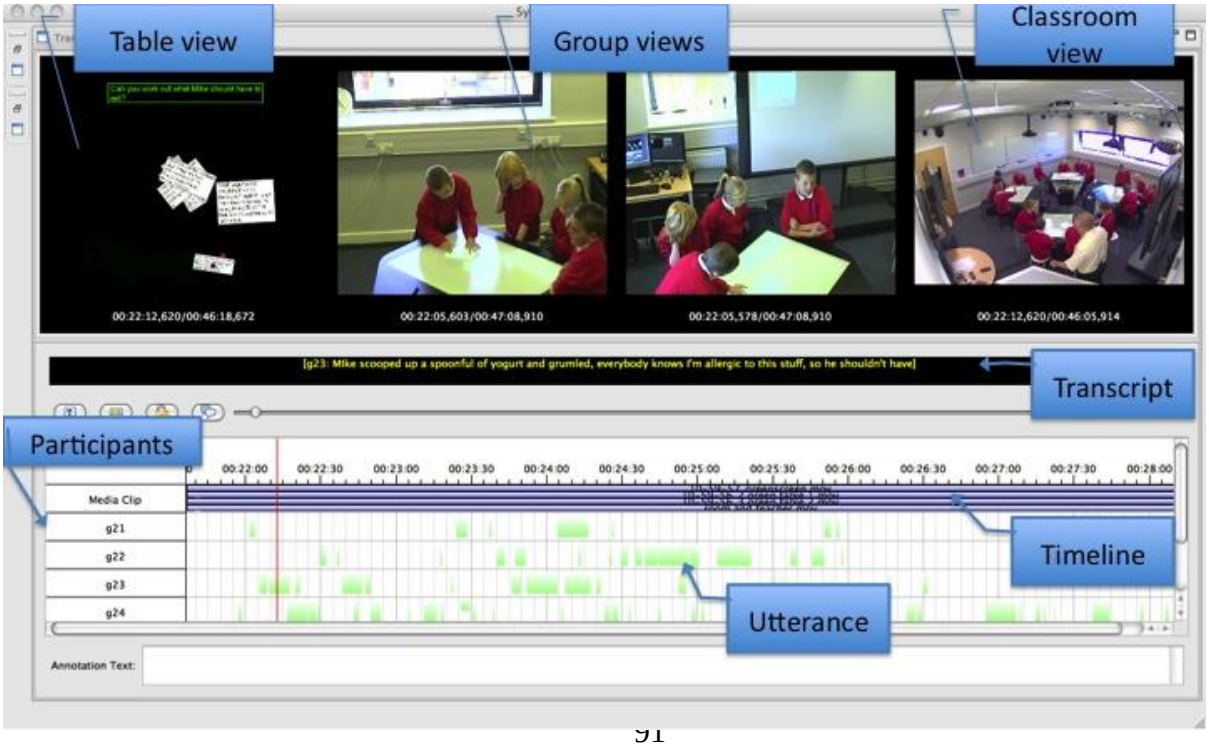
or she is interested in, and the human and technological resources available to this person during the transcription process." (Jenks, 2011, p.15).

An important part of the considerations of this section will be the technological resources available to the transcriber. It is neither desirable nor possible to separate the practicalities of transcription from the theoretical implications of this process. SynergyNet has attempted to develop a tool which does not just enable researchers to produce a thorough transcription, based upon as rich a source of video information as possible, it also provides a means to analyse the transcript produced in concert with original audio and video data.

### 3.6.7 The four roles of a transcript

A transcript has four roles in the process of research into classroom activity. The first is as a representation of what was said. However, it is important to remember that it is only a representation. Communication is spatial, temporal and ephemeral in nature. It is as impossible to fully analyse in real time as it is to fully capture upon paper (Jenks, 2011). A transcription is the process of taking something dynamic and organic and representing it in a fixed state (Bucholtz, 2007).

***Figure 3.4: The properties of the SynergyView tool***



The SynergyView transcription tool has tried to address this creating both a verbal and temporal transcript where each utterance is transcribed and allocated a set amount of time a timeline for the activity which shows each speaker separately, the properties of the tool are shows in Figure 3.4.

The tool is capable of presenting synchronised audio, video and transcription. Thus the transcription which is created in the SynergyNet transcription tool provides an enhanced representation of what was said, when and by whom to any observers in a way which is not possible with a normal transcription document which only lists utterances one after the other with only a start and end time to indicate duration or overall participation.

The second function of the transcript is to assist in the interpreting of other data sources. Even when complete, Jenks argues that the transcript should not be regarded as a paramount source but should, as far as possible, be studied in conjunction with as much audio and video data as possible. The transcript does represent details of talk and interaction which are often overlooked by the naked eye. “Data recordings are necessary, as they allow instant and nearly unadulterated access through the lens of a camera... while transcripts represent details of talk and interaction that are often overlooked by the naked eye (and/or ear)” (Jenks, 2011, p.5). Although there are there are transcription protocols such as Conversation Analysis, Santa Barbara School and Gesprächsanalytisches Transkriptionssystem that attempt to capture in great detail the micro and mundane elements of talk. Transcription alone may fail to convey the tenor and mood of interactants or the interaction. Therefore, the SynergyNet transcription tool allows the researcher to view the transcript in conjunction with multiple video and audio streams so that verbal and non-verbal interaction can be studied from several angles. Note also that the screens of the multi-touch tables are included as well.

This allows researchers to see what interactions subjects were having with the tables whilst speaking or listening.

Jenk's (2011) third function for a transcript is that it can be disseminated among researchers around the world. Stemming from their fourth use is that they can be verified. Researchers not present at the data collection, indeed years or miles distant, can study a transcript and confirm or dispute the findings of original researchers. Or alternatively, they can use the transcript for their own purposes and pose new research questions with which to interrogate the data. The SynergyNet tool is electronic so it is even easier to share data than with a physical hard copy. The combination of transcript and multiple audio-visual data sources means that the user of the tool has access to a very rich data source, which not only allows for more accurate assessments of the initial researchers' validity and reliability in their transcription and subsequent data analysis. It also enables the data to be used in a larger variety of studies, increasing impact and value for money.

### 3.6.8 The selective process of transcription

The North East of England has a number of strong dialects which can differ greatly example from Standard English in pronunciation and vocabulary. This was a significant theoretical consideration in the transcription process. Transcription, Ochs (1979, p.44) reminds us, is a selective process that is dependent on theoretical goals and definitions. To study the interactions of the subjects it was appropriate to transcribe their language as it was spoken by them, rather than convert regional vernacular into Standard English.

The advantage of doing so was that it captured the uniqueness of any interactions, rather than removing idiosyncrasies. It was felt the actual nature of the interactions would be more accessible through the transcripts and the audio recordings would make more sense when understood with the transcripts. It also removed the need for transcribers to make value judgements as to what would be considered 'standard' English. Such value judgements touch

on the issue of power in transcription and it could be argued that an attempt to record vernacular transcripts could be patronising for the participants or lead to negative social judgements by researchers about the subjects that coloured their perception of the character or abilities of the participants. One means by which it was hoped to avoid such judgements and caricatures was to have the researchers involved in the delivery of the activities, also involved in the transcription and analysis of the data.

However, this leads on to another potential difficulty, a restricted perception of the data and the transcript by the researchers, heavily involved in the research. According to Jenks it is possible to develop a tunnel vision about the development of the transcript leading to too much detail in some places and too little in others. Or even to researchers developing an emotional attachment to their subjects which may lead them to transcribe not what they said or how they said it but what the researcher would like to think they have said.

Two measures were taken to mitigate the potential effects of this. Firstly, preliminary transcripts and video data were discussed at length amongst all education researchers in the SynergyNet team. Different interpretations of ambiguous situations, or phrases were discussed as well discussing how, as far as possible to treat frequently recurring vernacular words and idioms. The outcome of these discussions was recorded and a transcription protocol document created that could be accessed remotely by transcribers. This included instructions on the following (A copy of the protocol given to transcribers is included in Appendix 2):

- Re-naming the schools to preserve their anonymity.
- Coping with overlapping teacher talk (not directed at the group being transcribed)
- Punctuation e.g. Not using quotation marks for students reading clues as it was often difficult to distinguish between clues which were being read and those which were being remembered.

- Inter-table talk: ‘other student’ was added as an option to participants of in each group transcription. This is where any utterances to group members from students on other tables are recorded as well as contributions to whole class discussions by members of other groups are recorded too.
- Names: students and teachers were given anonymised but easily identifiable alpha-numerical labels which preserved their identities. These also replaced names when spoken in the transcript by subjects.
- Unintelligible and ambiguous utterances: these were referred to the team members with knowledge of local vernacular who would try to interpret them before anything was labelled as ‘unintelligible’ in the transcript.
- Saving files: to ensure version control and avoid duplication, clear procedures for file saving were agreed.
- Checking the transcripts: undertaken by researchers with first-hand knowledge of local dialect and vernacular who had not been involved with the initial creation of the transcripts.

The SynergyNet education team (2 staff and 4 students) transcribed approximately 50% of all the data collected in the project. The remainder was sent for professional transcription in the UK and USA. I was first transcriber on 50% of the audio undertaken by the SynergyNet team. I was also transcript checker on 50% of the total number of collected transcripts. The research associate or another student working on the project checked any transcript made by me. This process of transcript construction took 12 months.

Transcribing in house and outsourcing transcribing both had advantages and potential disadvantages. Researchers in the project were familiar with all aspects of the data collection and frequently had good knowledge of the local vernacular spoken by the students. This could lead to a comprehensive and accessible transcription of the data with little labelled

unintelligible in the transcript. To guard against a restricted focus or emotional attachment, the transcripts were checked by other members of the team. Outsourced transcription was to two separate companies (to avoid over transcription by a small number of people). Whilst these had no knowledge of the research project or familiarity with the local dialect, they were able to work with detachment and speed. Their work was checked by one and sometimes two team members to ensure maximum intelligibility and coherence with the other transcripts. In the distribution of transcription tasks there is a tension between familiarity with the investigation, time and financial resources. The SynergyNet project aimed to balance these competing factors through clear processes and employing a range of transcription strategies.

### 3.6.9 Progressive refinement of hypotheses

The development of hypotheses based on explorations of video evidence in one of progressive refinement (Engle, Conant & Greeno, 2006). The traditional process of hypothesis generation relies on a clear separation between the research which has led up to the formulation of a hypothesis, what Karp Popper called 'the context of discovery' and the 'context of justification' which is the research which tests the falisifiability of that hypothesis by the collection and analysis of fresh data (Popper, 1959).

Although Popper regarded the process of hypothesis generation as a purely psychological and creative one, he did situate it within a cycle of inductive and deductive reasoning based on the interpretation of observed phenomena in the data. Whilst maintaining the distinction between the data collected which drives the induction of a hypothesis and the deduction of predictions based on that hypthesis of what will be seen in new sets of data. Engle *et al.* argue that in the meaningful interpretation of video evidence there is an interaction between hypothesis generation and evaluation which blurs the distinctions between the 'context of discovery' and the 'context of distinction'.

Every traditional hypothesis testing process should raise further questions and hypotheses to be tested in future investigations. However, the wealth and variety of data it is possible to extract from video recordings of the interaction between students and teachers is such that it is possible to revisit the material repeatedly to test multiple hypotheses which arise either directly or indirectly from its previous viewing and analysis.

## 3.7 The Coding Process

### 3.7.1 Introduction

The process of coding was combined with the process of segmenting the transcript into utterances. Both will be described in this section. It is another instance of transcription as a process of data construction which is informed at every stage by qualitative interpretation by the researcher carrying out the procedure. This section describes the protocols used for coding the level of success which groups had during each task, how the number and duration of interactions was recorded and how the number and category of teacher utterances was recorded as well.

### 3.7.2 Group success

Figure 3.5 shows the value, name and description of the levels of success which were assigned to groups. Deciding on the level of success to ascribe to a group was a process guided by several questions.

***Figure 3.5: The value, name and description of the levels of success assigned to groups***

| Value | Title | Description |
|---|---|---|
| 0 | *No progress* | No engagement, or extremely limited engagement, with the task. Confined to sporadic reading of clues by one or more group members. |
| 1 | *Some progress* | Two or more group members read clues. Little structure when sharing clues e.g. turn-taking. Calculations based on erroneous reasoning (such as taking numbers in clues out of context and using them in calculations). Only single step relevant calculations. |

| | | |
|---|---|---|
| 2 | *Good progress* | Coherent attempts by two or more group members to read and use clues. Multi-step calculations and reasoning to try and solve the problem but final solution are not reached. |
| 3 | *Successful* | Two or more group members solve problem. |

### 3.7.3 What is an interaction?

A single interaction between teacher and group must include at least one utterance by the teacher, it may include more. It may include utterances by group members. Interactions can occur at any time prior to the group completing the task. There is no limit to the time that an interaction may last. It begins with a teacher's first utterance and lasts until the teacher's attention is directed elsewhere. A single interaction may be punctuated by interruptions from elsewhere in the classroom that the teacher may briefly deal with before returning to their point.

### 3.7.4 Which group members were on-task?

For any progress to be made, at least two members of the four person group must be engaged with the task for some of the time. They demonstrate this either by making utterances which show they are engaged, talking about the task, or make relevant and timely gestures on the table in response to other student's utterances which show they are interacting with both the table and another group member.

### 3.7.5 How did the group deal with the clues?

For *some progress* to be made the group must share the information on the clues, the more obviously ordered this process is and the more receptive other group members are, the greater the progress will be.

### 3.7.6 What were the quality of the calculations the group uses?

One or more members of the group may attempt one-step or multi-step calculations or reasoning individually or simultaneously. Multi-step reasoning relevant to solving the

problem is an indicator of *some progress* by the group. Groups which did not make multi-step reasoning utterances only made *little progress* in the task.

### 3.7.7 Is the group successful?

Do they succeed at solving the problem? If so they are coded as being *successful*. If they did not but had attempted multi-stage calculations then they made *some progress*, if they only read clues and attempted single-stage calculations then they made *little progress*. If they did not make even single-stage calculations or single step reasoning they made *no progress*.

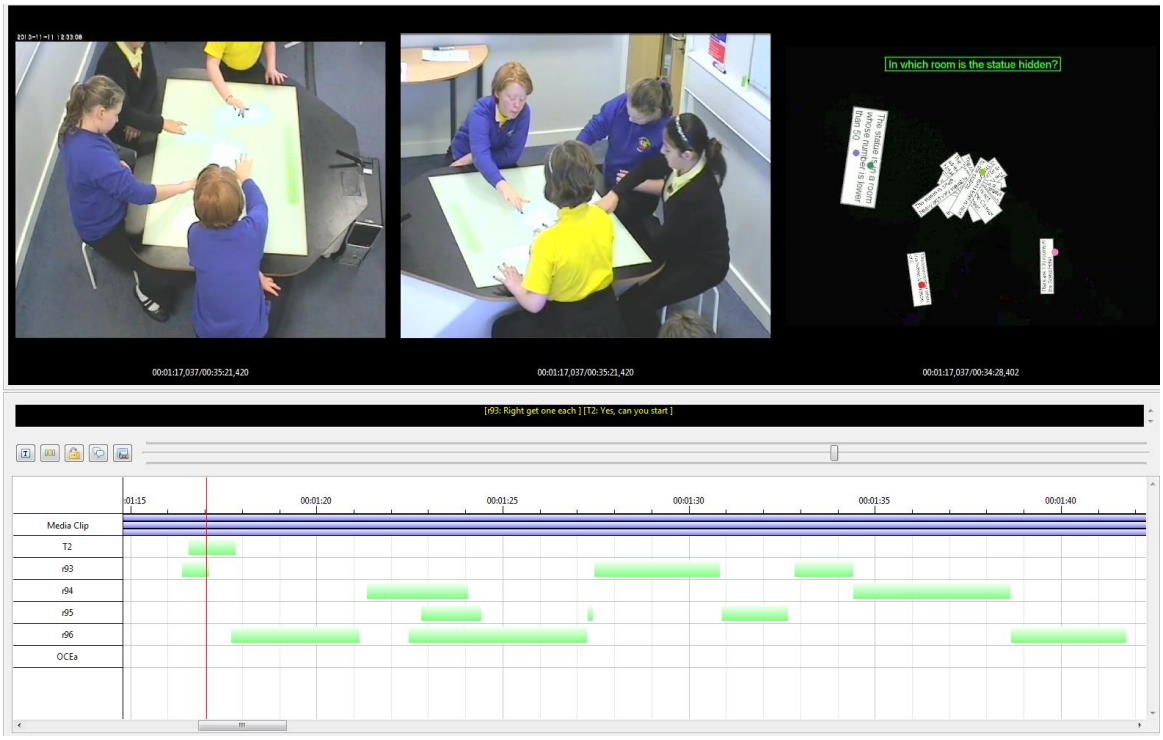
### 3.7.8 Inter-coder reliability

A Research Associate involved in the SynergyNet project also coded 10% of the 72 tasks completed in total (three tasks by each of the 24 groups). This gave an acceptable inter-rater reliability score of 86%.

### 3.7.9 Exemplification of group success: Easterburn Red group

The success of a group at completing a task was coded. Table 1 describes the four levels of progress towards success it was possible for each group to achieve. The three examples in this section show screen shots from SynergyView and written transcripts from one group's attempt to solve the Reasoning task. All are taken from one group, Easterburn Red group, an all-girl group in the tables facing forwards room orientation and taught by *David*. The first example shows a passage which was taken by the researchers as evidence of the group working together to read and discuss the clues. The second shows the group using multistep calculations to attempt to solve the problems together. Finally, the third extract shows disagreement about the correct answer, one student talks to the others the reasoning by which she and one of the other girls in the group has arrived at their answer.

***Figure 3.6: Easterburn Red – working together on the clues***




r93 *Right get one each*

*David* *Yes, can you start*

r96 *The statue is ... I'll just make mine bigger*

r94 *Shall I read mine first*

r96 *The statue is in a room whose numbers is lower than fifty.*

r95 *No we'll take turns*

r95 *Right*

r93 *The room in the number where it is hidden is a multiple of five.*

r95 *So it's lower than fifty*

r93 *And it's a multiple of five*

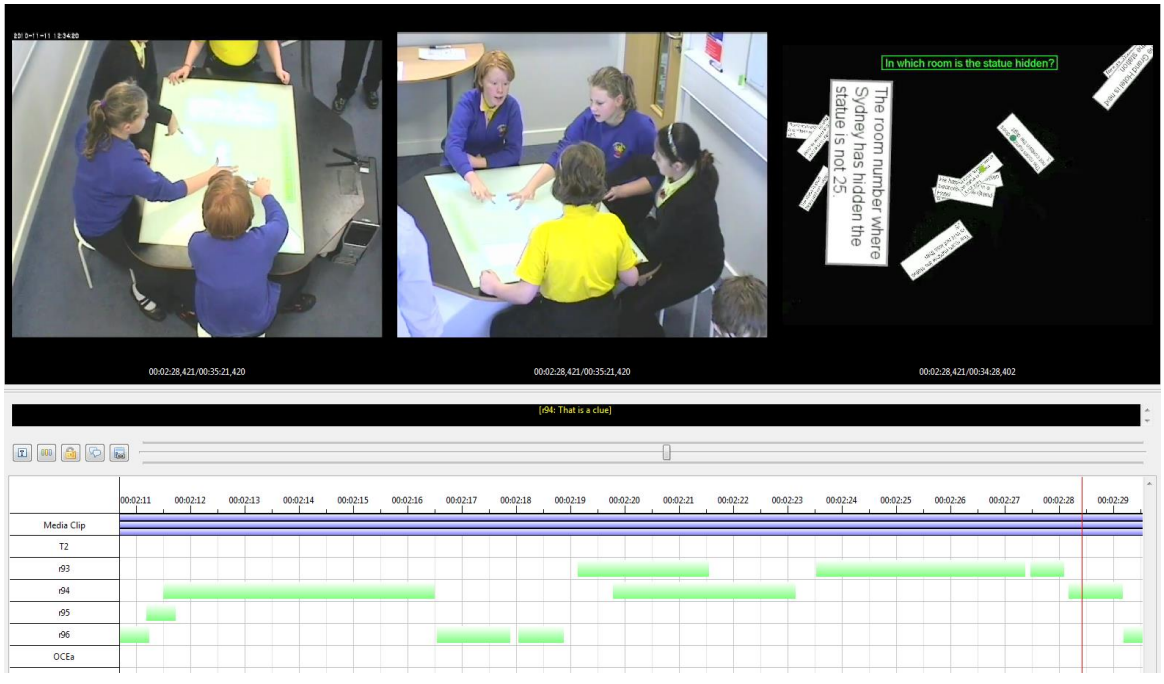
r94 *There are a hundred rooms in the grand hotel, that's not very important is it*

r96 *Well yeah, cos you could do five times a hundred.*

The transcript above shows that the group attempted to read and discuss the clues together as a group; expressing opinions and suggesting strategies in response to what each other reads. The still from the SynergyView videos (Figure XX) shows that the body language of the group is positive and focused on the multi-touch table as a shared space. The table surface data, the video stream on the far right of the tool, shows that three students are each touching different clues simultaneously. In the framework for progress and success this would be evidence for a group that is making *little progress* towards completing the task.

The second example shows the group members discussing the clues and their significance, beginning to make calculations based on the clues and combining the information to deduce the answer. Each of the tasks requires the students to combine information from at least three clues to find the right answer to the task.

***Figure 3.7: Easterburn Red – combining two or more clues to find the answer***



r94 *The room number where the statue is hidden is not even. So it must be odd.*

*David* *Just careful with the corner.*

r96 *Yeah it's a multiple of five*

r96 *Five, ten...*

r93 *The room number does not contain the digit three.*

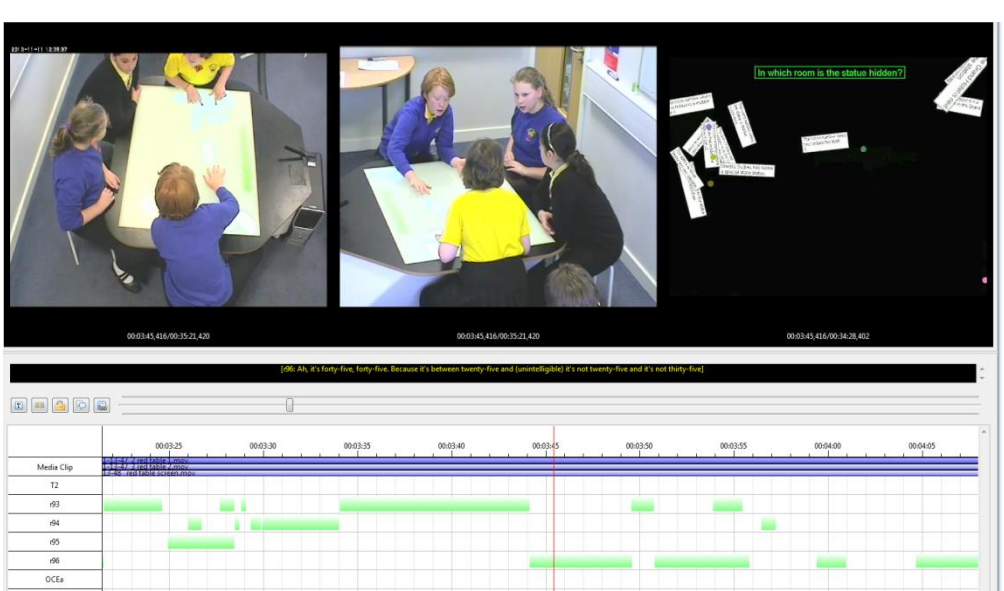
r94 *Yeah but one that ends in zero is even*

r93 *The room number does not contain the digit three, that is a clue (r96)*

The students are able to discriminate between the irrelevant clues and relevant ones (as r93 privileges the clue of r93 over r94). They are also combining three pieces of information; that it does not contain the digit three, that it is not even and that it is a multiple of five. By the framework of progress and success, they have demonstrated evidence that the group is now making *some progress* toward completing the task.

Finally the answer is arrived at but there is disagreement between two of the group members and one, who understands the correct answer, is obliged to go through their

***Figure 3.8: Easterburn Red – justifying reasoning behind the correct answer***



reasoning. Reasoning can be explicit in group talk or implied by gesture but there must be some verbal or visual evidence to show that students with the right answer have not simply overheard it from another group but arrived at it themselves.

*r96* *The room number where the statue is hidden is not... oh we've already done that one*

*r93* *The room number does not contain the digit three.*

*r95* *Sneaky Sydney has stolen a special stone statue*

*r94* *(unintelligible)*

*r93* *(y96) that's an important one the room*

*r94* *It's not*

*r93* *It is*

*r94* *It's not*

*r94* *Because you know it's in the five times table and three isn't in the five times table*

*r93* *No but it could be thirty five which is in the five times table. Thirty five, add thirty it's in the five times table. So it's not thirty five or thirty.*

*David* *Yeah and what else does it say about them. He's hidden it in a room, in a bedroom, in the Grand Hotel. Yeah*

*r96* *Ah, it's forty-five, forty-five. Because it's between twenty-five and (unintelligible) it's not twenty-five and it's not thirty-five*

*r93* *It could be forty (r96)*

*r96* *It's a multi- it's eh, it's got the (unintelligible)*

*r93* *Forty's not there*

*r94* *Look at that*

*r96* *Look, what, wait a minute, where is it.*

*r96* *There look, the room number that the statue is hidden in is not even.*

*r95* *It's not even*

*r96* *We know what it is*

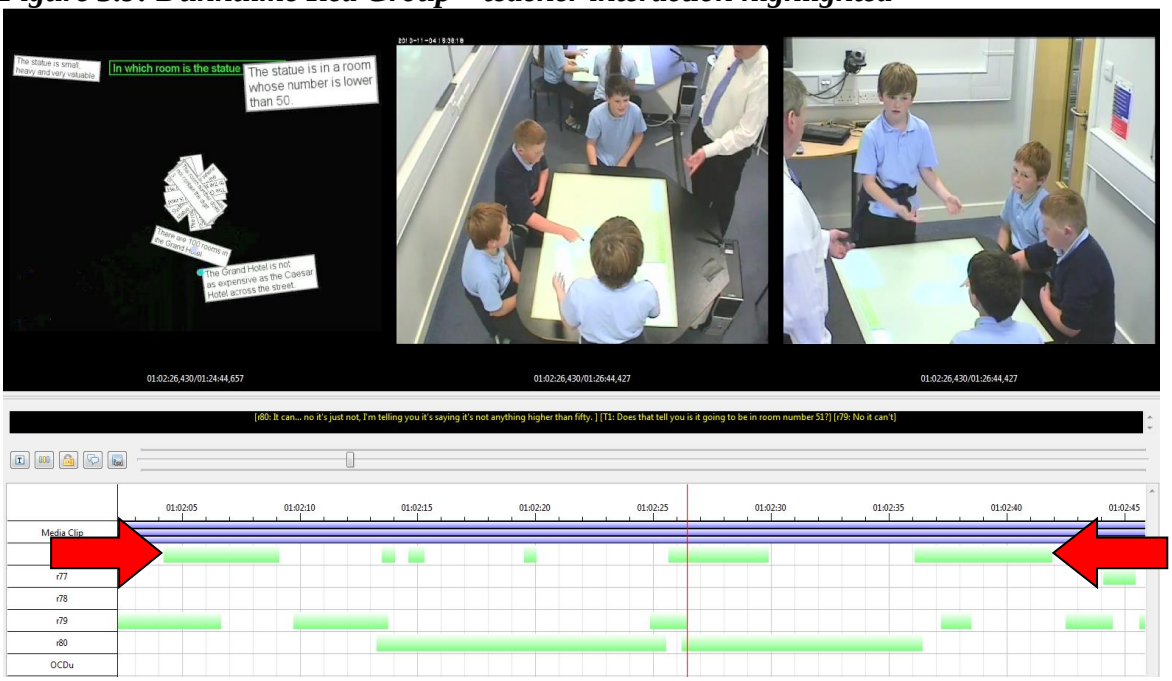
The group use clues to back up their claims to each other. They eventually agree and arrive at the correct answer to complete the task. At which point they are coded as having been *successful*.

### 3.7.10 Defining interactions in the transcript

Teacher interaction with each group was a key focus of this study. The definition of an interaction is presented in 3.7.3. To quantify the total duration of interactions between the teacher and one of the groups, the total number and duration of all the interactions of a teacher with a group were added together.

In the example below the group has an interaction with the teacher sustained over several utterances. Here the teacher is prompted to intervene when hearing a clue not relevant to solving the problem being privileged by one of the students. They interrupt the discussion and begin by reminding the group of the focus of the task.

***Figure 3.9: Dunhulme Red Group – teacher interaction highlighted***




r79 It might though because they want to keep it something so like something soft so it doesn't break cos it's valuable and heavy...

*Michael* But it's only which room is it in. I don't think that one's one of the more useful ones.

r79 I know but that will help us because we need to know which kind of room

r80 Sir... (unintelligible) it says there are a hundred rooms in the grand hotel... well yeah it says the statue is hidden in a room whose number is lower than fifty it should still go there shouldn't it?

*Michael* Okay,

*Michael* Yes?

*Michael* Well you know it's…

r79 No it can't

*Michael* Does that tell you is it going to be in room number 51?

r80 It can... no it's just not, I'm telling you it's saying it's not anything higher than fifty.

*Michael* I agree, I think (r80) right there. So that's a good clue because it automatically rules out half the rooms.

r79 Oh right, oh right

The teacher provides r80 (pictured standing in the screenshot) with the opportunity to explain their idea as an alternative to those of r79. The interaction is recorded as having lasted from 1:02:04 to 1:02:41 as shown on the screen shot.

There were two problems in identifying separate interactions between the teacher and the group. The first was identifying clearly when one interaction started and ended. Both

teachers frequently began an intervention, stepped back to see if group discussion would develop from this and then intervened again if it did not. Such cases were still counted as one interaction regardless of the length of time between utterances as the teacher returned to the same group and utterance.

The second problem was the opposite of the first. Some teacher interactions were single words, arising from a period of observing the group and interjecting quickly before moving on. In such situations only the verbal utterance was counted as it was not possible to tell the impact of a teacher standing quietly by the group and listening to their discussion. Despite its frequent occurrence in the video data, non-verbal communication was not recorded at all as it was not possible to tell either who it was directed at in all circumstances, or whether it was interpreted or acted upon by the intended student.

## 3.8 Defining utterances in the transcript

The audio-visual recordings and transcripts were analysed simultaneously using the SynergyView tool. The aim was to analyse the individual utterances which comprised each interaction the teacher had with the students. Figure 2 shows a screen shot of the transcription tool. Teacher interactions and utterances are shown below the video data on the timeline. The top line shows the utterances and the bottom line shows the interactions.

The first task was to check the way the utterances of the teacher had been divided. As these had initially been transcribed before this analysis was planned, it was important to make sure that the speech was divided into sense units of one utterance, rather than longer ones with two or more utterances. For example the teacher's utterance made by *David* in whole class talk during the Reasoning task with *Benbrook*;

"So we know it's more than 25. So it's 30, 35, 40 or 45. Okay, it's not even so that leaves us with 35 or 45. Excellent. And it can't contain the digit three so it must be 45."

This was initially transcribed as one phrase; however, it contains three separate ideas which the teacher is trying to convey. Therefore it was divided up in the SynergyView tool to be three separate utterances, each a different thought in response to a student's input. Separate coding was applied to each one. This is shown in the two images below. Figure 3 shows how the above passage was eventually coded into three utterances in the SynergyView tool. The text is expanded showing the utterances, with their duration and the codes which have been applied to them.

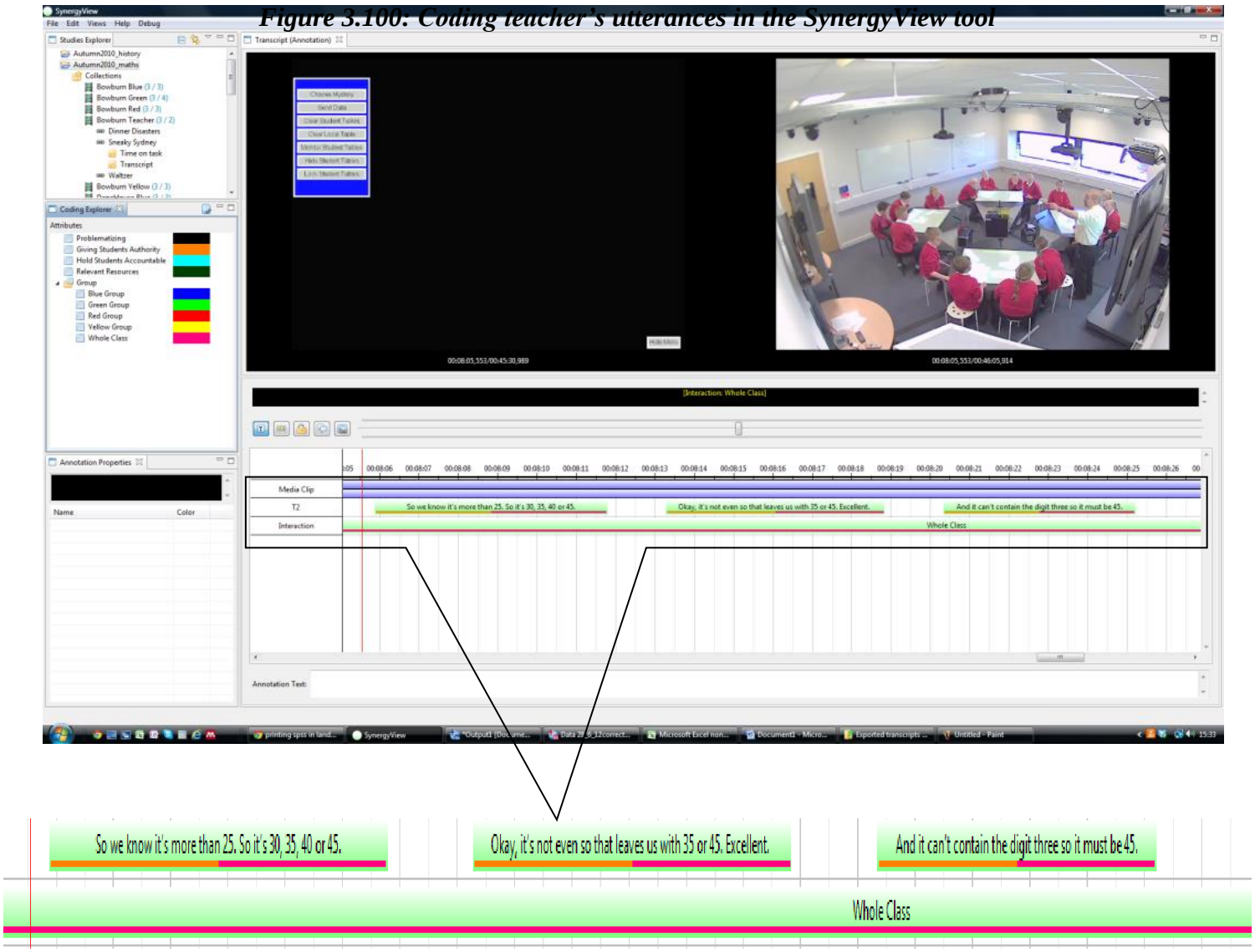



*Figure 3.100: Coding teacher's utterances in the SynergyView tool*

### 3.8.1 The categories of teacher utterance

Figure 4 shows a screen shot of categories of teacher utterance. There were nine possible codes to assign to each utterance. The first four were those adapted from the Engle and Conant teacher interaction study (2002). A full discussion of the nature of these four categories can be found in section (XX). The remaining five indicated whom the teacher was addressing in each interaction.

***Figure 3.11: The categories of teacher utterances***

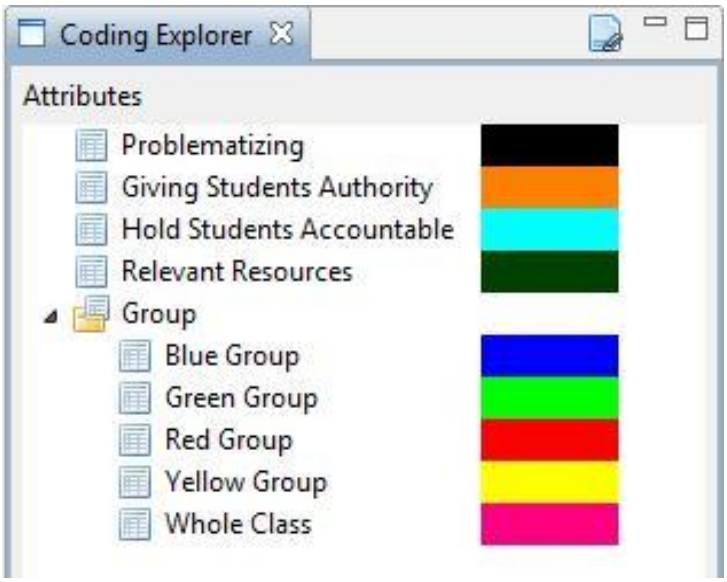
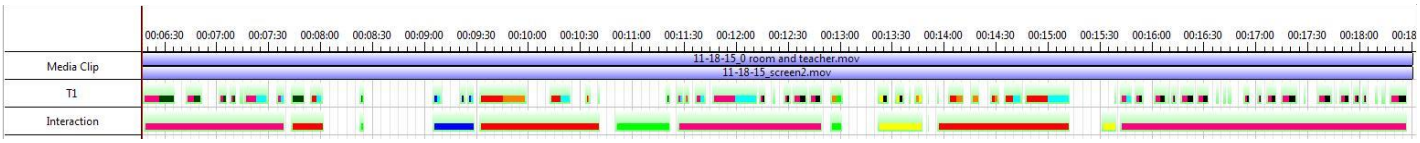



Figure XX shows the teacher is giving particiular students authority with their utterances (orange) and they are addressing the whole class with their utterance rather than one group (pink). The SynergyView tool has a timeline which is scalable. It is able to focus on one or two utterances which last only seconds, as in Figure XX. Or it can zoom out to show the utterances and interactions which comprise an entire task as in Figure 5 below. Figure XX shows the length of the interaction with a particular group. Inteactions comprise one or more utterances, this second line showed the duration of theinteractions (by the length of the bar) and the colour of the group to which the utterances were directed and withwhom the interaction was happening.  Note the pink lines at the begining, middle and end of the activity. These show the periods of whole class interaction whcih were taking place, an introduction, mini-plenary and final plenary.

Figure XX shows the complete SynergyView timeline of the Benbrook Reasoning task, from which the previous section of dialogue was taken. The transcription on the SynergyView tool shows all the teacher's utterances in the first line (*David* in this case) and then how these are grouped together into the interactions. In this case it is possible to see that the teacher had twelve separate interactions, three with the whole class, three with the red group, three with the green group, two with the green group and one with the blue group.

The number and duration of these interactions was recorded as were the categories of teacher utterances made to each group and in the whole class interactions. It is these which will be discussed in the quantitative section of the results.

***Figure 3.12: An example of a SynergyView timeline showing utterances and interactions by the teacher across one complete task: Benbrook Reasoning***




the teacher but also the codes which had been assigned as well.

The second stage of analysis, exploring whether the teacher's utterances were related to student performance when completing the tasks, required the coded utterances to be analysed quantitatively. Therefore the codes on the transcripts had to be prepared for analysis in SPSS. The variables of to be explored were; school, task, group, quality of utterance (denoted by Engle & Conant derived coding framework) and duration. Table 2 shows the values which were assigned to the different variables in each condition within the study and to the four different categories of utterance used. The table above shows that the whole class talk has been split into three separate codes. This is to reflect the different significance of this for the completion of the task and to allow for comparison between whole class and group interaction.

***Figure 3.13: Values assigned to different variables in each condition of the study and the four categories of utterances***

| School | Task | Group | Quality | Duration |
|---|---|---|---|---|
| 1= Benbrook | 1=Properties of number | 1=Blue | 1=Problematize | Rounded to the nearest second. |
| 2=Dunhulme | 2=Arithmetic | 2=Green | 2= Give students authority | |
| 3=Easterburn | 3=Logic | 3=Red | 3= Hold students accountable | |
| 4=Seacrest | | 4=Yellow | 4=Relevant Resources | |

| | |
|---|---|
| 5=Shadbrook | 5=Whole class before group working |
| 6=Yadstone | 6= Whole class during group working |
| | 7= Whole class after group working |

## 3.10 Potential limitations of the study

There are two features of the study which must be taken into consideration when discussing the data. These were unintentional but necessary for this given the wider constraints acting upon the project as a whole. These will be discussed below as will their implications for the validity of results drawn from the data.

The first limitation was that each teacher taught one more class in a particular room orientation than the other. David taught two classes in the centred room orientation, Michael taught two in the traditional room orientation. This was an unavoidable necessity based on the available resources of the wider project, including the funds and time required to data collect as well as the availability of personnel to carry out the research.

Whilst room orientation was a variable which could be examined in this study, this was not the primary reason for varying the room orientation; this was the primary focus of a different study (Mercier, Higgins & Joyce-Gibbons, in press). The results presented in Chapter 4 and Chapter 5 explore the interactions between the teachers and the groups in the two room orientation conditions. However, careful mention is made of the imbalance between the teachers and any possible statistical significance will be tempered in discussions to reflect this.

The second potential limitation of the study was that the researchers responsible for the design and analysis also enacted the role of the teacher in the class. This situation was unavoidable in within the constraints of an interdisciplinary project. The researchers were both qualified and experienced primary school teachers, familiar with the age of the students participating in the study. They had also worked closely with the computer science

development team for over a year before the data was collected. During that time they had acquired a familiarity with the hardware and software as it was designed and continued to evolve, driven both by the requirements of the education researchers and the researchers from computer science as well. It was not possible for participating schools to free teachers to work for days of training on how to use the software and hardware at that stage of its evolution. Having trained teachers working with their own classes was a long term goal of the project and one which was achieved towards the very end of the life of the project.

The role of the researcher in classroom observation is usually that of a participant observer (Gold, 1953; Atkinson & Hammersley, 1983). In this case they were both teacher and researcher. This left them exposed to two potentially problematic influences in their interactions. Firstly they may have been unable to engage the role of class teacher sufficiently; remaining too attached to their research role and its requirements. The temptation would then be to influence the research in some way. Alternatively, if the researcher began to identify too closely with their role as teacher, they may have believed that they acquired a more privileged understanding of the students' experience than they did. This could be thought of as a similar blurring of the perspective of a researcher to the phenomenon of 'going native' (Yin, 2011).

The joint role of teacher-researcher gave the study rich access the interactions which were taking place and a sense of the experience which was unavailable to researchers engaged in participant observation. Roth (2001) argues that this level of participation enables the researcher to appropriate the competence systems of the class and allows for greater posteriori reflective inferences.

A second advantage of the approach taken by the SynergyNet researchers was that teaching the class over multiple sessions, visiting them in school prior to the data collection, allowed the teacher-researchers to gain a greater understanding of their prior learning and

their understanding of mathematics. This allowed them to fulfill a more realistic role as teachers during the data collection. This ability to better situate interactions which took place during the data collection within the understanding of the teacher-researcher gives them the opportunity to better understand the potential educational value of the exchange (Mercer 2007).

A protocol was developed to keep the experiences of the researcher-teachers separate from each other during the data collection but to encourage critical reflection. Through a process of critical reflection to someone related to the project but not involved directly with the data collection was intended to mitigate researcher bias (Hall, 2007). The researchers in the teacher role were able to avoid becoming either too involved in the class they were working with. They were also able to avoid becoming too focused on one particular aspect of their research, so as to then take that into further data collection sessions.

Each researcher would teach separately, unobserved by the other. They would not discuss the interactions which they had had in the classroom with each other. Instead they shared their reflections with the Research Associate working on the project who made notes for future use. The Research Associate in turn did not have any dealings with the other students during the data collection, although they did help supervise them during breaks.

During the transcription of the data, the researchers and the Research Associate jointly discussed the video data and the transcripts under construction. Here the Research Associate shared any relevant insights they had noted from earlier conversations. The ability to scrutinize the performance of the teachers with the benefit of hindsight and multiple perspectives is one of the most powerful ways in which audio-visual data can be used to minimize the impact of skewed perspectives or bias which might have arisen during the data collection (Cohen, Manion & Morrison, 2007).

The researchers also played the part of the teacher because of the necessary constraints of the project. Their role carried some potential advantages in that it gave them an immediacy and insight that it would not have been possible to get from the video data alone which in turn informed their understanding of the video data later in the process of data construction and analysis. The disadvantage was that they may have influenced the data collection in subtle of subconscious ways despite the controls put in by the study team.

It is only possible to recognize that this may have been the case and to describe the steps which were taken to try and minimize this possibility. The greater the claims made by the study, the greater the potential weakness the role of the researcher as teacher will become. However, the study is an exploratory one which seeks to understand what is happening in the interactions between teachers and students. The aim is to identify areas for further study rather than to make definitive claims about the interactions observed. For these reasons the potential limitations which this challenge places upon the analysis and findings of the study are not great. It was a condition imposed by necessity and a nuance to be born in mind when considering the findings of the study. It is not a sufficient cause to disregard them.

Whilst no study is without threats to the validity of its conclusions, every effort has been made to expose and acknowledge threats to this study, to discuss them and describe what measures were taken to mitigate them. Cohen, Manion and Morrison (2007) identify 11 separate types of bias which threaten the validity of classroom observation research. Figure 3.14 lists each one and gives a brief summary of how it is guarded against in this study.

***Figure 3.14: Bias and measures taken to defend against it***

| Type of bias | Treatment in this study |
|---|---|
| *Selective attention* | Audio-visual recording of all groups so all speech is recorded even discussion when teacher is not interacting with the group. |
| *Reactivity* | Pre-study school visits were carried out to familiarize the students |

| | |
|---|---|
| *(Hawthorne Effect)* | with the staff and similar collaborative activities used in the study. A number of orientation activities designed to familiarize the groups with the tables and the activities were carried out prior to the data collection. |
| *Attention deficit* | The researchers were not relied upon to record any of their observations or report what they had been doing; this was captured by the audio-visual recording equipment. |
| *Selective data entry* | All transcripts were checked by two separate researchers to ensure that they included all possible speech in the study. |
| *Selective memory* | The participants' observations were used to enhance understanding of the context whilst constructing the transcript. However, they were not given preference over the audio-visual data collected, nor were they ever used instead of this. |
| *Inter-personal matters/ counter-transference* | Process of self-reflection during data collection facilitated by Research Associate. Collective discussion of video data and choices in the transcript. |
| *Observer-Expectancy* | Process of self-reflection during the data collection and conducting a number of orientation activities to re-immerse researcher in role of the teacher. |
| *Selective recording* | Audio-visual recording of all groups so no utterance by teacher or group member goes unrecorded. |
| *Number of observers* | Data not recorded by observers in real time but by audio-visual recorders, disagreements among researchers occurred and were resolved at data construction phase not data gathering. |
| *Problem of inference* | The researchers were not relied upon to record any of their |

observations or report what they had been doing; this was captured by the audio-visual recording equipment. Interpretation of the data was discussed by research team during the data construction phase of the study.

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## 3.11 Conclusion

The research questions detailed in this chapter seek to explore both the nature of the interactions recorded in the data collection and their impact. The transcription and coding of the data allows for quantitative as well as qualitative analysis to be performed. This is particularly important as there is a dearth of quantitative research to examine classroom interaction. A recent systematic review of dialogue and interaction literature (Howe & Abedin, 2013) found that out of 59 studies examining dialogue, only 7 used quantitative methods at all. It is hoped that the SynergyView tool will provide a granularity to the analysis which will allow for reliable analysis.

It is important that both of these elements are recognized despite a preoccupation among some researchers to only focus on the first of these without considering the impact they have on the latter (Mercer, 2007). It is also important that the subsequent analysis of data provides a clear rational for the path which it takes through the data. This will begin with the success of the groups, whilst this is not the only measure for successful learning; it is none the less one which is readily accessible. From there the factors which influence this, leading to the interactions between the teacher and the groups, will be considered. The study will look in detail at qualitative examples of various aspects of the interactions. However, these will be presented in the context of a clear rational for the selection of each one. The reader will be in no doubt that they have been chosen because they are representative of a feature of the interactions clearly identified in the quantitative exploration of the data.

# 6. Qualitative exploration of problematization utterances made during interactions with groups of students

## 6.1. Introduction

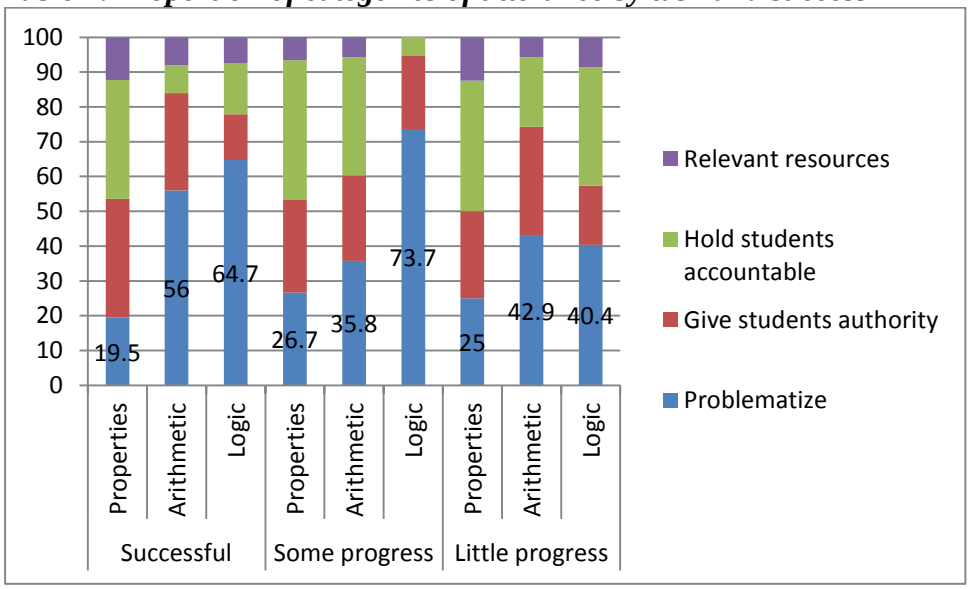
The SynergyView tool has provided a very rich data set which can be repeatedly interrogated to explore numerous gaps in the literature. The following two chapters are an example of how the tool has enabled researchers to look in greater detail than was previously possible to develop their understanding of issues which were framed by previous research but left under-explored due to the difficulties of data collection. Statistical analysis has been a means by which this data has been triaged. The qualitative analysis which follows is are examples of the detailed interpretive research which data rich sources, such as the SynergyView tool, enable researchers to undertake.

The exploration of the quantitative data suggested there was an association between the number of *problematization* utterances a teacher made during interactions with a group and their level of success in completing a task. Examination of the frequency tables showed that there was an increase in the number of *problematization* utterances made in during interactions with successful groups in the reasoning task, compared to those made to successful groups in the logic task. To explore this observation further, this chapter shall look in detail at the interactions between the teacher and groups from one school, focusing on the first task, the reasoning task, and the final task, the logic task. An exploration of the role, if any, of the *problematizing* utterances in facilitating group success will be carried out by comparing and contrasting the teacher-group interactions in these two tasks.

Section XX showed that the proportion of utterances categorised as *problematization* utterances used by teachers in their interactions with successful groups increased over the three tasks, from 20% of the total utterances in the *reasoning* task to 65% in the *logic* task.

This increase in the proportion of *problematization* utterances was also seen for groups categorised as making *some progress*. Only a small increase was seen for groups which made *little progress*. Table 72 shows the proportion of categories of utterances by task and group success. Not only does this indicate that the use of problematization utterances by the teacher is possibly related to the success of a group, it also shows that there is a decrease in the number of utterances which *hold students accountable* across the same tasks.

***Table 1: Proportion of categories of utterance by task and success***




The data to be studied in this section has been selected based on the analysis of the categories of utterances in Section XX, which examined the frequency of each category of utterance by *school* in each task. It showed the number of *problematization* utterances used by the teacher with groups from *Seacrest* school increased from the joint-lowest in the *reasoning* task to the highest in the *logic* task. Table 73 shows the frequency of the different categories of utterance for *Seacrest* school by task. The number of *problematization* utterances varies from one to 32 over the three tasks. However, the number of utterances which *hold students accountable* falls from ten to five. The subsequent sections will explore why and how this shift may have occurred.

***Table 2: Frequency of the different categories of utterance for Seacrest by task***

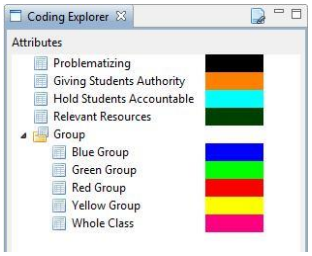
| | Problematization | Give authority | Hold students accountable | Relevant resources | Total |
|---|---|---|---|---|---|
| Reasoning | 1 | 3 | 10 | 1 | 15 |
| Arithmetic | 9 | 4 | 10 | 0 | 23 |
| Logic | 32 | 7 | 5 | 4 | 48 |
| Total | 42 | 14 | 25 | 5 | 86 |

## 6.2. Comparing the *Reasoning* and the Logic tasks

The SynergyView tool allows the researcher to view the data at different scales, from an extremely detailed, almost second by second, view to one where the audio-visual data streams are played whilst the whole timeline of interactions is shown at a glance. This section focuses on the timelines of the whole of each task. It examines these as evidence to interpret to get an overall impression of the character of the interactions in the task. It then compares these impressions to the known statistical data to see if a visual analysis is representative of the statistical data. If so then such visual analysis may be a reasonable way to initially view large amounts of data, allowing researchers to focus on anomalies or typical cases for further study.

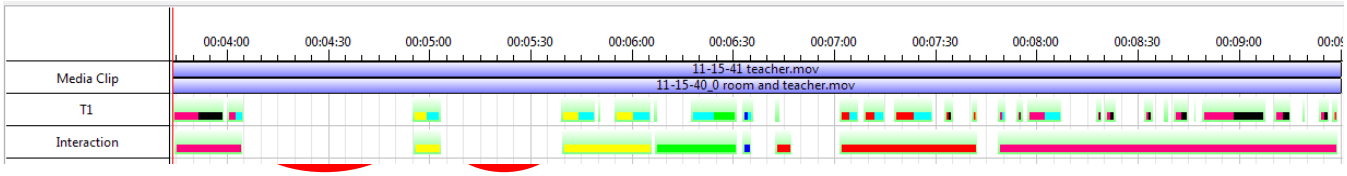
Figure 1 shows the structure of the interactions it the timeline of the *reasoning* task, taken as a screenshot from the SynergyView tool. The bottom row shows the length of interactions, the colour reflects the group with whom the interaction took place (interactions coloured purple are between the teacher and the whole class). The top line shows the category of utterances made by the teacher. *Problematization* utterances are coded in black, utterances *giving students authority* are coded in orange, utterances which *hold students accountable* are coded in light blue and finally, utterances which talk about *relevant resources* are coded in dark green. Figure 6.1shows the key used during coding using the SynergyNet tool.

***Figure 6.1: The key used to code utterances and interactions, part of the SynergyNet tool***



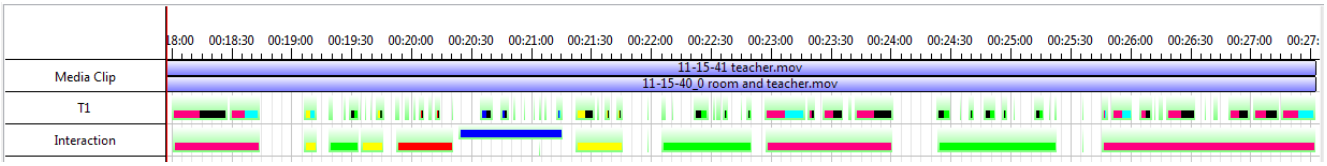
In the *reasoning* task there was whole class interaction at the beginning and the end of the task but here was no mini-plenary in the middle. At the beginning of the time line there are two periods of silence by the teacher, each lasted for at least 30 seconds. These are shown in the red rings on figure XX. The teacher had multiple interactions with the Yellow group and the Red group and a single interaction with each of the Green and Blue groups. A mini-plenary is an interaction between the teacher and the whole class which takes place during the group working phase of the activity.

***Figure 6.2: The Seacrest school Reasoning task SynergyView timeline***




In contrast the *logic* task timeline, shown in Figure 3, shows a more crowded timeline with no sustained periods of silence by the teacher. Here there was a mini-plenary between minutes 23 and 24. The teacher had multiple interactions with the Green and Yellow groups and a single interaction with each of Red and Blue.

***Figure 6.3: The Seacrest school Logic task SynergyView timeline***




The categories of utterances in the two tasks, shown in the top line of the timeline, are easily contrasted at a glance. The *reasoning* task has more visible light blue utterances representing those *holding students accountable* to the norms of the classroom. In comparison the *logic* task has none. However, the *reasoning* task has only one *problematization* utterance whereas the *logic* task has many evident. There are many

*problematization* utterances but no coded utterances that *hold students accountable* in the *logic* task.

The increase in the number of *problematization* utterances and the decrease in the number of utterances which *hold students accountable* between the Seacrest r*easoning* and *logic* tasks are representative of the pattern which was identified in the quantitative exploration of the data. Looking at the interactions between the groups and the teacher in these two tasks may show possible explanations for these patterns.

The timelines can provide an overview of the structure of the task which can enable the researcher to visualise features which are also shown to be present in the statistical data. However, care should be exercised as some utterances are too short to be visible when the timeline is viewed as a whole. There is a trade-off between an overview of the whole task which can be seen at a glance and a more detailed view which shows each utterance no matter how short. This should be kept in mind whilst reviewing large data sets and using the whole task view of the timeline to get an impression of the data.

Having sketched an impression of the over view of the *Seacrest reasoning* task based on the whole timeline, the next section will look in greater detail at the transcript of the task. It will explore the role of the utterances which *hold students accountable* and look at why there was only a single *problematization* utterance, as shown by the timeline overview and Table 66.

## 6.3. Seacrest: Reasoning Task

The *reasoning* task asks the question 'Where has Sneaky Sydney hidden the stone statue?' and requires the students to read the clues and use the information to reason about the properties of the numbers they contain. After the initial instructions were given, the teacher began by watching and listening to groups, walking around the outside of the tables. After 50 seconds he had a brief interaction with the Yellow group. He was concerned that the way one student was using the clues meant that other members of the group would be unable to interact with them. They make an utterance, categorised as holding students accountable to the norms of the classroom. Although framed as a question, it is an instruction to the group.

y49 It's not that one, it's not that one. The room number which Sydney has hidden the...

y52 There! The room number he has hidden it in is...is not less than 25.

y49 Not less than 25.

y51 It doesn't end with 3.

Michael Do you think it might be helpful if you had them so everyone could see them even though, you know, it's not the one that's being read, just thinking, because you might have to go back to some of the clues, you know. [Hold students accountable]

The teacher's utterance was clearly intended to maximise the amount of collaborative working which could take place by establishing working practices which would not lead to problems in the future. However, the teacher initiates this interaction without apparently taking into account the conversation which was taking place before it happened. All four members of the group are participating in the task, reading clues out to share the information.

After this the teacher pulls back and observes intermittently (casting their eyes about at the other groups but returning to Yellow group). After a 45 second silence he returns to the group, expressing concerns at the apparent lack of progress which they seem to be making. This time the teacher is more direct and wants to know why they are not making progress.

| | |
|---|---|
| y49 | Nah, we've read that one. |
| y52 | They're going out of the screen! |
| y49 | Put them where everyone can see them. |
| y52 | Do you think this one'll be... |
| Michael | So what's happening here - why are we - you're not making much progress on this one what's the problem? I think you're spending a wee bit too much time just organising them here. [Hold students accountable] |
| y52 | Yeah. |
| Michael | So, you see this - you need to be reading the questions, you need to be reading the clues and you need to be trying to work it out together, okay, because if we all just push these around it's not going to work, right? [Hold students accountable] |

The teacher makes two utterances, both hold students accountable to classroom norms. Once again, both are presented as questions. The teacher has identified that the group has shifted from completion focused talk to procedural talk. This is still task focused but the teacher nonetheless chooses to begin an interaction. Michael does not give any suggestion or scaffolding as to how to go about achieving the goal of *'trying to work it out together'*. He appears to be prompted to interact with Yellow group when he perceives a potential future problem in group functioning, a breakdown of sharing clues in the first case and gradual move away from task related talk in the second.

The teacher's attention switched to the Green and Blue groups, both tried to get the his attention to tell him they were finished at the same time. This provokes a defensive reaction from the teacher who responded by trying to downplay their success.

| | |
|---|---|
| T1 | [To Green group] Maybe. You guys, could you just wait here for a second and we'll talk about it all in the end, okay? The thing is, it's not just about - you've got to justify and explain why you've got it. So make sure you understand why. [Hold students accountable] |
| g54 | Yes, but we've said it, they've got it. |
| g56 | That's all that goes on about the rooms. |
| g54 | [Blue group audibly tell each other they have it]We had it first! |
| T1 | [To Blue group] You've got it. Well there's no biggie who's got it, I hope everyone's going to get it. [Hold students accountable] |

Once again the teacher makes an utterance which holds students accountable to the norms of the classroom. He appears to introduce an extension activity but without giving any concrete task or outcome for them to work to, nor indeed any scaffolding or method to work with. He moves quickly away to the Red group giving no further practical or positive input. The fact that the teacher adopts the vernacular, *'biggie'* suggests that he was placed under stress by the argument between groups. This appears to have been an attempt to calm the groups down but one which was neither preconceived nor clearly explained.

Michael then moved on to Red group and asks for a progress update. This group are not making good progress and are focusing on manipulating the clues on the tables rather than reading and discussing them:

| | |
|---|---|
| Michael | How are we doing here? [Hold students accountable] |
| r63 | Good, if we could get that smaller. |

Michael I'll do it. [Relevant resources]

r62 Oh, we kept them.

r62 Ohhhhhhh.

r61 What's wrong? [directed at r64]

Michael Right, are you guys all right here? There doesn't seem to be a lot of people talking about it. Do you know what the answer is yet? [Hold students accountable]

r64 No.

Michael So, do you think maybe you're spending a bit too much time organising the clues and not enough time actually reading them out and thinking about it? [Hold students accountable]

r63 [unintelligible]

Michael Yes - I think, you know, you're going to have to think about how to make sure everyone can see it, but also, remember, you've got to work out what the answer is to this question. Which room is the statue hidden in. [Hold students accountable]

Michael Okay?

r61 The bedroom?

Michael Well yes, it's a bedroom, but which one? It's in a hotel. [Problematization]

r64 The room number the statue is in is not less than 25.

Michael All right, so, that's helpful. [Give students authority]

Once the teacher has dealt with the issue of the resources, he must try to refocus the group on what they are supposed to be doing. He identifies the problem, that there aren't many people in the group talking about the task. The moving of the clues appears to be 'busy work' in which the students are engaging as an avoidance strategy. The teacher recognizes this and beings to refocus the group. His response to r61 is the only problematizing utterance in the whole task for any group. It is also the only question in this interaction which is not rhetorical.

He responded to r64 with encouragement, giving them authority and implying that they should look for more clues as he moves away. However, he immediately began the final plenary, locking the tables and bringing the group working stage of the task to a close. Why the teacher did not give the students the opportunity to progress further with the task, but still went to the trouble of having the prolonged interaction may be explained in the context of the three tasks as one session. The teacher may have been holding the students accountable to the norms of the classroom not to help with the successful completion of this task, which he knew was already too late; but to model working practices and methods of inquiry which the group could use to better tackle subsequent tasks in the session.

Drawing a contrast between the interactions with the Red and the Yellow groups highlights a potentially important difference between uses of *problematization* utterances and the uses of those that *hold students accountable*. The two interactions with the Yellow group were initiated by the teacher to try and pre-empt a potential problem which they were concerned would develop. These interactions were both focused on the procedure of successful group working and were exclusively conducted through utterances which held students accountable. However with the Red group, the teacher initiated the interaction by asking an open question about their progress. Then the teacher formed an opinion.

The key factor determining the course of interactions during this task appears to be whether the teacher had or had not formed an opinion of the needs of the group before they began an interaction with them. In the case of the Yellow group he had already done this. Although the teacher clearly thought the group was dysfunctional, examination of the group's interaction with each other prior to the teacher's intervention showed them to be clearly task focused. The teacher's analysis was therefore incorrect. In the case of the Red group, the teacher had not formed a strong opinion and was more open to the responses he received from the students and more open in the questions he asked. In both cases the teacher used utterances which held the students accountable to the norms of the classroom. However, in the case of the Red group the interaction led to a focus on the problem and a problematizing utterance.

Student initiated interactions provoked hasty and inappropriate reactions from Michael as shown by the outbursts by Blue and Green groups. He had not prepared himself and was taken by surprise. Given that for them the task was over, it was not an interaction in the same way as those for Yellow and Red where the task was still incomplete. However, it shows the importance to the teacher's equilibrium that they have the opportunity to evaluate what is happening in a group before interactions take place.

## **6.4.** Seacrest: Logic task

The *logic* task asks 'Can you work out what Mike should have for dinner?' Students have to sequence a set of meals based on the clues they are given. Despite the differences in the interactions between the two tasks, shown in Table 66, there are some similarities to notice too. The teacher again begins an interaction with the Yellow group. Prompted to interact because he thinks someone is hoarding the clues the teacher again interrupts when at

least three of the four group members are focused on the clues. The teacher does not give any clear instructions, rather he points out what is wrong and makes a joke.

Arguably the similarity is that the teacher focuses on Yellow group early in the task, unnecessarily. They are in fact already focused on the task in hand, only the teacher does not pick up on this from their observation. However, there is a difference with the intervention in the reasoning task. The teacher has interacted with Yellow group to remind them of his presence, pre-emptively, in an effort to keep them on task. They are on task at that time; he wishes them to remain so. The use of humour suggests that he does not want the student he is addressing to lose face or become disaffected.

| | |
|---|---|
| y51 | This one's mine. |
| y52 | Hey, anybody want these chicken wings? asked Grace. I don't like anything with meat in it. |
| y49 | YUCK! cried Ruby... |
| y51 | Don't look at me, moaned Jack. I hate any food with cheese...with cheese in it, on it. At that, he pushed away his cheeseburger. |
| y50 | Ey, the table's not working. |
| Michael | Right, see, now that's not going to be helpful, is it, if you - I bet you're the sort of person who hides jigsaw pieces just to put in at the last one. [Hold students accountable] |

After visiting Yellow the teacher moves to the Green group. He initiates the interaction with an open question which suggests that he has not got a preconceived idea of what he must do to help the group but instead wishes to find out what they need. His utterance *gives students authority* to tell him what they know.

| | |
|---|---|
| g54 | Tanya...Tanya... |

Michael Sorry? What's this Tanya.[Give students authority]

g53 She can't stand...

g54 She is...she em...she only eats yogurt.

Michael Right, so, who has yoghurt? [Problematization]

g54 Tanya.

Michael No, but, who has the yoghurt? Mike has the yoghurt so Tanya gets Tanya's yoghurt – yes? [Problematization]

Because he doesn't know what he needs to do to help before beginning the initiation, Michael takes his cue from the students and asks open questions to elicit both the difficulty and also to scaffold the next stage in the problem for them to work on.

*Problematization* utterances have been characterised broadly in this research. They may be brief and form part of an IRF sequence. Alternatively, they may be more open-ended. The following extract shows a variety of *problematizing* utterances, following Engle and Conant's (2002) initial definitions. The teacher then moves to the Red group, who have been focused and working independently in marked contrast to the *reasoning* task:

r63 Yeah, but we're on about Mike, not Jack.

r62 Oh.

r62 YUCK, cried Ruby, making a face at the slice...ah, I can't read.

Michael So she can't have pizza - she doesn't like pepperoni pizza does she? [Problematization]

r63 And he doesn't like cheese. Well...

Michael Is there anyone we know for sure... [Problematization]

r61 And he...he's...

r61 He's allergic to emmm yogurt.

Michael Right, what does Mike have? [Problematization]

| | |
|---|---|
| Michael | Mike can't have the yoghurt can he? Is there anyone who likes yoghurt? [Problematization] |
| Michael | [Student puts hand up] No I mean here. [Problematization] |
| r63 | Tanya. |
| Michael | So Tanya gets Mike's yoghurt so what does Tanya have? [Problematization] |
| r64 | Salad. Salad! |
| r63 | Salad. |
| Michael | So is there anyone who might like a salad? [Problematization] |

Through modelling questions about the task in his exchange with the students, Michael gets them to start with Mike. His dinner is displaced and the students must work through the chain of clues to work out where each dinner goes. The teacher tackles misconceptions, such as the clues and discussion only referring to the characters and not to the group members and then he leaves them with the next step in the problem to work out.

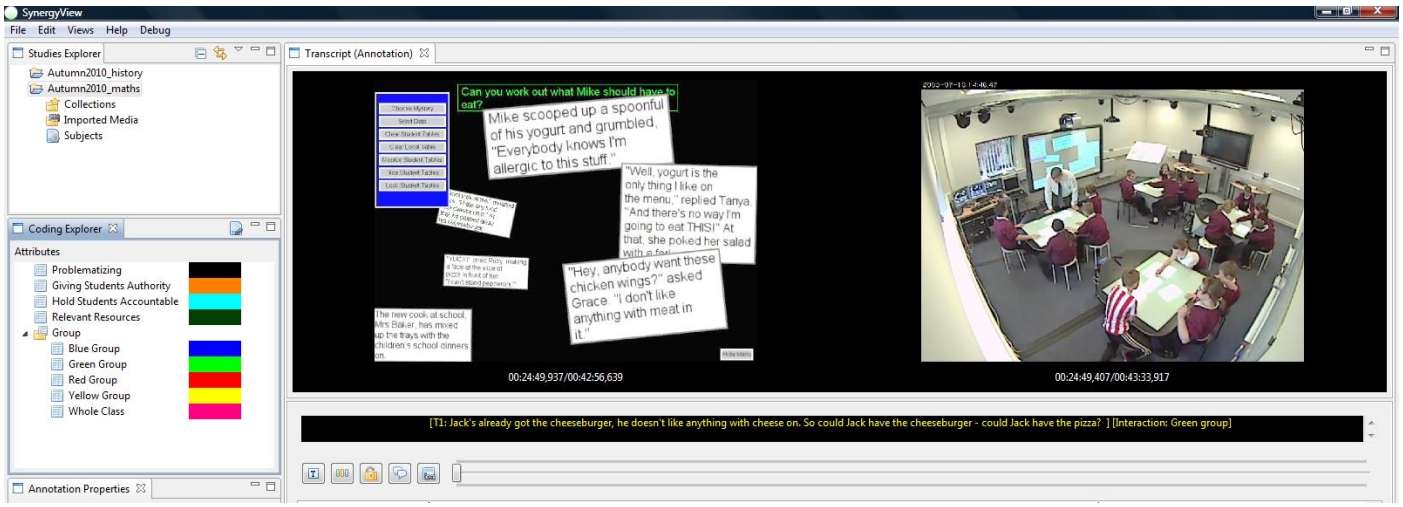
Finally, after visiting each group and ensuring they were all starting with Mike and to whom his meal should go, the Michael tried to get the students to work through the clues systematically to find the logical choice for all the dishes. The final group he visits is the Green group again; who have moved further in their working than the other groups did. Once he finishes talking to this group he stops all the groups by freezing the tables and has a mini plenary.

| | |
|---|---|
| Michael | Right. Can I just stop you a second? We're nearly there. So, I just want to - because a few people have said: "Mr [Michael], I've got it, I've got it!" and they may or may not have the right answer, but they haven't thought about all the possibilities. You've got to explain to me who gets what for all of them, so Mike starts with yoghurt and he doesn't like yoghurt, so who gets the yoghurt? [Hold students accountable] |

| | |
|---|---|
| b59 | Tanya. |
| Michael | Tanya gets yoghurt, because she says, "Well, yoghurt is the only thing I like on the menu." Okay? Now, she has a salad, who might like the salad? [Problematization] |
| r63 | Grace. |
| Michael | Grace, Grace might like the salad, because? [Problematization] |
| Michael | She doesn't like meat. Okay. Now well this is the one I, this is the looks of it. We'll just leave that to the side - it's important, but we'll just leave that one to the side. So you've still got Jack and Ruby and Mike to find out. Can you please just take a second - a few seconds to try and finish it. Off you go. [Problematization] |

The teacher uses the mini-plenary to repeat the steps which he has modelled with each group and to set up the end of the task. He also models arranging the clues on the tables by using the teacher orchestration desk to manipulate the clues which are then represented on the interactive whiteboard. This is shown on the screen shot Figure 6.4. The three clues he has

***Figure 6.4: Teacher's organisation of clues in the Logic task during the mini-plenary***




talked about have been enlarged and he has made them overlap in a semi-circular pattern to show their relation to each other.

After the mini-plenary, the teacher spends the remainder of the group working time interacting with the Green group. The group is on task and discussing the problem, one

student, g56, even says the right answer but then does not follow this up in subsequent conversation. The teacher interacts by asking open questions by which they try to clarify the group's thinking, repeatedly pressing them to back up back up their answers to his questions with reasons. This appears to be an effort to extend an able group to be more rigorous about their reasoning and echoes the instructions he gave them as early finishers in the *reasoning* task discussed in section 5.2.3. Although in that case he gave no support or clear direction as to how he expected the students to achieve this.

| | |
|---|---|
| g56 | Ruby gets the chicken wings and Jack gets the pepperoni pizza. |
| g54 | I can't even turn these! |
| g53 | So what does Mike get? |
| g56 | Mike gets the cheeseburger. |
| g54 | Mike doesn't get the cheeseburger, he doesn't like dairy. |
| g53 | He doesn't like dairy. |
| g56 | Ruby gets the chicken wings and Jack gets the pepperoni pizza. |
| Michael | All right, so Ruby's - Mike's not vegetarian. So who gets the chicken wings? [Problematization] |
| g56 | Grace...no! Ruby, Ruby. |
| g53 | Ruby. Ruby, Ruby. |
| Michael | Why does Ruby get the chicken wings? [Problematization] |
| g56 | Because em... |
| g53 | Why does? She doesn't like pepperoni pizza. |
| Michael | Right, she doesn't like pepperoni pizza, but what about Jack? [Problematization] |
| g56 | Jack gets the cheeseburger. |
| g55 | I hate anything with cheese on it....At...at that, he pushed away... |

| | |
|---|---|
| Michael | Jack's already got the cheeseburger, he doesn't like anything with cheese on. So could Jack have the cheeseburger - could Jack have the pizza? [Problematization] |
| g56 | Yes, Jack gets the pizza. And then Mike... |
| g53 | What if...what does... |
| Michael | Why would Jack have the pizza, because he doesn't like anything with - [Problematization] |
| g53 | Cheese in it. |
| Michael | What does pizza have on it? [Problematization] |
| g56 | Cheese. |
| g53 | Cheese. |
| g55 | Which means that emmm that...that... |
| g53 | Jack...gets the... |
| g54 | He could have a hamburger! |
| g56 | Mike gets... |
| Michael | So Jack had the chicken wings, but what would that leave Ruby with? There's cheeseburger and there's pepperoni pizza. [Problematization] |
| g55 | He gets the... |
| g55 | That would leave... |
| g56 | Mike!? Mike? |
| g54 | Pepperoni pizza! No! Cheeseburger, and emmm Mike gets the pepperoni pizza. |
| g53 | Ruby would get the... |
| Michael | Just sort it out. [Hold students accountable] |
| Michael | Tell them not me, tell them not me. [Hold students accountable] |

The two final utterances are ones which echo the interaction with Green and Blue groups in the *reasoning* task. Once the task is finished the teacher asks groups to share

the answer and make sure that each student understands the reasoning behind this. However, in each case he does not give any instruction as to how to achieve this.

There are other similarities in the behaviours of the teacher between the tasks. His first interaction is with Yellow group to ensure they are on task. He maintains clear expectations of Red group to engage with the task and not simply push clues around. This repetition may be a factor in the decreasing number of procedural utterances (*hold students accountable* and *giving students authority*). Brief reminders may be all that are needed once good working norms have been established. Circumstantial support for this may be seen in the screenshot, Figure 4. Whilst the teacher's attention is focused wholly on Green, the students in the three other groups are focused on the clues. At least one person from each group is gesturing to or touching a clue, other group members are showing signs of joint attention in their body language and gaze direction.

## 6.5. Summary

The qualitative data in section 4.3 showed that there was a decreasing proportion of utterances which *hold students accountable* and an increasing proportion of *problematization* utterances among successful groups between the *reasoning* and the *logic* tasks. Seacrest was used for a more detailed examination of the two kinds of utterance as it is a school which was representative of this trend which was present throughout the whole dataset.

*Problematization* utterances were categorised in this research by their focus, rather than their effects. A more precise characterisation of them could be one which tries to move a group further towards the completion of a task by challenging them, creating a cognitive dissonance between their ideas so far and the idea put forward by the teacher. The group would then have to accommodate this new idea within their existing understanding. Such a definition however also presents problems of interpretation of intention and requires further

analysis of the uptake of teacher's utterances. In this study a problematization utterance is one which is directed at the problem. It may be made concerning a particular clue, or more than one clue. Further research could usefully explore this further.

The description of the interactions in section 5.3 and section 5.4 indicate that there are two factors which seem to affect the use of *problematization* utterances or utterances which *hold students accountable*. The first is the context in which the interaction is initiated. If the teacher initiates an interaction with a preconceived idea of an issue affecting the group which they have decided is important; then the questioning was closed and the utterances held students accountable to classroom norms. The teacher reinforced a required procedural behaviour which they perhaps thought was lacking or insufficient. On the other hand, if the teacher responded to a student initiated interaction (prior to the task finishing) or initiated an interaction without having a predetermined issue to address; then the teacher's questioning was open and the teacher used more problematization utterances.

The second factor is range of functions which *problematization* utterances appear to perform in their use by teachers.

**Reinforcing behaviour:** They can be part of an interaction which focuses on holding students accountable to the classroom norms and group practices of collaborative working. This was part of the teacher's interaction with both *Seacrest* Red group during the *reasoning* task in section 5.3 and *Seacrest* Green group in the *logic* task in section 5.4.

**Clarifying misunderstanding:** Problematizing utterances can be used by the teacher to diagnose and then fix any misunderstandings of the clues which arise through their reading and discussion. This was the case in section 5.4 in the Seacrest Red Logic task.

**Breaking task into manageable steps.** Groups can arrive at wrong conclusions because they have made a single mistake in chain of calculations. The teacher can problematize clues one at a time to lead students through the calculations to the mistake they

have made and then move them on from there. This was the case in the Seacrest Red *reasoning* task (section 5.3).

**Extending group thinking past a barrier it had reached.** This was seen in the Seacrest Green in section 5.4. The teacher finds that the students have gone as far as they appear able in their exploration with the clues. He then either models reasoning with them or develops a response sequence with them that moves them past this and gets them thinking either about new clues or about clues they are already familiar with in different ways. The teacher moves the group past the impasse but does not lead them to the final conclusion, rather leaves them with a final *problematization* which allows them to complete the *reasoning* for themselves.

Problematization utterances frequently require some temporary cessation of authority by the teacher to the students. They involve input from the students and are the result of interaction if not always dialogue. An example of this is the problematization utterances in the interaction between the Green group and the teacher in section 5.4. The teacher cedes authority, only to reclaim it in a sequence of problematization utterances. Utterances which hold students accountable are the result of observation by which the teacher has gathered authority to himself. An example of this is the interventions with the Yellow group during the reasoning and the logic tasks (sections 5.3 and 5.4). The first of these is also an example of the teacher using this authority to intervene in a group's working in a way which may not in fact contribute to the progress of that group. Teachers sometimes get it wrong.

# 7. The use of mini-plenaries during tasks

## 7.1. Introduction

Chapter 6 provided a showcase for the SynergyView tool and how the synchronisation of multiple streams of data can enable researchers to enhance their understanding of areas of research which were previously identified but not explored fully due to challenges of multiple sources of data. This chapter is similar in its aim; however, it looks at a feature of classroom practice, the mini-plenary. This is accepted as a common place tool for class room orchestration among practitioners. However, it is almost entirely absent in published research. Griffenhagen (2011) talks of interrupting collaborative activity to deliver messages but he does not mention discussion or interaction.

The SynergyView tool allows the capture of detailed data in an unobtrusive manner which therefore enables a more realistic environment for classroom interaction. It is through the use of discreet data collection as well as the ability to analyse this data in detail that highlights the potential importance of hitherto under-researched elements of the teacher's repertoire. This chapter is an exploration of the data collected on mini-plenaries and shows the potential for examining or reappraising teacher behaviours and their impact upon collaborative learning.

Mini-plenaries, such as the one mentioned in section 5.4 present a puzzle when trying to understand how teachers interact with groups in collaborative tasks. Teachers introduce tasks and then give pupils the independence to work on it themselves. However, frequently they then stop these and ask the students to cease working together and participate in a whole class discussion. This chapter will explore what, if anything; makes mini-plenary interactions with the whole class different from the interactions of the teacher and a single group. It will then go on to look at some of these mini-plenaries in greater detail before finally suggesting

some reasons as to why both teachers saw fit to stage interventions in group work in this manner.

## 7.2. Mini-plenaries in the different conditions of the study

This section will use frequency tables to explore the use of mini-plenaries in the various conditions under which the study was carried out.

### 7.2.1. Mini-plenaries by school

Each school had at least one mini-plenary during the tasks. Table 74 shows the number and duration of mini-plenaries initiated by the teacher for each school.

***Table 3: Number of mini-plenaries by school and duration***

| | Mini-Plenaries | Mean Duration |
|---|---|---|
| Benbrook | 3 | 44.33 (54.134) |
| Dunhulme | 1 | 76 |
| Easterburn | 1 | 2 |
| Seacrest | 3 | 44 (35.157) |
| Shadbrook | 3 | 51.33 (19.858) |
| Yadstone | 1 | 42 |

### 7.2.2.

### 7.2.3. Mini-plenaries by task

Mini-plenaries took place in each task and could last either a few seconds or over a minute. Table 75 shows how many schools had a mini-plenary initiated by the teacher for each task and how long they lasted.

***Table 4: Number and duration of mini-plenaries by task and duration***

| | Mini-Plenaries | Mean Duration |
|---|---|---|
| Reasoning | 4 | 10.25 (12.606) |
| Arithmetic | 5 | 73 (24.413) |
| Logic | 3 | 44.33 (26.671) |

### 7.2.4. Mini-plenaries by room orientation

There were a similar number of mini-plenaries in both room orientation conditions and these were somewhat similar in their duration and number, differing in their

mean duration by only a few seconds. Table 76 shows the number and duration of mini-plenaries in the two room orientation conditions.

***Table 5: Number and duration of mini-plenaries by room orientation***

| | Mini-Plenaries | Mean Duration |
|---|---|---|
| Centred | 7 | 47 (35.166) |
| Traditional | 5 | 42 (36.194) |

### 7.2.5. Mini-plenaries by gender

There were equal numbers of plenaries in single-gender classes as there were in mixed-gender classes (despite there being twice as many mixed gender classes). Table 77 shows the number and duration of mini-plenaries in the two gender conditions.

***Table 6: Number and duration of mini-plenaries by gender***

| | Mini-Plenaries | Mean Duration |
|---|---|---|
| Single-gender | 6 | 45.67 (27.396) |
| Mixed-gender | 6 | 44.17 (42.428) |

### 7.2.6. Mini-plenaries by teacher

Both teachers used mini-plenaries, David initiated two more than Michael. However, the mean duration of Michael's mini-plenaries was longer. Table 78 shows the number and mean duration of mini-plenaries initiated by each teacher.

***Table 7: Number and duration of mini-plenaries by teacher***

| | Number of Mini-Plenaries | Mean Duration |
|---|---|---|
| Michael | 5 | 50 (28.810) |
| David | 7 | 41.29 (39.140) |

### 7.2.7. Summary

The number and mean duration of mini-plenaries seen in the various conditions in the studies presents a puzzling dimension to the teacher interaction. With from half of the schools receiving one in each task and half receiving only one in any task, the mini-plenaries are

remarkably similar in all of the conditions. This lack of variation shows that mini-plenaries are common phenomena during the study, one which appears not to be contingent on any of the other features of the groups and tasks. Why, then, do they occur? Is there a particular quality to the interaction which teachers need to use? The next section will examine whether obvious variation existed between the categories of utterances in the mini-plenaries compared to the interactions between the teachers and groups of students.

## 7.3. Categories of utterances in mini-plenaries and group-work interactions

The three tables below show the proportion of utterances by category for each of the three tasks. Utterances relating to *relevant resources* were only used by the teachers in the interactions with groups, not the whole class. Teachers did not use mini-plenaries to address technical issues. However, each class had been given instruction as a whole prior to the beginning of the tasks as to how to use the tables (see section XX). Table 79 shows the number of each category of utterance in each task in the group interactions and in the mini-plenaries.

***Table 8: Categories of utterance by task in group interaction and mini-plenaries***

| | | Problematize | Give students authority | Hold students accountable | Relevant resources |
|---|---|---|---|---|---|
| Reasoning | Group interaction | 20 (23%) | 26 (30%) | 32 (36%) | 10 (11%) |
| | Mini-plenary | 10 (36%) | 6 (21%) | 12 (43%) | 0 (0%) |
| Arithmetic | Group interaction | 62 (41%) | 47 (31%) | 34 (22%) | 10 (7%) |
| | Mini-plenary | 50 (40%) | 36 (29%) | 38 (31%) | 0 (0%) |
| Logic | Group interaction | 77 (57%) | 21 (16%) | 27 (20%) | 9 (7%) |
| | Mini-plenary | 20 (63%) | 4 (13%) | 8 (25%) | 0 (0%) |

A greater proportion of utterances in mini-plenaries during the reasoning and logic tasks are problematization utterances, compared with the group interaction phases. This is also true of utterances which hold students accountable. The proportion of problematization utterances is greater in the *logic* task and the proportion of utterances which hold students accountable is reduced in comparison to the *reasoning* task. This mirrors the finding, discussed in section XX, for the group interaction sections of each task.

Given that the categories of utterances have similar characteristics to those in made by the teacher in their interactions with the groups of students; their purpose is unclear. Why do teachers choose to use these particular interventions instead of continuing to talk to groups one at a time?

## 7.4. *Are there teacher behaviours which suggest why they begin mini-plenaries?*

The decision to initiate a mini-plenary seems to differ between the teachers. *Michael* always initiates plenaries immediately after interactions with individual groups. *David* initiated them after a period of silent observation of the whole class. In the case of Shadbrook Arithmetic task, *David* observes the groups silently for one full minute prior to instigating one.

### 7.4.1. Michael

*Michael* appears to take interaction with one group as a proxy for the current state of progress of the whole class. He initiates mini-plenaries to correct misunderstandings he has encountered during his preceding interaction with a single group with the whole class. For example, when interacting with *Seacrest* school during the *logic* task he appears to think that if one group has been prone to a particular misunderstanding, then others could also be at risk of the same confusion:

Right. Can I just stop you a second? We're nearly there. So, I just want to - because a few people have said: "Mr [Michael], I've got it, I've got it!" and they may or may not have the right answer, but they haven't thought about all the possibilities. You've got to explain to me who gets what for all of them.

Michael

In this case Michael has worked through a section of the problem with Green group who were stuck, believing two of the characters in the Logic task swapped their meals rather than passed them in a chain. Once they realised this (by relooking at clues they had previously discarded) they were able to move forward. It was then that the teacher stopped the class and initiated the mini-plenary. This pattern was also closely followed when he initiated a mini-plenary with *Yadstone* during the *arithmetic* task.

In the case of *Dunhulme* and *Seacrest* Arithmetic tasks, Michael listens to the *reasoning* of a particular group which is erroneous. However, rather than correct the group explicitly, the teacher initiates a mini-plenary and by guiding it through a process of closed questions, addresses the issue which he encountered in one group, with the whole class.

*r78* *Yeah, we've got it*

*r78* *Sir, we've got it*

*Michael* *Do you think you've got it because there's some clues there you haven't read.*

*r77* *We haven't*

*r79* *Yeah we have actually, I've got it*

*r79* *Oh, I've lost it now, I was thinking of it.*

*r80* *Eight times two hundred and fifty*

*r79* *Yeah*

*r80* *Thanks*

*r80* *Two thousand*

*r79* *That's four thousand*

*Michael* *Why do you need eight times two hundred and fifty*

*r79* *We've got it, it's two thousand.*

*r80* *Well we've got this ten rides every hour, there's eight hours each day so that's eighty*

*r79* *Then it's two pound each time so two times two thousand is four thousand pound.*

*Michael* *Right, okay, so let's…*

*r79* *Four thousand pound.*

*Michael* *Can I stop you there please, right what do we know so far? We know there… Tell me an important fact. There are…?*

In this case, *Dunhulme* Red group are interacting with the teacher. This group had two strong personalities in it who were convinced they had the correct answer and would not listen to the teacher's suggestion that they may have some clues still to read. When they would not question their own reasoning *Michael* chooses to initiate a group discussion rather pursue a potentially confrontational interaction with the group.

Michael therefore seems to have two separate and contrasting motivations for initiating mini-plenaries arising from interactions with single groups. Firstly he takes the group as the proxy for the whole, initiating a conversation which is aimed at helping other groups avoid misconceptions that would mean he would have to have the same conversation four times in a row. The second motivation turns the first on its head. He is unable to successfully get a group to think about a fault in their *reasoning* process. Therefore he initiates a conversation with the whole class in the hope that the rest of the groups can show by example where the first group is going wrong.

## 7.5. David

Whilst Michael appears to use mini-plenaries as an opportunity to correct misconceptions he has encountered; David seems to do so to establish a minimum level of progress in the task that all groups should have reached. If they have not already arrived there, then the mini-plenary is used to bring their progress towards task completion in line with other groups in the class. He is explicit in asking whether the class knows what they have to do. Here David is instigating a mini-plenary whilst working with *Shadbrook* school during the *arithmetic* task:

*David* *Right, I'm going to stop you for a moment and just see where you're up to, because this is quite a tricky problem. Have you worked out what you're trying to do yet? And I don't want you to give away the answer but if you can explain what you're thinking is about what the problem is.*

He uses the mini-plenary to ask open ended questions as to groups' progress as well as to elicit information and important pieces of reasoning from groups with whom he has already interacted or he has observed. He knows that some groups have already made progress with the task and he uses the mini-plenary as a chance to have groups model their reasoning to show how they made progress for the benefit of those groups which had not done so. In the *Shadbrook arithmetic* task, David had spent time observing Red group before initiating the mini-plenary. Therefore he was able to use them to model desirable patterns of reasoning to groups which had not made the same progress.

*David* *Right, I'm going to stop you there just for a sec and make sure everyone knows what it is they've got to do. So can you just look this way a sec. What's the problem? What's the question about? What do you need to know?*

*g38* *Are we trying to work out how much it costs to keep the waltzer running?*

*David* *Not quite but you're on the right lines.*

*y34* *Is it how much the waltzer o, the waltzer makes, how much money it makes?*

*David* *No*

*r45* *It's how much money he needs to give every 10th person a cuddly toy.*

*David* *Yes, exactly. The waltzer owner wants to get more people to go on his waltzer so he's going to give away a free cuddly monkey for every tenth person that goes on the ride. And you've got to work out how much it's going to cost him to pay for a monkey for every tenth person who goes on the ride. So you're going to need to know how many people go on the waltzer in a day. What are your first thoughts?*

Where Michael uses the mini-plenary discussion to refocus groups who were moving down a path that would not lead to task completion, David uses it to bring groups who had not made as much progress further along regardless of whether they seemed to be making on potentially successful lines.

It also may explain why Easterburn, a school taught by *David*, did not experience any mini-plenaries. Groups from Easterburn enjoyed a high rate of success, particularly in the Logic task, (see Section 3.4.2). David may well have been satisfied that the groups were all making sound individual progress and he did not see a need to intervene.

## 7.6. *What impact do mini-plenaries have on the success of individual groups?*

Given these two competing rationales for initiating mini-plenaries, one concerned with bringing the class along as a coherent unit and the other focused on making sure that all groups do not replicate the mistakes of one group; it is reasonable to assume that the mini-plenaries initiated by each teacher will impact differently on group success. However, it is not possible with the confines of the present study to quantitatively explore the impact of mini-plenaries.

Nevertheless, a number of observations can be made. The first is that not all schools needed mini-plenaries. Easterburn had no mini-plenaries whatsoever and enjoyed very high

levels of task completion compared with the other classes in each of the tasks. If all the groups in a school were appearing to make similar progress, David would not feel it necessary to instigate a mini-plenary. If groups were not using erroneous reasoning which could inhibit their progress, Michael would not instigate one.

Secondly, there was at least on instance, the *Seacrest* Red group in the *logic* task (part of their interaction with the teacher is discussed in section 5.4); where the mini-plenary was helpful in refocusing a group which had become to develop unconstructive working patterns. After the mini-plenary the group became re-energised in their collaboration and ultimately successfully completed the task. However, this positive effect may not have been related to the reasons which the teacher may have had for initiating the mini-plenary. It may have been the physical break from an unhelpful conversation which in fact had the positive influence.

### 7.7. *Summary*

Mini-plenaries are interesting episodes in the data collected. Each teacher appears to have clear strategies for their initiation. Michael appeared more avoidance focused in using them as opportunities to shepherd the class away from the mistakes made by one group. He would use the class to collectively spot and correct the errors of the single group, thereby becoming aware of the potential error. David used them to focus the groups on success, bringing them all up to the standard of those groups which had made most progress. He used these groups to model the necessary reasoning for progress using students he had identified during periods of observation whom he knew had already mastered this. Quantitative analysis seems to show that the use of the teaching strategy of mini-plenaries was not dependent on any of the conditions in the study. Both teachers in the study consistently reacted to the progress of the groups in the classes in stopping the class and refocusing them in some way. They each appear to have clear reasons to initiate mini-plenaries which is evident in their interaction and both did so regularly. They seem to have used them for different reasons but

both thought that they were important. Both teachers used these breaks to maintain group coherence. On the one hand this was achieved by David through ensuring that the groups all made at least minimum levels of progress towards task completion at a particular point. On the other, for Michael, coherence was maintained by the avoidance of serious errors or unproductive discussion. Metaphorically, David could be described as acting as a sheep-dog and Michael as acting like a traffic cone.

Mini-plenaries will be discussed in relation to the research on teacher orchestration in section 8.4. However, one aspect of their use it is important to note here is that, to teachers and other classroom practitioners, the idea of the mini-plenary is a very familiar one. The need to refocus or rephrase students arises regularly and is a standard part of the 'armamentarium' of the teacher, to borrow Shulman's phrase (1986). However, despite being regarded as common place by teachers and teacher trainers, there is scant treatment of them in the literature on classroom dialogue. They may be familiar to classroom practitioners, but their absence from the literature must surely puzzle researchers once they are aware of it. This leads on to a wider potential field of study too, one which asks what are the differences in the conceptions of teacher orchestration tools for classroom dialogue between researchers and classroom practitioners. Further a study which could potentially reveal numerous potential differences in perceived aims and methods.

# 8. Discussion

## 8.1. Introduction

The results of this study present an exploration of the facets of teacher-student interaction in the three mathematics tasks. Much of the literature on classroom interaction offers examples of desirable interactions between students and teachers. However, they rarely provide a coherent rationale as to why they have arrived at these particular vignettes. The process followed in the preceding four chapters aimed to show how a large volume of data could be analysed at different levels of granularity. The first quantitative chapter focused on interaction as its unit of analysis; the second focused on the utterance. It was because of this preceding analysis that vignettes were selected which either typified the processes which were indicated in the exploratory statistical analysis or deviated from them in some way. The results therefore contain a number of findings whose key strength is the process by which they have been derived. Their presentation allowed for their further qualitative investigation. Thus when vignettes have been employed it has been because they were indicated by the preceding quantitative analysis.

The development of the SynergyView tool has allowed a large quantity of high quality data to be collected, allowing researchers to look in great detail at the interactions of small groups with each other and with the teacher. In fact, the volume of this data is one of the greatest challenges to its meaningful use in research: the challenge of how to describe the general features of the data and then to prioritise which instances or themes to examine in greater detail.

This study aims to accomplish this by describing general features quantitatively and then looking in greater detail at two of the themes which were present within this quantitative data. This involved a degree of qualitative interpretation of this quantitative data: it was only

exploratory and associative in nature. Little emphasis has been placed upon the quantitative findings due to these limitations, other than to inform the refinement of further research questions.

The two qualitative explorations which have been dealt with in this study have shown the use of small verbal orchestration devices with which the teacher uses to balance collaboration and task completion. The quantitative and qualitative analysis process used in the preceding chapter are by no means the only ones which could be applied to this data, rather the approach is one possible avenue which could be followed when presented with such a rich data collection and detailed analysis tool. The contribution of the study, to be discussed further in this chapter is to explore the methodological challenges presented by this tool as well as to explore some of the theoretical insights which it brings to the area of classroom research.

This discussion considers the implications of the study in the wider context of the literature, relating features observed to those already documented, such as the behaviours of successful and unsuccessful groups, adding to the work of Barron (2003) in particular. It will also consider role of the teacher in relation to the power dynamics of the classroom, the contrasting styles of the teachers which may also have affected how they and the groups interacted. This factor of power and the role of the teacher impacts upon the application of the Engle and Conant (2002) framework to classroom interaction. How best this can be employed in the understanding of classroom interaction going forward will be discussed as well. The role of the teacher in shifting the discourse between interactions with the individual, to interactions with the group and then to interactions with the class will be discussed. The basis upon which teachers make such decisions will be related to the literature on how teachers create and employ theories

about what is transpiring within a dialogic space and how they then try to transfer this to a zone of intermental development.

Given the discussion relating to the process of learning which involves the individual learner as one of a collaborative group of learners which was presented in Chapter 1, the findings of the study and the observed features of teacher - student interaction will be discussed with reference to models of learning through activity and the processes at work upon the teacher in their orchestration of the technological, pedagogical and content knowledge which they must co-ordinate to enable the learning to function effectively.

Finally, the SynergyView tool's potential as a research tool will be discussed in relation to its potential impact on the theoretical background of research upon classroom dialogue. A tool (be it SynergyView or something potentially like it) which is able to integrate multiple data streams in a timeline and allow the researcher to interrogate these using multiple units of analysis at varying levels of granularity is one which must play a role in changing the way research on classroom interaction and discourse is conducted and reported.

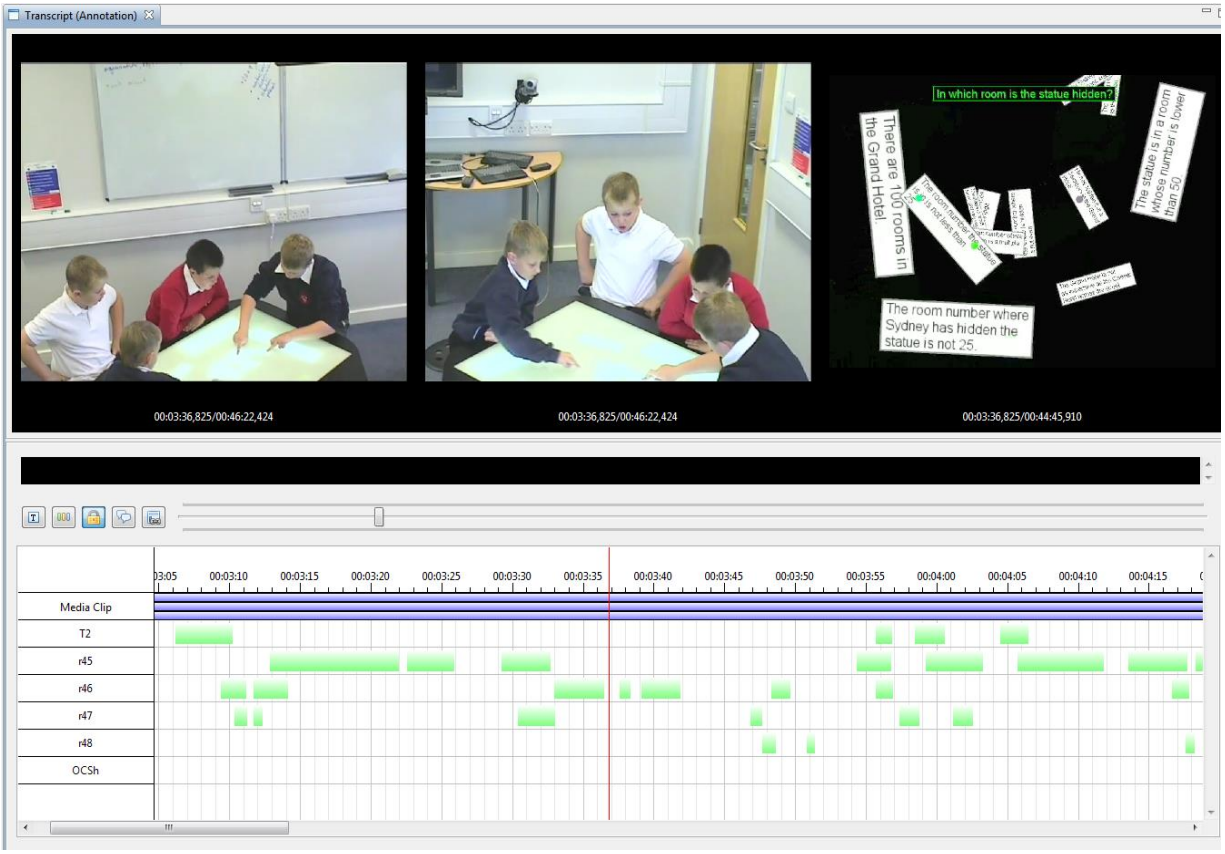
## 8.2. Group efficacy

According to Barron (2003) the ability of groups to succeed at a collaborative task rests upon the ability of the people in that group to deal constructively with the ideas put forward by other group members (see section 1.3.5). Successful groups built upon each other's ideas whereas unsuccessful groups rejected them without explanation. This was certainly seen with groups in the study. This section will explore some examples of these to show the alignment of the evidence in this study with Barron's findings. It will then develop this further by looking at how the teacher relates to the collaborative practices of successful or less successful groups.

Students participating in the study were allowed to choose where they sat as long as it was in the gender conditions relevant to that particular session in the study (mixed tables of boys and girls in two sessions; boys-only and girls-only tables in four others). This was done because the regular teacher of the class was not present (sometimes they came along and watched remotely, sometimes they stayed at school and a teaching assistant came). This led to some students sitting in friendship groups, others found themselves on tables away from friends. Whilst this was not necessarily a barrier to the establishment of successful collaborative working practices, or to group successfully completing the task, it may have helped some groups to establish a natural order or to develop roles within the group.

The boys-only group Shadbrook Red represent examples of different roles the students developed within the tasks. One student (r45) was acknowledged by the group as the best at Mathematics. Another student, (r46) saw it as his role to ensure that the group worked smoothly. This extract is taken from the very start of the Reasoning task, this was the first one in the session and the screen shot, Figure 8.1 shows the overview of the interaction on the time line of the SynergyView tool.

***Figure 8.1: Shadbrook Red group, ReasoningTask (from left to right: r45, r46, r48 and r47)***




| | |
|---|---|
| *David* | *Thank you. Is that, okay, you can start. Thank you very much. [Holding students accountable]* |
| *r46* | *There, this one, this one* |
| *r47* | *Out of the way* |
| *r47* | *Wait man* |
| *r46* | *(to r47) Stop telling us to wait, you wait* |
| *r45* | *This one's important, I got this one last time, it's hidden in a room that number is lower than 50* |
| *r45* | *The grand hotel is next to the station, we don't need that* |
| *r45* | *Reasoning has stolen a special statue* |

*r47* *[singing]*

*r46* *You can talk (r47), look at the size of yours, idiot*

*r46* *Wey smallen it then*

*r46* *You don't need it that big unless you're blind, get off*

*r47* *Stop being so*

*r48* *I'm definitely moving after dinner*

This section, the beginning of the Reasoning task, shows tensions already present between r47, who wants to explore the clues alone and change their size in particular; and r46 who wants him to be aware of what r45 and he are doing. The screenshot of the SynergyView tool in Figure 1 shows r45 reading clues, r46 indignant at the size of r47's clue enlargement (see the clue on the far left of the table data stream: 'There are 100 rooms in the Grand Hotel'). R48 is engaged peripherally, watching the manipulations of the clues without discussing their content.

R45 is the student most focused in the group on finding solution to the task. R46 appears to recognise this and adopts a role of enabler. The short hand in the SynergyNet team for students, usually boys, who played this role, was 'sergeants'. These students were predominantly focused on the process of the task and ensuring that those in the group they saw as better at mathematics were able to continue to solve the problem unmolested by those who just wanted to play with the clues. Student r48 played little part in the solving of the tasks. Unlike r47 who used manipulation of the objects on the tables as a masking activity for their lack of engagement with the task, r48 made no effort to engage with the tables. This may have been related to the group he was with on the table, his friends were at a different table and he was in a group of people he would not normally work with. Like r46 he also found r47 difficult to work with however, rather than engaging with this he disengaged.

R45 proved very capable at solving the tasks, although he did not do so entirely single handedly in the Reasoning task, he did do the bulk of the work. This was celebrated at the end of the Arithmetic task and the beginning of the Logic task by the whole group:

*r46* *Go (r45), go (r45), go (r45), go (r45)*

*David* *Right, we're going to one last, one last maths mystery before we get some other people in to help. The last one isn't numbers; it's thinking. It's mathematical thinking. It's a logic puzzle. So, and it's about school dinners that get mixed up. People have their choice of school dinners and you've got to work out who gets which dinner. It's called dinner disaster.[Holding Students Accountable]*

*r45* *Shut up*

*r45* *Shut up*

*r46* *Yeah, we're going to do it again*

*r46* *We're going for a hat race*

*r45* *Stop it*

*r45* *Annoying*

*r45* *Me get everything and everybody else gets nothing*

*r47* *(unintelligible)*

*r47* *All of us gets*

*r45* *Yeah, all of us gets something but me get the most and everyone else get nothing*

*T2* *Ok )[Holding Students Accountable]*

*r47* *No*

*r46* *Everyone else gets stuff*

The working of the group is far from equal but it is perceived as equitable by at least three of the students. By this stage, two thirds of the way through the tasks, r46 and r47 are less antagonistic towards each other and r47 is more task and group focused in his talk. The ways which students negotiate their own working practices appear to be a mixture of play and role-play which integrate their work on the task.

In the Shadbrook Green group, again, a group of four boys, there is also one child (g37) who feels that they have done more than their fair share of the task. He mentions this to the other students and they come to a different arrangement about their roles:

*g39* *Look I've done*

*g37* *(g39), I've done loads of work can you do something please, so I…*

*g38* *Right, I'll get the important information this time.*

*g37* *Right, (g38) gets the important information, I'll read some stuff out, cos I've done loads of work.*

*g40* *Hey, everybody want these chicken wings asked Grace I don't like anything with meat on it, in it.*

*g38* *In it [any?]*

*g37* *that's anybody not*

*g38* *that's what I said*

*g37* *you said eeney body*

*g37* *eeney body*

*g40* *That's probably cos my voice was going.*

The example of the two boys groups from Shadbrook shows that although researchers are able to list the characteristics of successful collaborative groups, be it Johnson and Johnson

(1999) or Barron (2000a), the reality of the process by which this happens can be an erratic one of negotiation within the group. The schools which participated in the study were largely unfamiliar with the kind of collaborative learning tasks used in the study. The students were given some input in pre-sessional visits by the researchers as to the basic strategies which could lead to successful collaboration. However, these amounted only to a reminder of turn taking and basic listening procedures.

Not all attempts to negotiate collaborative working practices are successful. Students also attempted to repair working practices which had deteriorated. In the case of Shadbrook Blue group in the Reasoning task, this was unsuccessful:

*b43 It's 45 (unintelligible), it's 45, I just heard Michael say it's 45*

*b42 there you go*

*b44 Yeah, but we don't copy off other people then ourselves*

*b41 and we just started*

*b42 (unintelligible)*

*b41 we just work it out for ourselves*

*b44 so read the triangle(?) how?*

*b41 I know, I know you were*

*b43 Yeah well I'm saying so's we*

*b44 The staute is in a room whose number is not even*

*b44 in 50*

*b44 and this says there are a hundred rooms*

*b42 The room number isn't even*

*b44 It's not less than (unintelligible) where the statue is hidden is not even*

*b44 Is not even*

*b43 Is the number 25*

*b44 Did you work it out by yourself?*

*b44 Or have you heard somebody else say it?*

*b43 I'm not going to tell you til you've earned by trust*

The extract cited above come 4 minutes into a 5 minute period of group work. In this group, b43, may be engaged in social loafing (Blumenfeld, Marx, Soloway & Krajcik, 1996) and has not engaged constructively with the group up until this point. Their statement is rejected by the group. Despite being the correct answer the group are unwilling to accept it without working it out. B43 appears to take this rejection very seriously, suggesting one more answer but refusing to truly engage with the group discussion.

Therefore the attempts at negotiation of collaboration captured by the study are the result of the students attempting to meet the relatively new challenge of complex collaborative tasks head on. Whether they were able to transition to successful collaborative group working practices impacted greatly on the level of success achieved by a group. This also impacted upon the way in which the groups were able to use the teacher as much as how the teacher perceived their own best, most useful, role.

## 8.3. The role of the teacher in establishing collaborative group practices

Throughout the whole study, only one group makes no progress towards completing a task. This group is Yadstone Red in the arithmetic task. The group is challenged by conflicts between group members throughout all the tasks they were involved in during the study and

during the previous session, the History tasks. However, in this task matters come to a head. The teacher is initially moved to begin an interaction when he sees one of the students is close to tears. The teacher tries to discuss and reinstate joint collaborative working practices however; these are no longer present in the group:

| | |
|---|---|
| *Michael* | *You alright there, sunshine? You suffering a bit? [to r15] [Gives authority to the student]* |
| *r14* | *Oh (r13) stop pressing it!* |
| *r13* | *It's not my fault that I'm pressing that is it?* |
| *Michael* | *Why are you getting annoyed? ] [Gives authority to the student]* |
| *r15* | *Cos of these just messing on* |
| *r14* | *No I'm not the one messing on, he's the one messing on* |
| *r15* | *Cos they're annoying so it's helping less because of that* |
| *Michael* | *Sorry? Alright, so what's the problem? You think they're messing on. How do you think they're messing on and how would you like them to behave? Are you listening lads? So, how would you like them – how's it helping or not helping to solve the clues? [Holding students accountable]* |
| *r13* | *That?* |
| *r15* | *They're annoying and they're helping less and they're fighting over that* |
| *r13* | *(unintelligible)* |
| *r14* | *(unintelligible)* |
| *Michael* | *So, what – ignore him. You have to organise yourselves so that you don't fight over it. [Holding students accountable]* |

*r13* *Well I was reading…*

*r14* *(unintelligible)*

*Michael* *Whoa, excuse me; I was just asking a question. How can you organise yourselves so that you don't fight over the clues? Share them out? Or take turns reading one each? [Holding students accountable]*

*r14* *We'll read one each*

*r13* *(unintelligible)*

*Michael* *Do you think we could make a start doing that? Okay?*

*r14* *Yeah but*

*Michael* *Who's going to start? [Giving students authority]*

*r13* *Not me*

*Michael* *Not you? (r16) want to start? You read the first clue. [Holding students accountable]*

*r13* *We've already done one clue*

*Michael* *And then who's going to read the next? So, let's go (r16) this young man, this young man, this young man. Can you read round that way please? Okay? Thank you. [Holding students accountable]*

*r16* *He only knows my name*

The teacher is unable to focus the students on the task as a group, after he leaves the group they do not make any attempt to follow the teacher's suggestion. This group serves as a reminder that although collaboration can be a powerful asset to enable deeper and more transferrable learning as Barron (2003) and others have shown, one can't expect groups of students unfamiliar with the practices of collaboration to automatically assume roles conducive

to collaborative learning. For it to be successful, collaborative learning practices need to be taught, for some groups this should mean being taught for longer than one introductory session prior to the data collection (in the case of this study). Without the right context of collaborative working practices and their careful orchestration by teachers, any activity can descend into sullen isolation or humiliation and frustration for the students involved (Blumenfeld, Marx, Soloway & Krajcik, 1996, p.38). The difficulties encountered when implementing group work from 'contextual classroom issues' in this study echoes the findings of Blatchford, Kutnick, Baines & Galton (2003, p.169). Just because students are sitting in groups, they don't always work together.

Whilst examples of dysfunctional groups unable to collaborate successfully is disheartening for the researchers, primarily because of the distress caused to any students involved, highlighting these does serve to show two important points. Firstly, that collaborative activity within classrooms is far less straight forward and more messy than some research would lead us to believe. Talking of dialogic interaction and collaborative practices in the abstract (such as in Mercer and Littleton, 2007 or Barron and Darling-Hammond, 2008) does not always take account of the considerable orchestration which teachers need to accomplish to make this a reality. Recognising these difficulties strengthens rather than weakens the findings of this study as it highlights the chasm between classroom practice and the research of classroom practice. The level of data collected and the ability to look at the role of the teacher as a totality or just as they interact on the periphery of one group's experience means that the disparity between what teachers do and what they think they do (and also what researchers may perceive them to do) is shown to be stark indeed.

The example above is also a powerful one for the consideration of power and authenticity in student teacher interactions. This will be the subject of the next section which will explore whether dialogue is possible between students and teachers, and whether researchers can claim to replicate this relationship as well as any implications arising for methodology based upon these claims.

## 8.4. Power and disciplinary norms

The role of the teacher in the maintenance of collaborative learning situations is essential, however, the extent to which they can ever participate in these is limited. In section 1.2 it was argued that the concept of power interfered with teacher participation in dialogic interaction. Scott, Mortimer and Aguiar (2006) argued that the teacher moved between dialogic and authoritative interactions. Wells (1999) suggested that there was dialogic interaction but this was not the interaction of equals. However, the evidence presented in this study shows that the power relations within the classroom still work to inhibit any dialogic interaction.

The example cited earlier in section 6.4 of an interaction between the Dunhulme Red group and the teacher during the arithmetic task shows how power impacts upon interaction.

| | |
|---|---|
| *r78* | *Yeah, we've got it* |
| *r78* | *Sir, we've got it* |
| *Michael* | *Do you think you've got it because there's some clues there you haven't read. [Problematization]* |
| *r77* | *We haven't* |
| *r79* | *Yeah we have actually, I've got it* |
| | *……* |
| *Michael* | *Why do you need eight times two hundred and fifty [Problematization]* |

*r79* *We've got it, it's two thousand.*

*r80* *Well we've got this ten rides every hour, there's eight hours each day so that's eighty*

*r79* *Then it's two pound each time so two times two thousand is four thousand pound.*

*Michael* *Right, okay, so let's…*

*r79* *Four thousand pound.*

*Michael* *Can I stop you there please, right what do we know so far? We know there… Tell me an important fact. There are…? [Hold students accountable]*

During the interactions leading up to the mini-plenary the teacher is twice over-ruled by the group. This is a form of cognitive conflict which conflicts with the contextual factors within the classroom; it could be seen as a challenge to the teacher's authority, it could be a dysfunction of the group's collaborative practices which would take too long to address in the context of the task, it could raise an emotional reaction, such as frustration, from the teacher which they may find it difficult to suppress.

For any of these reasons the teacher could choose to stop the interaction abruptly and change register. The difference between the interactions between the teacher and the students compared to those between the students themselves is that in the latter the students know that they still have a voice; they don't have to accept a situation without the opportunity to convey its impact upon them to the others who are part of the dialogic interaction. They share an accountability to each other as shown by the dissent of Shadbrook students b43 and g37 when raising their complaints about group behaviour. However, the students and the teacher both know that such mutual accountability does not exist within the dialogic interaction for the teacher. They may be accountable for their behaviour within the classroom. However, their Magisterial

voice is not accountable to the voices of the learners (see Cheyne and Tarulli, 2005, in section 1.2).

It is the student's acknowledgement of a teacher's power which means they also acknowledge the lack of accountability they have in the dialogic process. Meaning is constructed with the dialogic space; this is an unreal space which the students have entered into as actors, role-playing a part. The part they play is that of school student, they have been playing this role for a long time and it has been crafted rather than transmitted throughout their school career by countless semiotic and dialogic transactions either within the classroom, within the school or more broadly within their interactions with society at large. Within this role of school student, individuals play a number of other roles. To succeed in collaborative learning, the students must adopt the role of a collaborative learner, as described by Barron (2000a).

Engle and Conant (2002) argue that the teacher has to foster a culture of productive disciplinary engagement. By disciplinary engagement they mean some relation between the activity of the student in school and the issues and practices of a discipline's discourse. This engagement then becomes productive when it supports progress in intellectual challenge, when the student is "getting somewhere", as they put it (2002, p.403). Essential to achieving this is the role of the teacher who must problematize the issues, scaffolding them to make them manageable. They must give the students authority to explore these issues themselves. They must hold students accountable to the disciplinary norms of the activity which is taking place and finally they must provide the students with relevant resources with which to complete the task .This study took these four categories of teacher activity and modified them, arguing that the discipline within which the student was operating was the classroom. This was the disciplinary norm to which they would be held accountable.

Examination of the results has reinforced that original assertion. The discussion in section 5.3 of the interactions between Michael and the Seaburn Yellow group in the Reasoning task shows him make three utterances which hold students accountable. However, each his couched as a question:

| | | |
|---|---|---|
| First interaction | Michael | *Do you think it might be helpful if you had them so everyone could see them even though, you know, it's not the one that's being read, just thinking, because you might have to go back to some of the clues, you know. [Hold students accountable]* |
| | | …… |
| Second interaction | Michael | *So what's happening here - why are we - you're not making much progress on this one what's the problem? I think you're spending a wee bit too much time just organising them here. [Hold students accountable]* |
| | | …… |
| | Michael | *So, you see this - you need to be reading the questions, you need to be reading the clues and you need to be trying to work it out together, okay, because if we all just push these around it's not going to work, right? [Hold students accountable]* |

However, this is not how they were interpreted, nor arguably, how they were intended to be interpreted. The utterances the teacher makes in the activities do relate to problem solving, exploring ideas and exchanging them such as may happen within the discipline of Mathematics. Indeed this kind of exchange and problem solving which mathematicians might be happy to see taking place in schools (Lockhart, 2009). However, it is framed within the context of the classroom and the students' role as learner. The perlocutionary force with which the teacher

speaks is different from the surface meaning of the words. The teacher wants the students first to organise themselves better then later to move on from organizing the clues to using them productively. He wants them to develop a process which is oriented towards task completion.

In the case of the first interaction, the teacher gets their initial assessment of the groups interactions wrong. This can be seen in Table 81, a screen shot from SynergyView:

***Figure 8.3.1: Seacrest Yellow group in the Reasoning task (first teacher utterance highlighted)***

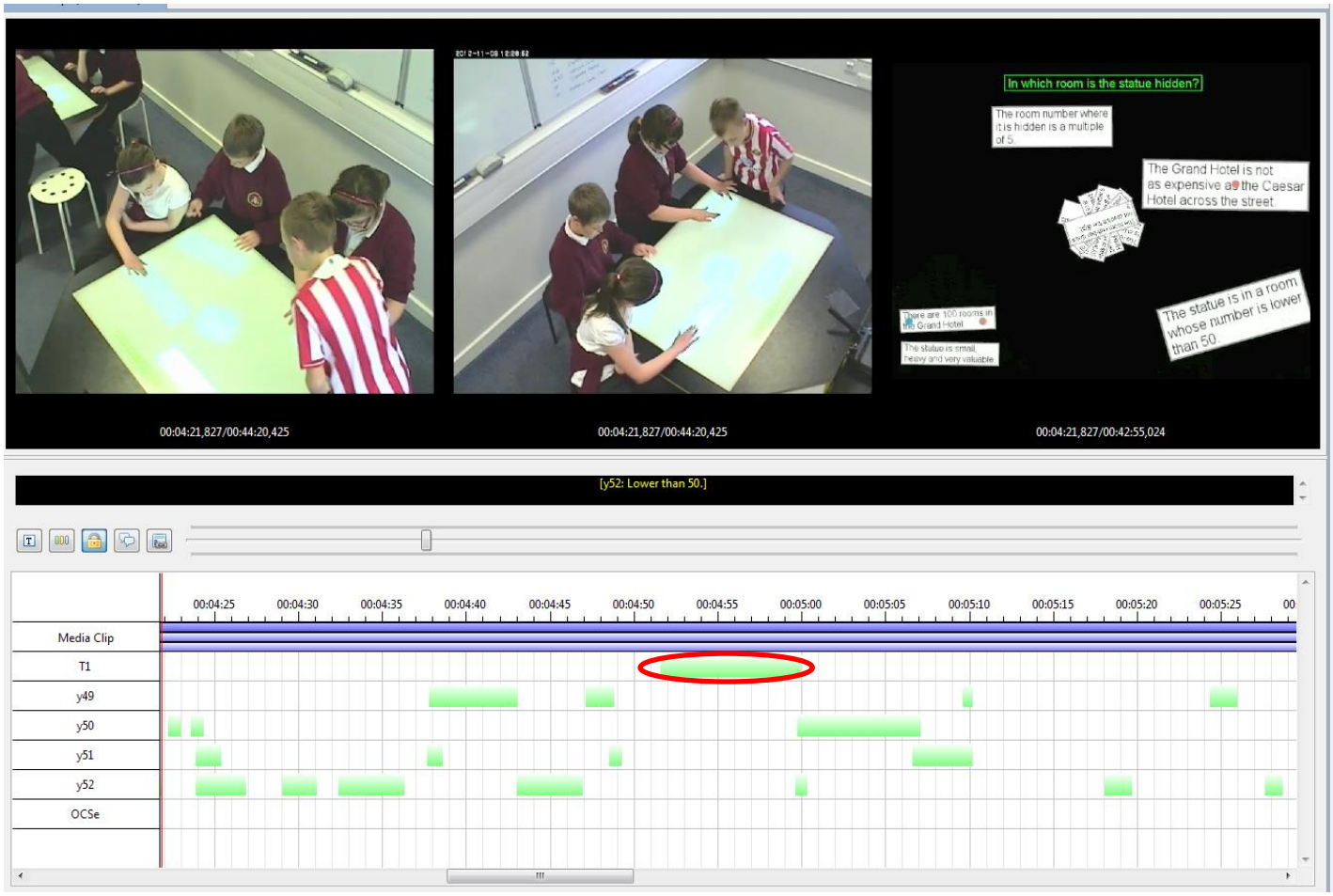
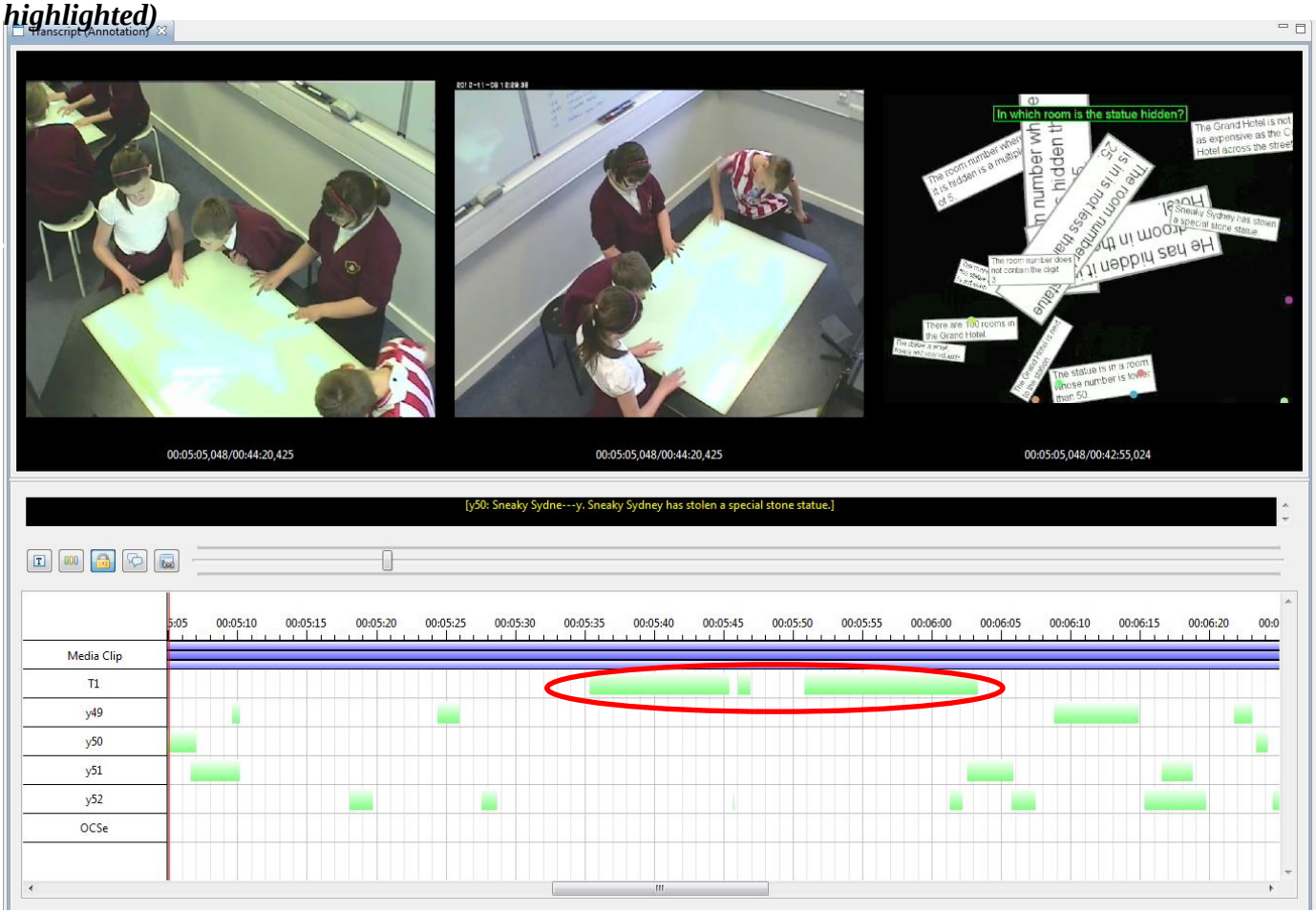


Figure 8.2 shows the 30 seconds prior to and after the teacher's utterance. There was more student talk in the preceding thirty seconds compared to the following thirty seconds. In this case the illocutionary force of the teacher's words did not have the effect that he perhaps thought they would. Rather than fostering greater discussion this petered out. Perhaps what the students heard made them believe that they were inadequate to the task in spite of their efforts and therefore they lost enthusiasm. The teacher created a passing theory that the students were not working constructively, acted upon this but then did not evaluate the impact that this had. In fact it was rare for either teacher to remain observing the impact of what they said after they had finished an interaction. Their attention was usually diverted to the needs of other groups. Thus they did not know how their advice or instruction was being interpreted, only how they thought that it would be interpreted.

The teacher's second interaction with the group, shown in Figure 8.2, had a different

***Figure 8.3.2: Seacrest Yellow group in the Reasoning task (second teacher utterance highlighted)***



effect upon the collaborative behaviour of the group:

Here the uptake of the teacher's utterances is good and the students move on from the inactivity preceding the interaction to more activity afterwards. They also progressed in the complexity of what they were doing, moving from reading out clues to reasoning about the evidence contained in them (Mercier, Higgins, Burd & Joyce-Gibbons, 2012):

*y52 Do you wanna read this one first?*

*y51 We know that it's more than 25, it's less than 50.*

*y52 It's not, it's...*

*y49 It's...it's not twenty-five, and it is not under 25.*

*y52 So it must be, it must be more than 25, 35, 40, 45.*

*y51 It's more than twenty-five, it's uneven*

*y49 No, it is even...*

*y50 The room number where...*

*y52 No, it's saying it isn't...is not.*

*y51 Not even.*

*y50 It's a multiple of five.*

*y51 So what could it be? What number is a multiple of five, over twenty-five...*

This change in the level of complexity of reasoning in the talk is an example of the positive impact a teacher could have on group reasoning. However, again due to the differences between the perlocutionary and illocutionary forces of the teacher's utterances it is not possible to establish a definite causal link between these and the increased reasoning. Nonetheless the

group does seem to be exhibiting a greater coherence and an ability to engage with and respond to each other's ideas, characteristics Barron (2003) describes as necessary for successful groups.

Looking at group uptake of teacher interactions is one possible avenue for future research which will be discussed in section XX. However, whether there is a direct causal link between group activity and the teacher interactions directly preceding it is still a matter for debate. This was not something which was indicated by the statistical exploration of the data in section. In section 3.2 there was shown to be no statistically significant association between the number of teacher interactions and the success of a group in a task. However, there were more successful groups that did have interactions with the teacher during the course of the task than successful groups that did not. Section 3.3 showed a statistically significant association between the duration of interactions with the teacher and the success of a group in a particular task only in the arithmetic task. Teacher student interaction can be said to be important, however, it was not clear whether quantity or duration was a key factor. The ambiguity may rest in the differing interpretations of the teacher's utterances by the students.

The difference between the intended meaning, the surface meaning and the understood meaning of the teacher's utterances coded as holding students accountable reveal the tensions within classroom interaction. The teacher is not able to hold students accountable to the disciplinary norms of a discourse other than the one they are situated in because the students will never accept such accountability as authentic. They will always regard themselves as situated within the discourse of classroom learners. They may play a role which requires adopting some elements of an external discourse within this one but which is always situated within their discourse as students in a primary school. They will interpret all utterances by the teacher in this context and not purely with in their role as role-players within a discipline.

### 8.4.1. Giving students authority

Paradoxically, one of the simplest ways to see the operation of power as a dynamic within the classroom is to examine the way in which the teacher appear to give power away and look at why they do so. The Engle and Conant framework presupposes that teachers need to give students the authority to explore the discipline in which they are engaged for themselves. They argue that with their own sense of authority students will critically engage with the evidence and develop a sense of authorship for their own ideas. It is a sense of authority which will change them from passive consumers of knowledge into active producers of it (see section 1.5).

However, this was a difficult concept to operationalise within this study. The work of Engle and Conant (2002) was based on multiple observations of a class groups within a class working on a science project over an extended period. The challenges required the assimilation and evaluation of a wide range of information but unlike the tasks in the present study they were not expected to arrive at a defined 'right' answer.

The initial context of the Engle & Conant study was a term-long open investigation into a science topic. This involved a large amount of extra study by students who were encouraged to develop their interests and become experts in particular areas of the issue studied (2002). However, in this study, which was conducted with six separate schools, with each class only interacting with the teachers involved for a relatively short time, and working together on discrete Mathematics problems, the context required limited the teachers' opportunities for 'holding students accountable' within the constraints of this research project. It was therefore taken as an invitation from the teacher to a student to respond to an open question to justify their current thinking. In section 3 the utterances where the teacher holds the students accountable to the disciplinary norms of the classroom were show to frequently be framed as closed or rhetorical questions. These utterances are frequently phrased as open questions.

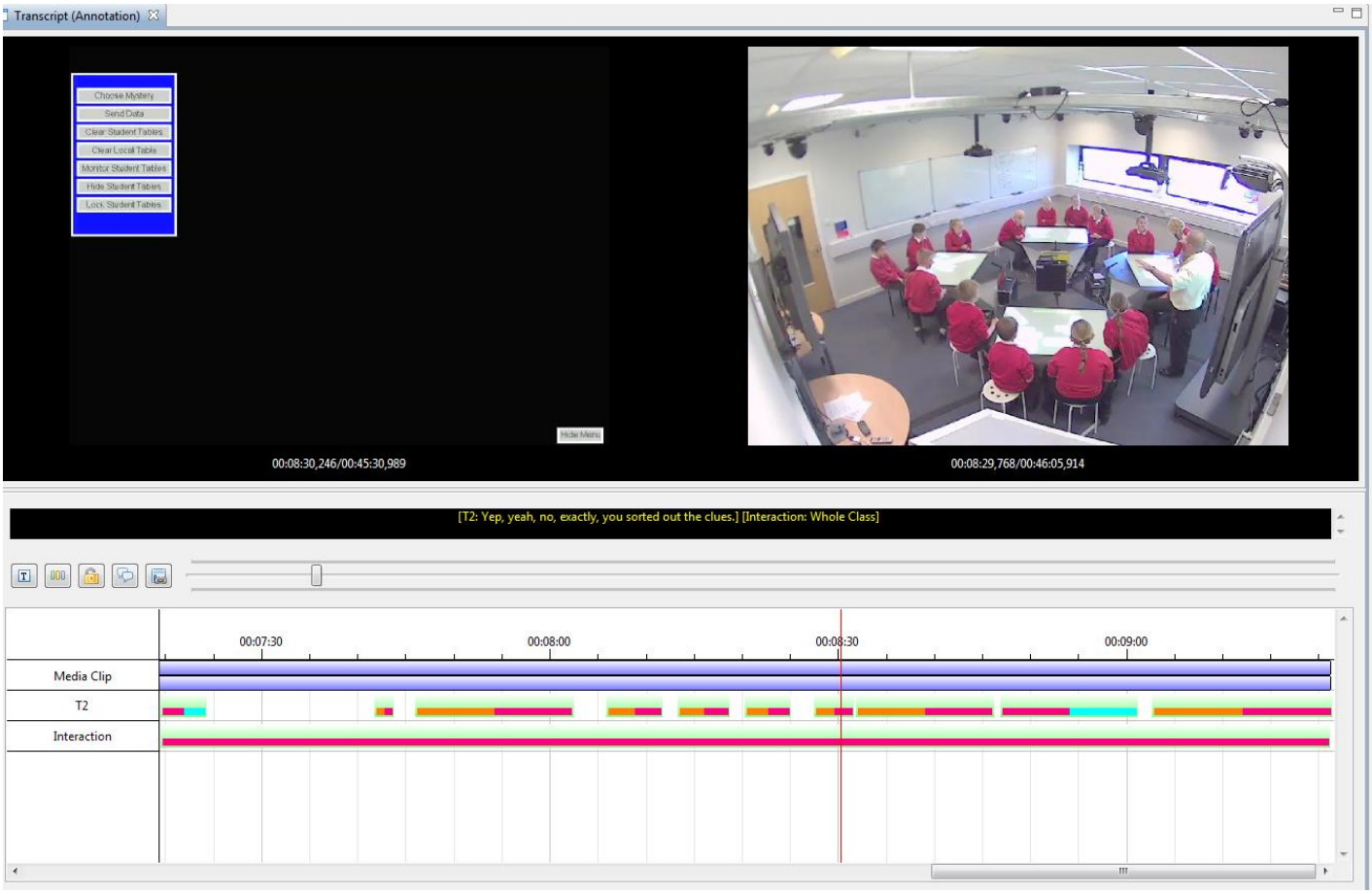
They do not occur frequently during interactions with the groups and are most commonly used by the teachers during the mini-plenaries or plenaries at the end of the tasks. This example, during a group work interaction with Benbrook Red group during the reasoning task, shows the teacher asking an open question before developing from there:

| | |
|---|---|
| *David* | *You worked it out already?[Hold students accountable]* |
| *r31* | *We're stuck! We don't know what to do!* |
| *David* | *I'm sorry?[Give students authority]* |
| *r30* | *We don't understand.* |
| *David* | *Okay, uh...what...[Give students authority]* |
| *r30* | *Do you just add all these?* |
| *r32* | *(r31), have you seen your mam?* |
| *David* | *You've got some statements about the different room numbers and you've got to work out which room the statue is hidden in. So can you give me an example of a clue that tells you something?[Problematization]* |
| *r32* | *The Grand Hotel is not an expensive...* |
| *r30* | *There are a hundred rooms in the Grand Hotel.* |
| *David* | *So you know there are 100 rooms so it'll be from 1 to 100. [Problematization]* |
| *r31* | *And then there's this one here, what gives you a better clue. The room numbers where hidden in a multiple of 5.* |
| *r29* | *Easy.* |
| *David* | *So what does that mean?[Problematization]* |

The teacher gives authority to the student to speak, to tell them something which is not known by them; in this case, whether or not the group is having difficulties. However, once they have established this, authority is taken back and the teacher focuses on the problem but at the same time seizes back control.

Later on in the same task, the teacher is leading the plenary session, inviting individual students to give input during group discussions. Figure 8.4 and transcript below show a different means of the teacher giving students authority. They echo the words of the speaker:

***Figure 8.3.3:Teacher David leads whole class discussion with Benbrook during reasoning task.***




The whole class discussion starts with an utterance by the teacher which holds the students accountable (shown as a pink and light blue bar on the T2 line). The utterances which

give students authority (shown as pink and orange bars on the T2 line) are interspersed with student responses which are shown in the transcript below. This screen shot was chosen from the SynergyView tool rather than one which showed the all the students utterances too, because this was the view which showed the teacher talking to the whole class. One can see in the right hand video data stream the teacher gesturing to the class, is indicating the groups he is most pleased with whilst addressing the group which needs to change their working practices to be more effective. The transcript below shows the exchange:

*David* *Okay, these two groups were really quick. Can you explain your thinking? [Hold students accountable]*

*b27* *We broke it down like, we started with 100 then 50, than 25 then it said the multiple has to be...*

*b28* *is not even*

*b27* *is not even and it has to be in five and it says it's not 25 so the only answer it could be is*

*b28* *and it can't be three either*

*b27* *so the only answer*

*David* *And what do you mean by it can't be three.[Give students authority]*

*b28* *it can't contain the digit 3*

*b27* *3*

*David* *So [Give students authority]*

*David* *So, let's take this a bit more slowly. So, we start off with 100. Then we knew it was less and 50. So it's between one and 50. Then we know that it's a multiple of five. So that's 5, 10, 15, 20, 25, 30, 35, 40, 45. [Give students*

*authority]*

*b27* *so the*

*b28* *yes*

*b27* *em, em*

*b28* *yes*

*b27* *yes*

*b27* *And then we knew it was in between 25 and 50*

*David* *So we know it's more than 25. So it's 30, 35, 40 or 45. [Give students authority]*

*b28* *and it can't be even*

*b27* *It can't contain*

*David* *Okay, it's not even so that leaves us with 35 or 45. Excellent. [Give students authority]*

*g21* *Thirty-five or forty-five.*

*b28* *and it can't contain the digit 3*

*b27* *it can't contain*

*David* *And it can't contain the digit three so it must be 45. [Give students authority]*

*b28* *45*

*g23* *That's the exact same answer what we got, the same way.*

*David* *Yes. Exactly, you sorted out the clues. [Give students authority]*

*David* *What I really like, can I just make a suggestion to this group. Can you see that the other tables, they've got their relevant and irrelevant clues in a nice list, as have this group, as did this group. So they worked out the really important ones. And the reason they were successful quicker was that they listened to each other. You were there and you knew what you were doing, you just didn't quite get there because you… [Hold students accountable]*

*r32* *I knew it was half of ninety! That's good.*

*David* *There isn't a clue about half of a ninety (Laughter). Nice try. Nice try. [Hold students accountable]*

During the group stage of the task, the teacher has seen the working of three groups. He knows that the Blue group and the Green group have both arrived at the correct solution and used collaborative techniques to work together to arrive at this answer. One group, Red group, has been somewhat dysfunctional despite his intervention cited earlier in this section. The group is still having difficulty, in the teacher's mind, forming a reasonable collaborative working partnership. The whole class discussion is underpinned by the subtext of the teacher subtly pointing out why Red group have not been successful. He echoes the words of Blue and Green groups in a process of call and response. However, he does so only to reinforce his own point that Red group need to work more collaboratively together.

In the first example, the interaction with Red group, the teacher makes an utterance which gives authority to the student because he needs more information to form a passing theory as to the needs of the group. He knows they are not progressing as he wanted but does not know why so he asks them. In the second example, he has a fixed passing theory in his mind as to the reasons why the group did not perform adequately and again, he gives students authority. This

time he is using one group as an example for another group to follow. The teacher is using utterances which give authority at a more surface level to ultimately reinforce his own authority at a deeper one.

Authority therefore is something which is not given as such in the classroom context here. Rather it is ceded by the teacher as a means to an end. The students are expected to go along with this and may be regarded as part of the role play. However, the teacher is able to take it back at any point because they are not participants in the students interaction and role play of classroom participation, be that in group work or in whole class discussion. They are external to this and accountable at the group interaction level.

### 8.4.2. Conclusion

On the whole the Engle and Conant framework was one which allowed for a comprehensive coding of all teacher utterances during the task. There were no utterances which did not fit into the coding scheme. It was adapted substantially, partially to reflect the differences in task and setting which were present in the SynergyNet project compared to the original study. Utterances regarding relevant resources, for example, were those which referred to the operation of the tables which allowed the students to access the Mathematics resources. These coded utterances were not statistically significantly related to the key questions of the study and played little part in teacher-student interactions, largely because any problems with the operation of the tables or familiarization of the students with the tables had already occurred by this point in the programme for the day.

The adapted coding scheme showed the kinds of interactions between teacher and student at both a quantitative and a qualitative level. When coded into the SynergyView tool they also provided a means of visually exploring the relationships between the categories of utterances to generate further hypotheses about the interactions.

Two categories of utterance have shown the tensions between the roles which the students were expected to play as classroom students, collaborative learners and explorers of the discipline of Mathematics. They have also helped to show some of the power relationships within the interactions between the teachers and the students.

The next section will explore the role played by problematization utterances and look at them in relation to the use successful groups make of these when completing their tasks. It will also look at the way in which the teachers orchestrated the classroom and how problematization and mini-plenaries played a part within this orchestration.

## 8.5. Orchestration

The relationship between the teacher's utterances and the orchestration of the lesson by the teacher is not a straight forward one. Section 7.3 and section 7.3.1 both presented indications of how teachers develop and refine their passing theories as to the needs of the student. However, orchestration, particularly as presented by Dillenbourg and Jermann (2010) does not deal with the teacher's refinement of lessons during their course. Indeed, although the list of characteristics presented in their article is comprehensive for the activities which need to take place during teacher orchestration, their view elides the difference between the practical orchestration with the cognitive orchestration of the lesson. There are physical and pragmatic factors which the teacher must take account of in their preparation and delivery. However, it is their adjustments to attune their activity to their perception of the learning needs of their students thereby enabling the students to better make progress, which is the most meaningful orchestration in the sense of the concept presented by Kennewell, Tanner, Jones and Beauchamp (2008).

Section 4.3 established that there was an increased proportion of problematization utterances throughout the tasks and a decrease in the number of utterances which held students

accountable throughout the tasks when one looked at the proportion of utterances made to successful groups in any given task (though these were frequently, though not necessarily, the same groups). However, the relationship between utterances and orchestration is not a clear one. The utterances are the product of (ongoing) teacher orchestration. They are the expression of the teacher's passing theories as to the meaning being made by the students, the sense they are making of their task and the roles they are expected to play within those roles. Teachers do not orchestrate their utterances; their utterances are a signifier of their orchestration. The orchestration is a dialogic process and an intermental one. The teacher takes the information available to their senses, semiotic signs they observe and verbal interactions (either ones in which they observe or ones in which they participate). This information is made sense of within the teacher within whom it forms a part of a dialogic meaning making with their intentional self. Like the student the teacher is required to role play the part of the teacher. When they make sense of the lesson as it is unfolding there is a dialogic space between the interpretation of what they have taken in and the part of them which role plays the teacher and the task this persona has to accomplish (the successful orchestration of the completion of the task).

To return to the model of orchestration put forward by Kennewell, Tanner, Jones and Beauchamp in section 1.4.1 , the dialogic space within which the teacher creates their own meaning of the task as they experience it is reflection in action by the teacher on their orchestration.

***Figure 8.3.4: Analysing teaching and learning in activity settings framework (Kennewell, Tanner, Jones & Beauchamp, 2008, p.67) adjusted to take account of teacher's intramental dialogic processes***

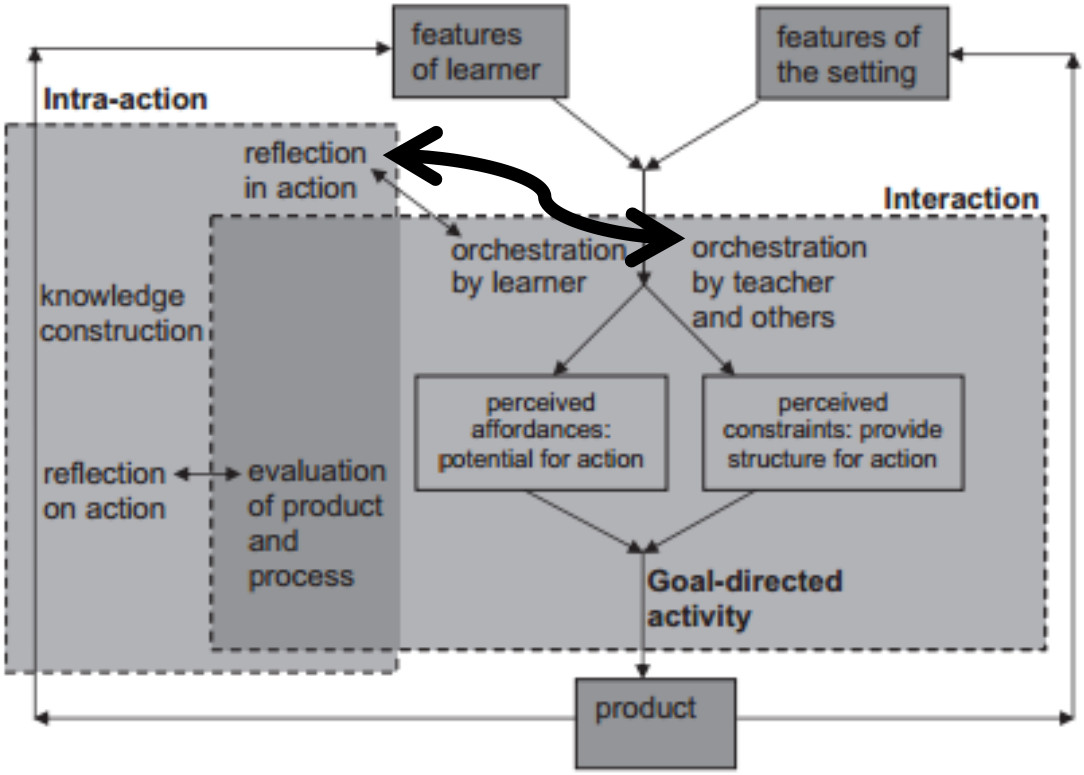



Figure 8.5 shows that the process of orchestration is iterative both within and between tasks. It is also iterative within and between activities within that task. It is how the teacher 'makes the best of' what they have to work with.

Both Easterburn (taught by *David*) and Seacrest (taught by *Michael*) were schools in which all groups were successful at the final logic task. The coded ribbon of the teacher's interactions throughout the reasoning and the logic tasks for each school are presented below:

*Figure 8.3.6: Easterburn reasoning task*

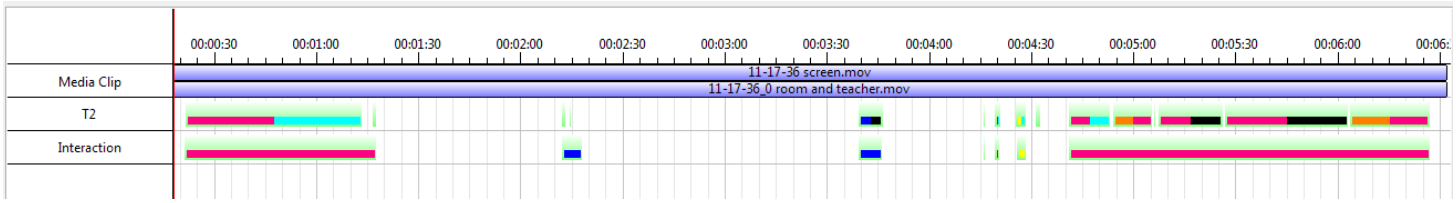



*Figure 8.3.7: Easterburn logic task*


*Figure 8.3.8: Seacrest reasoing task*

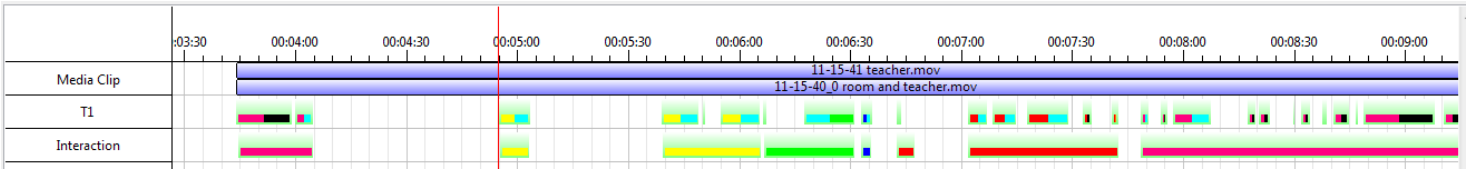



*Figure 8.3.9:Seacrest logic task*

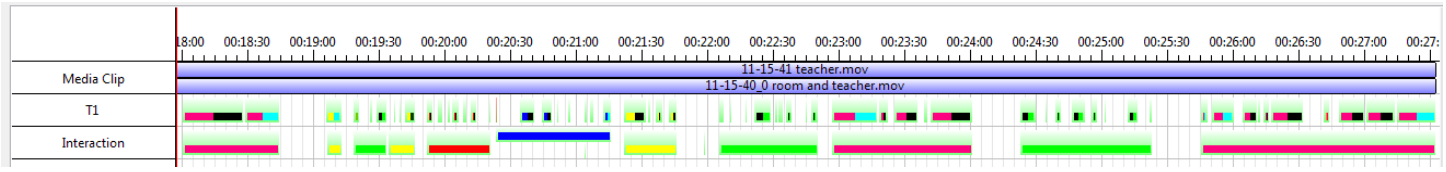
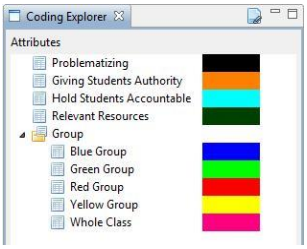


***Figure 8.3.10: Framework coding key***




Both teachers interacted considerably less with the students during the reasoning tasks than they did during the logic tasks. This is particularly pronounced in the case of Easterburn where *David* spent very little time interacting during the reasoning task but almost all his time interacting during the logic task. *Michael* also spent longer interacting during the logic task than he did during the reasoning task. In both cases the teachers spent their time observing the activity of the groups during the reasoning task. They were not idle, but watchful.

This lack of interaction suggests a possible explanation for the difference in the number of problematization interactions in the first compared to the last task. The teacher formed passing theories as to the needs of the group and then spent time addressing them. In the reasoning task for Seacrest, the teacher does spend some time interacting with the Green, Red and Yellow groups. His interactions hold the students accountable (the light blue strips on the T1 ribbon of the time line). However, his interactions in the logic task show are focused on problematization (the black strips on the T1 ribbon). Both teachers have assessed the situation; in the case of *Michael* he formed a passing theory of the groups which needed to be held accountable to the norms of the classroom (to enable them to formulate better collaborative working practices). In the case of *David* he has chosen to keep observing.

The Intermental Development Zone (see section 1.2), is the space in which the teacher includes the student or the group of students in their intramental meaning making to influence

their further orchestration. For Mercer and Littleton this is a continually reconstituted point of activity (2007, p.68). However, the evidence of interaction from this study argues that it may be a briefer process which then sets in train other processes.

Once engaged in an interaction with a group which was focused on the problem, characterised by repeated problematization utterances, the teachers may be described as entering and then leaving the IDZ. There is a tension at work within the IDZ between the need of the teacher to facilitate task completion and the need to scaffold a collaborative working environment. It is possible that the IDZ, with the tasks as currently constituted, is not able to sustain the conflicting needs of cognitive challenge (task completion) and collaborative working.

The interaction between *David* and Easterburn Blue group in the logic task illustrates this tension. It also illustrates the variety of utterances which are categorised as problematizations. The reason for their categorisation, they are in some way relevant to the completion of the task, is discussed in section 6.5.:

| | |
|---|---|
| *b90* | *There's only one clue with Mike in it* |
| *David* | *That's right, so you've got to use all of the other clues to make a chain of clues. [Problematization]* |
| *b89* | *Right* |
| *b90* | *That's what I don't get* |
| *David* | *Don't worry.* |
| *b90* | *Cos these don't like it* |
| *David* | *Look the easiest one to start with is – is that the clue about Mike – Mike and Tania, so Mike's got the yoghurt and he doesn't like yoghurt…* |

*[Problematization]*

*b89* *But she does like yogurt*

*David* *…but she does. That's the only thing she can have [Problematization]*

*b89* *So she might give him the salad.*

*So, well, I think you've got to work out all of them, not just swap. 'Cause*

*David* *Tania's got to have the yoghurt. Now Grace doesn't like anything with meat*

*on, so she can have the salad. [Problematization]*

*b92* *Oh yeah, that's right*

*b91* *And then, and then, Mike can have the chicken wings*

*b92* *What about Jack?*

*Well, the problem with Mike having the chicken wings is that Jack doesn't*

*David* *like anything with cheese on, so he can't have the cheeseburger or the pizza,*

*'cause the pizza will have cheese on [Problematization]*

*b92* *So does he have the chicken wings?*

*David* *So he needs to have the chicken wing. [Problematization]*

*b89* *And … the…*

*And Ruby doesn't like pepperoni but she can have the cheeseburger.*

*David*

*[Problematization]*

*b92* *So then he can have…*

*David* *So Mike can have the pizza. [Problematization]*

*b89* *Right, yeah, we've got it then.*

The teacher begins this interaction by responding to a student dilemma, they can only see one clue within the task that relates to the question. They then progress to structuring the thinking of the group in a series of statements which invite response, an IRF sequence. However, as they progress through working with the group, the teacher appears to become increasingly focused on completion of the task themselves, twice they actually talk over b92 and b89. The final utterance from b89 suggests that the group is left with the feeling that they have accomplished the task and may even believe that they have done so in a collaborative manner.

This example contrasts with *Michael's* interaction with the boys in Yadstone Red group cited in section 7.2. Here the teacher is so focused on ensuring collaborative working and trying to force group agreement that they are not able to either engage the group towards finishing the task or to get them to genuinely agree any collaborative strategies:

*Michael* *Whoa, excuse me; I was just asking a question. How can you organise yourselves so that you don't fight over the clues? Share them out? Or take turns reading one each? [Holding students accountable]*

*r14* *We'll read one each*

*r13* *(unintelligible)*

*Michael* *Do you think we could make a start doing that? Okay?*

*r14* *Yeah but*

*Michael* *Who's going to start? [Giving students authority]*

*r13* *Not me*

*Michael* *Not you? (r16) want to start? You read the first clue. [Holding students*

*accountable]*

*r13* *We've already done one clue*

*And then who's going to read the next? So, let's go (r16) this young man, this*

*Michael* *young man, this young man. Can you read round that way please? Okay?*

*Thank you. [Holding students accountable]*

*r16* *He only knows my name*

The teacher comes to the group to try and address a particularly challenging situation where one student is upset and frustrated. They try to engage the students in an IDZ to come to some solutions to the problem. However, the group were not willing to engage with this and the teacher pressed on nevertheless. The final comment from r16 suggests that they group are left without a sense of accountability or of interest from the teacher. Perhaps they thought the teacher was interested in the process more so than them.

These two examples highlight two tensions. The teacher must attempt to resolve two imperatives; the need to foster collaborative working by the group and the need to support the group in the completion of the task. Progress towards both of these should be orchestrated in such a manner that the two converge. The imperative for the group to collaborate successfully should support the imperative for the group to complete the task. Within the confines of the classroom (such as the time, space, different relative speeds of the groups to finish the task) the establishment of IDZ though an interaction with a group can sometimes only reconcile these two imperatives with difficulty.

The mini-plenary may potentially be regarded as one way in which teachers attempt to reconcile these tensions when they have become too great to manage at group level. Section 6.6 offered two possible explanations for the initiation of mini-plenaries during group work in each

of the tasks. The first was that it was a way of the teacher alerting students to a potential mistake which one group had made and they wished other groups to avoid. This approach was noted in sessions supervised by *Michael*. The second approach, to bring all groups up to the same level of progress towards task completion, was employed by *David.*

The decision to shift the register of the classroom discourse from the group to the class may be regarded within the context of the IDZ. This is the space where the teacher brings their own intramentally formed dialogic understandings into interaction with the students. The two tensions within the IDZ are the imperative to work collaboratively juxtaposed to the need for the group to complete the task successfully. When these tensions appear to be irreconcilable within the confines of interaction at group level then the teacher may decide to change the focus of their interaction.

The process of orchestration is an intermental and necessarily unstable one, it requires the constant reformation of the teacher's passing theories as to the meanings being made by the words and actions of the students and what these mean in terms of their progress towards the goals of collaborative working and successful task completion. This reformation occurs through reflection in action as well as reflection on action and requires the teacher to orchestrate their own learning to facilitate this process as well as the learning of the students. The level at which the teachers have sought to orchestrate this learning in the data collected in this study has been at a group or a whole class level. Sometimes this has been a simultaneous process with different meanings orchestrated for different individuals. An example of this is the subtext of the whole class plenary run with Benbrook during the reasoning task and detailed in section 7.3.1. The teacher intended one meaning for the whole class and a supplementary meaning for the blue group whom he intended to show how they needed to improve their collaborative practices.

Having considered the issues of power and orchestration which arose in the literature review, in relation to the coding schemes used and the data analysed, the discussion will now turn to the processes through which the teacher can better facilitate learning within the classroom and the role they place as a mediating factor in the students learning using the Technological Pedagogical Content Knowledge (TPACK) model (Mishra & Koehler, 2009) and the emerging theories within the SynergyNet group of teachers, teams, tools and tasks.

### 8.5.1. TPACK, Orchestration and the Intermental Development Zone

The TPACK framework, discussed in section 1.4.3, describes some of the areas of understanding which the teacher has to orchestrate to support the learning of the class. The unique balance of these factors required to operate in the developing SynergyNet classroom with its integrated multi-touch tables and interactive whiteboard was the principle reasons why researchers were the only ones capable of working with the students during this study (see section 2.2).

The interactions between the students and the teachers analysed in this study predominantly reflected the pedagogical knowledge and content knowledge aspects of the TPACK framework. The utterances holding students accountable to the norms of the classroom and the utterances which gave students authority both can be considered as predominantly pedagogical content knowledge. These were means by which the teacher got the groups to reflect upon their own learning or held them to account in some way for the process of learning. The utterances classed as problematization were focused on scaffolding a solution to the problem were primarily content knowledge but with elements of pedagogical knowledge.

Given Merleau-Ponti's achievement of meaning-in-the-world through doing-in-the-world as a means of achieving the transcendence of the subject-object dichotomy which Gibson first put forward (Bonderup-Dohn, 2009, p.163) each element within the TPACK framework can be

thought of as describing an attribute. Each of these attributes engenders an ability within the individual. Figure XX shows the attributes described in the TPACK model with a description of their attendant abilities:

***Figure 8.3.11: The elements of the TPACK model as applied to the present study***

| Attribute | Ability |
|---|---|
| TK | Ability to use the orchestration tools to manage the tasks. |
| PK | Ability to create and sustain a pedagogical learning environment among groups. |
| CK | Ability to understand and apply the mathematical skills necessary to solve the tasks. |
| TCK | Ability to manipulate the clues and display tools to support whole class discussion. |
| TPK | Ability to know how and when to use pedagogical affordances of tables to manage group learning. |
| PCK | Ability to scaffold process of reasoning to enable groups to develop more complex ideas. |
| TPCK | The ability to orchestrate all of the above abilities in the optimal measure given the changing circumstances of the classroom. |

The above table of abilities were essential to the successful administration and support of the tasks in the study. It was not possible to train the class teachers of the pupils in the SynergyView Project sufficiently in the tools available in the orchestration desk in the time which was available (even if the class teacher was present), though the final stage of the project moved on to this. However all of these attributes were necessary if the two teachers, Michael and David, were to adequately establish an IDZ in which to attempt to support students in their group activity and have fluent control of the technology.

The passing theories formed in the intramental dialogic space within the teacher are also informed by the perceived affordances and constraints of the orchestration of the potential

actions available through the technology. The IDZ is a space where the actions enabled by these attributes are put into action.

### 8.5.2. Conclusion

This chapter has discussed the relationship between the teacher and students, when working either in small groups or as a whole class. The creation of an ideal dialogic space between the teacher and the student is not possible. Figuratively, the power relations which are ever present in the teacher's interactions with the students interpose themselves into this space. The teacher may cede authority at times, only to rescind this when it suits their purpose. This presence of power in each interaction also explains some of the difficulties surrounding getting students to think with the mindset of a particular discipline, in this case the disciplinary norms of mathematics. They cannot escape the inherent power relations of the classroom and they but they can use these relations in their orchestration of classroom activities. The nearest approximation is that their role play within the classroom (in which they already role play a version of themselves as a classroom learner) is expanded to include a form of disciplinary role play, being a teacher and being a teacher of mathematics.

The teacher may therefore enable the establishment of a dialogic space between groups of students but not fully participate in this with them. Through their interactions and observations the teacher creates passing theories which they use to make meanings of the group's interactions. In the same way the students create passing theories with which to make meaning of the teacher's utterances. Thus the perlocutionary and illocutionary force carried by the words of the teacher or of the students might be very different. The teacher's intended meaning may differ both from the literal meaning of the words they use and from the way in which these words are interpreted by the listener (see, for example, the framing of utterances holding students accountable as questions).

Teachers and their students may not therefore be able to form a dialogic space together. However, they can make use of each other to form that dialogic space intermentally (in the case of the groups of students) or intramentally (in the case of the teacher). The teacher's orchestration can be a means by which they employ themselves as a tool which mediates learning of students. This is based upon their interpretation of the needs of the students. Their interpretation of the needs of the students, the passing theories they create, can be understood as the result of a dialogic interaction between the roles which they play and the tensions between these roles. This dialogic interaction is an intramental one.

The outcome of this intramental dialogic interaction is the selection of the tools they use, be they mental or physical, to orchestrate the lesson, based on their perception of the affordances and constraints of these tools. This orchestration is instigated within an Intermental Zone of Development (IDZ). The IDZ is the space in which the teacher engages with the students to orchestrate their learning based upon the passing theories they have formed in their intramental dialogic space. However, it is an inherently unstable creation. Ideally it is a place where the imperatives of the teacher's role in the task (supporting collaborative working and supporting the groups in the successful completion of the task) should be intertwined and mutually reinforcing. However, this is not always the case in practice. Often the IDZ collapses with one or other imperative taking over, such as a teacher leading a group through structured questions to the answer, or a teacher trying to establish a framework of superficial collaboration whilst ignoring deeper underlying tensions and the goal of task completion. In cases where the tensions between these two imperatives become two great the teacher may choose to instigate a mini-plenary. This is a dramatic form of orchestration which changes the register of the discourse within the class;

temporarily stripping the groups of their autonomy and requiring them shift their attention from the group to the teacher.

The means of orchestration at the teacher's disposal, the affordances and constraints which they perceive to possible activities can be described through the TPACK framework. This framework describes attributes that correspond to activities. This study as focused primarily on the pedagogical knowledge and content knowledge aspects of Shulman's original idea. However all the elements described in figure XX were at play within the orchestration by Michael and David of this study. These activities may be thought of as tools with which learning can be mediated. However the mediation is in the meaning created by the students who interpret the orchestration of the teacher according to the passing theories which they themselves develop (which include their perceptions of the power relationships which lie within the classroom).

The concluding chapter will consider how the findings of this project might be developed in future avenues of research. This will include the SynergyView tool and how the use of temporal analysis software might impact upon the understanding of classroom interaction. It will also consider the implications of the findings of this study on the practice of teachers when supporting collaborative activities.

# 9. Conclusion

## 9.1. Research Aims and intentions

The overall research question which this study sought to address was set out in section 3.3:

*How does teacher orchestration of collaborative Mathematics tasks relate to the learning and interaction which takes place?*

This question was explored using both quantitative and qualitative methods. The quantitative chapters showed few results where there was a statistically significant association between the interactions or utterances and the success of the group. Similarly there were few associations between the interactions or utterances and the conditions under which the study was run. This was perhaps not surprising given the relatively small scale of the study with two teachers and groups of pupils from six schools, involving 96 students in total. However, there was shown to be a pattern among successful groups. The number of utterances they received which held them accountable decreased from the reasoning task (the first task) when compared to the logic task (the final task).

This difference in interactions suggests that the teacher was able to modify the passing theories which they used to interpret the groups actions and words. Instead of this interpretation indicating that they needed support establishing group working practices (and hence the utterances which held the group accountable to the norms of the classroom), it indicated rather that they needed support in scaffolding their thinking to make sense of the task so as to be able to complete it.

This difference was less marked for those groups categorised in each task as having made only some progress towards task completion. However, it is important to note that not all groups which were successful at completing the reasoning task were successful at

completing the logic task and therefore this result is not a direct comparison of successful groups compared to groups which made some progress.

The discussion of this result above argues that the reason for the difference in the kinds of utterance made by teachers to successful groups in the two tasks is related to the process of meaning making which goes on within the teacher, a process which reflects that taking place within the group. This process of meaning making happens intermentally within a group and intramentally within the teacher. They have a discussion; however, it is an internal one.

The behaviour noted in qualitative analysis of the Seacrest groups, the mini-plenary, is related to this process of meaning making as well. The teacher orchestrates the interactions of the class based on the meaning they have made, or their passing theory (Davidson, 2001). This orchestration is enacted within the Intermental Development Zone (IDZ), a place of interaction between teacher and students where they engage with them seeking to affect their progress towards collaborative completion of the task. This interaction in the service of twin goals, collaborative working and task completion renders the IDZ frequently unstable. When it is no longer possible for the teacher to orchestrate the working of a group in a way which meets these two goals, they may initiate a mini-plenary.

## 9.2. Theoretical contributions

The argument put forward in Section 8.1 is based on the analysis of the data collected in this study. It builds on and informs the body of research which is concerned with the teacher's use of perceived affordances and constraints to orchestrate collaborative learning. The teacher may temporarily change register to allow the re-establish an IDZ which is able to serve the imperatives of collaboration and task completion. It also informs the research into the creation of a dialogic learning environment in the classroom. It does so by showing the way in which the power relationships inherent in teacher student interaction disrupt the

possibility of creating a viable dialogic space between them. Rather the teacher must form an intramental dialogic space in which to understand the learning taking place in the dialogic space formed by the students.

## 9.3. Contributions to practice

There are two contributions to classroom practice. The first is the recognition that the students, in their activities, may never be able to escape the discourse of the classroom and the imposed authority of the teacher in dialogic interaction. Teachers should not labour under the assumption that they will be able to do so. Rather the nature of the role play which students are asked to engage is should be recognised. They are always classroom students but in different lessons they may be asked to role play the part of a Mathematician or a Scientist. This is not to say that they should not be encouraged in every possible way to develop this role. Nor should learners be discouraged from adopting the questioning and experimental investigating which Mathematicians need to function (Lockhart, 2009). In fact this may be a process made easier by recognising that these factors are already nascent in the classroom learner, they may not easily be taught, they may be even less easily adopted but they may occur naturally with greater frequency if unforced.

The learner and the teacher can never escape the power imbalance and perceived power imbalance with which they experience the classroom. Again, teachers should not try to do so. They should not confuse an interaction with a shared dialogic understanding. This does not appear possible on the basis of the analysis in this study. Rather they should seek to ensure that the students are able to create their own dialogic spaces within their own groups for effective construction of meaning. In most circumstances the teacher cannot be involved at an authentic level due to their own knowledge of the curriculum, the subject and the task, they can watch, choose how to interact and monitor the progress of groups, the learning of individual and the whole class.

Related to this is the inherent instability within the IDZ. Teachers are caught between conflicting goals which they are tasked with reconciling. They need to support collaborative learning but they also need to support students to complete the tasks. They have a limited amount of time to spend, frequently determined by the speed of the fastest group to finish the task. The mini-plenary can be a means of attempting to reconcile these goals by switching register to the class level from the group level. This can establish a uniformity to the thinking of the groups, or rather; it can expose groups to a uniformity of thought as played out either in a statement by the teacher or by a dialogue between the teacher and some of the students in the class. The skills necessary for collaborative learning to take place are not developed quickly, or within one session. It may be that some students struggle to develop these, or are unable to do so in combination with certain other students in the group or at particular tasks at any particular point in time.

## 9.4. Limitations of the study

This study also set out to explore the large amounts of audio visual data created during the detailed analysis of teacher student interaction during collaborative learning tasks. It was part of the wider SynergyNet project described in Chapter 3. As such the demands of the project did limit the data collection in two ways. Firstly, there was imbalance in the number of classes taught by teacher in the two room orientation conditions. This was due to the possible number of days available for data collection and the needs of other studies in the project. The experimental nature of the tables was such that they were not easily adjusted. To alter the layout of the classroom took two days of work for two people. Therefore, to satisfy the requirements of interdisciplinary demands of the study, it was necessary to carry out research in the two conditions. Analysis of the interactions in the different room orientation conditions did show some associations between group success and the room orientation, favouring the more ‘traditional’ room orientation. It also showed that there was an association

between the categories of utterance used by the teacher and the room orientation conditions in which they were working. Because of this imbalance, these results have been noted but only limited reliance has been placed upon them in the discussion of the findings.

The teachers who worked with the students in this phase of the project were also researchers who worked on the wider SynergyNet project. This was again due to the constraints of the overall project. The experimental nature of the tables, the operating system of the multi-touch environment and the constantly evolving software meant that full-time teachers were unable to devote the time to familiarizing themselves with the orchestration tools and the collaborative learning tasks at this stage of data collection. This was a process which initially took at least a day and changed several times, often at short notice, depending on the needs of the computer science research team who were simultaneously running their own data collection during the period of the study.

The precautions which were put in place to ensure that the roles of teacher and research did not overlap in a way which would threaten the validity of the interactions are detailed in section 2.7. However, the discussion of the study findings does involve a protracted consideration of the role of power in the classroom. The dual roles of teacher and researcher are an inescapable feature of this study. This feature is recognised and reflected in its exploratory nature. It represents a beginning to research using the detailed audio-visual data collection tools and advanced teacher orchestration devices which will be developed further through the inclusion of the classroom teacher teaching their own class. Nevertheless, the class teacher inevitably has a different power relationship to their own students compared with the researcher. Just as it is argued in this study that students will never forget that they are in a classroom and respond accordingly; it was also impossible for them to forget that they were in a research lab and not a classroom. In terms of their behaviour and interaction, this appeared to put them on their ‘best’ behaviour. The students were all reported by their

chaperones (either the class teacher or a teaching assistant who knew them well) to be very well behaved and cooperative even in comparison to their behaviour in the regular classroom. The level of complexity added by asking the students to role play a further role of 'student out of school' did not appear to inhibit their collaboration or their interaction with the teacher during the tasks.

If the study had been run by their teacher, particularly if it had been run in the students' regular classroom environment, then there may have been differences in their behaviour or interactions. The teacher knows the students well and would have already established their own relationship with each of them. There is no way of knowing how, if at all, this would have changed the dynamics between the teacher and the students. Whether the teacher would have been able to manage the IDZ in a different way or whether they would have taken similar approaches to the teacher-researchers who ran the sessions.

The study was an exploratory one and as such, it made the best use of the space and resources available whilst endeavouring to replicate the classroom environment and relationships as closely as possible. Because of the limitations above, findings of the study are indicative rather than conclusive. Tests for statistically significant association were applied rather than more complex techniques which may have looked for statistically significant differences or clearer associations with task success. Nevertheless it succeeded in achieving a plausible recreation of a classroom environment and the interactions which occurred within this. This recreation was captured and studied in detail and has been able to contribute to the existing body of literature in the fields of teacher orchestration and interaction with students.

## 9.5. Methodological contribution

This study investigated the role the teacher plays in orchestrating classroom interactions during collaborative tasks in the multi-touch environment. It used a modified

version of the framework first put forward by Engle and Conant (2002) to look at the teacher's orchestration of interactions based on an analysis of its key features and potential to answer the key research questions (Mercer, Littleton and Wegerif, 2004) have suggested that some research has done. The framework was adapted to take account of the dynamics present in classroom interactions.

The study has considered the different registers which teachers use in their interactions with students. It has looked at the possible reasons teachers might transition between group and whole class discourse. This was a need described by Dillenbourg and Jermann (2010) and echoed by Howe and Abedin (2013).

The study initially intended to employ a process of progressive refinement of hypothesis described by Engle, Conant and Greeno (2007). Although the full reflexive cycle of interpretation was not always achieved, it used the facilities afforded by the digital audio-visual data and transcript which could be replayed and revisited with successive research questions and enable fresh interpretation of the phenomena observed, not accepting a fixed interpretation of the data but regarding it as a contextual artefact which mediated the learning and interpretation of the researcher (Engle, Conant and Greeno, 2007). The transcribed audio visual data developed different significance over time depending on the stage of the analysis which was focusing on.

Finally the use of the SynergyView tool answered the need articulated by Mercer (2008) for a multiple data channel tool which allows for the temporal analysis of interactions at varying granularities from the micro analysis of individual utterances, through the multiple exchanges which might comprise an extended interaction through to the macro analysis of whole tasks and the shapes they take.

The SynergyNet classroom in the Technology Enhanced Learning aimed to recreate an authentic classroom environment which was both technology rich and also a place for

detailed data collection. The study was able to study the collaborative working of groups which were nested within a technology-enhanced classroom environment. This level of interaction analysis was something which is rarely attempted across multiple groups and tasks, much of the research in computer-supported collaborative learning being done on the interactions of single groups with or without the teacher being present (Dillenbourg & Evans, 2011; Higgins, Mercier, Burd & Hatch, 2011).

## 9.6. Agenda for future research

The SynergyNet project funding is now at an end. However the research has left a considerable legacy and some firm foundations upon which to build a future research agenda. Over the four years of the project technology has also developed which give research in the fields of multi-touch tables and classroom orchestration far more options than were available previously.

The end of the project saw a final round of experimentation and data collection. The orchestration software was finally stable enough and user-friendly enough to invite teachers to come into the TEL lab and learn how to use it themselves. Figure 9.1 shows two images of a class teacher using the classroom on consecutive days as they and their class were invited in for an extended period (the image on the right shows them using in a whole class discussion during the logic task).

***Figure 9.1: Students and the class teacher from a local school familiarise themselves with the tables and the mysteries running on them.***

The next study to be undertaken will follow the use of the tables (or a variant on these tables which employs the SynergyNet operating system in one or more actual school classrooms. It will follow the teacher and students using this technology with problems of the teacher's devising (planned with the support of the researchers). Interaction within the context of a familiar classroom and with a familiar teacher will be observed and compared to the data already collected.

The enhanced authenticity of the school context will better enable reliable analysis of the uses of problematization utterances and of the uses of mini-plenaries in lessons. It will also allow the application of the framework in a variety of subjects to see if there are any differences between subjects in the way the teacher interacts with students at an individual, a class or a group level.

A smaller and more immediate study will be carried out on the data which has already been collected on History based mystery tasks. This data has been analysed in relation to the process and problem focused talk of students (Higgins, Mercier, Burd & Joyce-Gibbons, 2012). However the role of the teacher and their interactions with the students has not been analysed. This would be a good starting point and inform any hypotheses which might be framed as to the interactions between students and teachers in the classroom in subjects other than Mathematics.

Whilst the questions raised relating to the teacher's role in the success of small groups in collaborative activity and the alternation of registers between group and class talk are both important and relevant for further study, they are not the only are in which this study has implications for further research. This study is one instance of the potential value which SynergyView and other data collection and analysis systems present for researchers. The challenge will be for the researchers to come to understand in greater detail the role of the child within the group and the class as well as the teacher. Further work is needed on data

captured the natural setting of the classroom to explore the advantages and disadvantages of detailed data collection on the actions and words of individuals within the classroom. This requires theoretical and practical development of ideas to ground the available technology in an epistemological and methodological framework which values them for themselves and in relation other techniques available to the researcher, including those which may be superseded by these developments.

The data collection and multi-touch table technologies available now mean that the possibility of using the tables and the mysteries in actual classrooms rather than in the lab also now exists. SynergyNet and SynergyView software is now available as freeware (https://code.google.com/p/synergynet/ and https://code.google.com/p/synergyview/; last accessed 23/09/13). Therefore data collection in a variety of classrooms becomes a possibility.

Further theoretical work needs to happen to develop understanding of the meanings created by teachers during the orchestration of classroom interaction and collaborative activity. The way the teacher blends the elements of the TPACK model and perceives the affordances and constraints of the activities and tools available to them, and the choices that they make, including those around the move from group to class, such as the mini-plenary, is worthy of further study. This will require a range of methodologies which explore the reasoning of teachers, their intermental dialogic processes; and the relationship these have to the success of the students in collaboration or task completion.

Finally the teacher's role in the classroom as an orchestrator of activity needs to be articulated. The teacher interacts with the teams (the groups of students completing the collaborative activity), the task (managing the imperatives of task completion and supporting collaboration through their own pedagogical and content related abilities), they must orchestrate these teams in relation to these tasks with a rapidly emerging variety of tools

(such as the iPads and Kinect sensors employed in Figure XX). Finally they must do all this in the context of a classroom environment with its attendant semiotic relationships for the students and the teachers (Mercier, 2013). This challenge is elegantly represented in Mercier's (2013) diagram: the 4Ts of CSCL in the classroom context (Figure 9.2) illustrating the complexity of interaction between these dimensions in technology enhanced learning settings. The further application and articulation of this diagram will be a productive challenge for years to come.

***Figure 9.2: The 4Ts of the CSCL classroom***