Making Small Groups Work:
Overcoming Barriers to Collaborative Learning in the Mathematics Classroom

by

Jo Denton
Student Number: 1255558

Dissertation presented as a partial requirement for the award of the Degree of MSc Mathematics Education of the University of Warwick

Module ID Code: IE913
Affiliation: Centre for Education Studies

August 2014
4. Discussion
The Barriers: Agreement in the Research
Classroom Management and Practicalities
Time Management
Assessment Issues
Impact of Prior Experience and Teacher Knowledge
Solving Problems on the Constructivist Continuum
Increased Engagement and Participation
Developing Group Skills
Developing Elaboration Skills
Increased Teacher Confidence
The Importance of a Variety of Methods
Limitations of the Research

5. Conclusions

References

Appendices
1. Kagan’s Cooperative Learning Structures
2. Pre-Intervention Teacher Interview Schedule
3. Final Learner Questionnaire
4. Post-Intervention Teacher Interview Schedule
5. Original Pilot Learner Questionnaire
6. Refined Pilot Learner Questionnaire
7. Application for Ethical Approval
Acknowledgements

Foremost I would like to express my sincere gratitude to my supervisor Andrea Pitt for the guidance and feedback through the learning process of this dissertation. Your support has been invaluable. Furthermore I would like to thank Dr Jenni Ingram, Faye Baldry and Mike Ollerton for everything I learnt in my masters taught modules to get me where I am today. I would also like to thank the participants in my action research, particularly the teachers who have willingly shared their precious time during the processes of interviewing and planning. Finally I would like to thank my husband, Chris, who has supported me throughout this entire process, by believing in me, keeping me sane and looking after our young children Emma and Samuel to allow me the space and time to study.
Abstract

This dissertation aims to uncover and address the barriers to implementing small group work in the mathematics classroom. The literature review outlines the research that exists in this field to date both conceptually, from a constructivist perspective and empirically, through exploration of cooperative and collaborative learning techniques. Research questions addressing the barriers teachers face and how structured group work could help to overcome any barriers, are investigated through an action research project in the author’s school. A combined methods approach using both qualitative and quantitative methods from a constructivist epistemology and interpretive methodology is used in the research design. The findings from the empirical research show that a phased approach from cooperative to collaborative structures was positively received by both teachers and learners furthermore that structured group work increased teacher confidence in implementing small group work in mathematics. However the findings also indicate that further research is required to support learners in developing their mathematical explanations to maximise the potential of constructing knowledge through peer discussion in small group work.
Introduction

Background Context and Research Aims

Despite a wealth of research over the last few decades suggesting that small group work has a positive effect on both attainment and attitudes to mathematics (see e.g. Davidson, 1985; 1990; Nichols, 1996; Boaler, 1999; Swan, 2006; Allen, 2012), the subject is often perceived by learners as more isolating than any other school subject where the work set lends itself to working individually on problems (Nardi & Stewart, 2003). This is mirrored by my own experience as a classroom teacher, an AST (Advanced Skills Teacher) and a Secondary Strategy Consultant, where I have had the opportunity to observe not only mathematics lessons but also lessons in other subject areas, leading me to agree with Nardi and Stewart (2003) that achieving effective group work seems more problematic in mathematics than other subjects with many mathematics teachers avoiding group work altogether.

So what’s so hard about getting small groups to work? Learners need to be taught the skills for working in groups in the same way as they need to be taught a new mathematics objective and this needs to be worked up to gradually (Slavin et al., 2003): you wouldn’t try to teach compound interest to someone who had no comprehension of percentage; instead you would first teach the concept of percentage, exploring mental, written and calculator methods to finding a percentage of a quantity; this would probably lead on to developing these methods to increasing and decreasing by a given
percentage which would then give rise to multiple ways of understanding and calculating successive percentage changes, i.e. compound interest. In the same way I believe that learners not only need to be taught how to break a task into more manageable chunks but they also need to learn how to work together with their peers to achieve their learning goals.

**Definition of Terms**

The terms cooperative and collaborative learning will be used throughout the dissertation and the debated definitions will be discussed in depth in the literature review. The review concludes that cooperative learning refers to a structured approach to small group work where the teacher retains control of the learning process and the learners work towards a shared learning goal, whereas in a collaborative learning environment there is a greater responsibility given to the learners who support each other to achieve individual learning goals. I believe that it is the handing over of responsibility to the learner which is the greatest barrier for mathematics teachers to using small group work consistently and effectively and believe the *structures* described in adopting cooperative learning strategies (e.g. Kagan, 1989; Aronson, 1978) could be the key to overcoming this barrier. Cooperative *structures* are simply ways of organising small group tasks, however with hundreds of these structures to choose from (see for example Kagan, 1994), how can mathematics teachers decide where to start?
Research Questions

This dissertation aims to investigate the barriers for teachers in using small group work in mathematics and as an outcome of empirical research provide effective small group activities to provide scaffolding for the teacher to introduce small group work in a structured way in mathematics. The initial aim of this research therefore is to investigate the following questions:

1. **What are teachers’ perceptions of the barriers to group work in mathematics?**

2. **Does the use of structures for group work change teachers’ perceptions?**

Overview of Study

From a constructivist epistemology with consideration of radical constructivist, social constructivist and situated cognition perspectives, Chapter 1 presents and discusses a review of both the relevant literature for these theories to frame this research as well as a literature review of collaborative and cooperative learning, particularly those relating directly to mathematics. The literature review aims to present and analyse research that exists to date; the conceptual element of the review will look at how radical constructivism, social constructivism and situated cognition describe the construction of knowledge through small group work; the empirical review will examine prevailing research in the field of cooperative and collaborative learning to identify evidence which supports my research questions and
ultimate findings and will also identify elements of the field which require further empirical investigation.

The empirical research for this dissertation is conducted by means of action research at my own school, a federation of two 11-16 single-sex schools, working with teachers and classes identified as needing support to implement group work. The two schools have recently undergone a colocation move and mathematics lessons for both boys and girls are now taught in the same area, however the vast majority of classes remain single-sex. The Federation is non-selective and located on the south-coast of England in a town where two out of the ten secondary schools are grammar schools. The proportion of learners who are from minority ethnic backgrounds or speak English as an additional language in the Federation is above average. This study does not make any attempt to generalise beyond the author’s school however; the context of the schools simply provides the reader the potential to compare the findings and conclusions from this research with similar schools.

Chapter 2 describes this action research approach and considers theoretical standpoints and data collection methods in relation to this methodology and reflects on the reliability and validity of the chosen methods, in order to consider the limitations of the study. A combined methods approach of both qualitative and quantitative methods is described to both address the diverse nature of the data and to attempt to triangulate any findings. These methods include semi-structured teacher interviews, informal classroom observations
and learner questionnaires. Sampling and ethical implications are also considered in this chapter and an interpretive analysis rationale is outlined. The findings from the analysis of the results of the action research are presented in Chapter 3. These findings are discussed in depth in Chapter 4 and are compared and contrasted with the previous research in this field, making links back to the literature review. Finally, in Chapter 5 conclusions are drawn from the empirical findings for *making small groups work* in mathematics.
Chapter 1

Literature Review

There is a wealth of research promoting the use of small group work in mathematics (see e.g. Davidson, 1985; Slavin; 1990; Nichols, 1996; Boaler, 1999; Swan, 2006, Johnson & Johnson, 2009), however if you walk into most English secondary schools’ mathematics classrooms, you are likely to find the desks set out facing the front (Kutnick et al., 2005) in a traditional approach to teaching and learning through transmission of knowledge from teacher to learner (von Glasersfeld, 1998). This would seem to go against the major epistemology associated with group work in education, that of social constructivism (Mercer, 2008). However is social constructivism necessarily the most appropriate theory of learning to describe the construction of knowledge in small groups in the mathematics classroom?

Conceptual Review: A Constructivist Continuum

Constructivism and Social Interaction

“If one seriously adopts the constructivist approach, one discovers that many more of one's habitual ways for thinking have to be changed”. (von Glasersfeld, 1995a).

Do mathematics teachers need to change their way of thinking and hence their pedagogy in order to support learners, aided by their peers, to construct knowledge for themselves? A constructivist epistemological stance believes
that learners have to construct meaning for themselves (Wheatley, 1991).

French educational psychologist Piaget, considered the father of constructivism (Walshaw, 2004) believed that “development moves from the individual to the social” (Rogoff, 1999, p.76), that is that cognitive development of the individual is required in order to later develop socially. However Piaget believed that by approximately secondary school age, the formal stage in his genetic epistemology (Dulit, 1972), cognitive processes are primarily supported through language and hence thought can become predominantly collective (Rogoff, 1999). The lead researcher on social constructivism, Russian educational psychologist Vygotsky (von Glasersfeld, 1995b) differed in this perspective believing that thinking develops through social interaction from the very beginning and formed the basis of social constructivism on first constructing knowledge in a social environment aided by cultural tools to build the foundations for individual understanding (Rogoff, 1999). It is the impact of the type and the context of social interaction on cognitive development which separates the two theories at this formal stage (ibid). On one hand Piaget believed in achieving equilibrium in group discussion, emphasising “cooperation as the ideal form of social interaction promoting development” (ibid, p.72). Piaget set out conditions to achieve this equilibrium, including having common intellectual values and reciprocity within partners (Rogoff, 1999), in order to discuss differences of opinion and work out those differences, an element of what he termed cognitive conflict (ibid). Vygotsky on the other hand believed that the ideal partner should be more knowledgeable and defined the Zone of Proximal Development (ZPD) as the “distance between the actual development level as determined by
independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (Vygotsky, 1978, p.33).

A criticism on Vygotsky’s theories has been that they were just that, theories, not empirically tested or verified (Mercer, 2008), however subsequent studies claim that the relevance of his ideas to the classroom context have been demonstrated (ibid). Nevertheless a limitation of the novice and more capable other in Vygotsky’s ZPD model is that it could be considered teacher-centric (Litowitz, 1993) as at the start of the process it relies heavily on the teacher to guide the learner which could be seen as a criticism in learner-centred practices which are particularly prevalent in current teaching and learning models (Schweisfurth, 2013). This was not the intention of Vygotsky however, who believed there is scope for a peer to take on the role of the more knowledgeable other (Vygotsky, 1978) and while partners should not be equal, this “inequality is in skills and understanding rather than in power” (Rogoff, 1999, p.79). Rogoff (1999) further believes that because of this “interaction with either adults or peers can bring about cognitive growth” (p.79). But what does this look like in practice and how can teachers get this to work in the mathematics classroom?

**Situated Cognition: Is Environment Everything?**

Boaler (2006a) offers a framework for utilising group work for the learners to take on the role of the more knowledgeable other through mixed ability groupings, based Cohen’s and Lotan’s Complex Instruction (Cohen, 1994;
Cohen & Lotan, 1997), where learners support each other in solving problems rather than relying on the teacher for that support. Here Boaler’s model is underpinned by a situated epistemology, as she is not only considering the importance of language and communication in learning but also the impact of the environment on learning. In situated cognition teachers are the managers of that environment and it is the culture of the classroom which provides the context through which cognition is situated, that is where learning takes place (Lave and Wenger, 1991). A more recent example of using peers as the more knowledgeable other is through the use of Lead Learners in classrooms (Stewart, 2009), where selected students become the expert and support the learning of their peers, which again supports a more learner-centred approach to teaching.

From the perspective of situated cognition, Boaler (1999) carried out a longitudinal empirical study over a three year period of two schools, Amber Hill and Phoenix Park, with very different approaches to the teaching of mathematics: Amber Hill was very didactic in teaching style and traditional in terms of setting and predominant use of textbooks in lessons; whereas Phoenix Park was more progressive and learner-led within mixed-ability groups. Boaler’s findings on the effect of group work on attitude and attainment (1997a; 1998) are discussed in the empirical review later in this chapter; in terms of this conceptual review Boaler (1999) describes learning mathematics in small groups through a situated cognition epistemology, where environment is everything. Lave and Wenger (1991) refer to this learning environment as a community of practice, where solving problems as
part of the culture of this community is vital for knowledge transfer to take place. This is particularly pertinent to the teaching of mathematics, for example abstract concepts in algebra can be situated by the creation of a community of learners encouraging participation and discussion, which creates a context of solving problems as mathematicians (Lave, 2011).

Boaler attributes the lower attainment at Amber Hill to the fact that the learners at this school viewed the mathematics classroom as one community of practice, but regarded “other places, even the school examination hall as different communities of practice” (Boaler, 1999, p279). Boaler aimed to “show how the perspective of situated cognition illuminated the complexities of students’ mathematical behaviour” (ibid, p.259). Here, their mathematical behaviour illustrates that for a community of practice to allow for transferable knowledge and skills, it needs to be a broader environment, tackling a variety of problems and ways of working.

A limitation of situated cognition to describe learning in small groups could be the actual process of transference of knowledge to other situations, however Bereiter (1997) believes that if an abstract relationship between two situations is developed then knowledge transfer is achievable. Boaler (1999) concludes that the transfer of knowledge from one situation to another for pupils at Phoenix Park was made possible through the mathematics classroom becoming a “social arena” (ibid, p.279) as opposed to the formal textbook approach at Amber Hill, which together with open-ended nature of the problem solving enabled the pupils to see the connection between school mathematics and real-world mathematics.
Radical Constructivism and Ontological Reality

Radical constructivist epistemology follows the constructivist stance that transmission of knowledge is not possible and knowledge must be constructed, however radical constructivism is thus named due to its unconventional theory that “knowledge does not reflect an “objective” ontological reality” (von Glasersfeld, 1984, p.5). As such it is not prescriptive in the teaching techniques used as it is a self-proclaimed theory of knowing and learning, as much ontological as epistemological, and it is down to the teacher to decide what works best (von Glasersfeld, 1995) as long as the emphasis is on “[t]eaching [r]ather than [t]raining” (ibid, p.178).

A main component of radical constructivism is the need for intrinsic motivation on behalf of the learner, which von Glasersfeld (1995) believes is not possible without learners learning to solve problems for themselves, hence gaining the confidence to solve other problems. This concurs with Bruner’s (1972) take on constructivism who believes these intrinsic rewards come from the sense of autonomy a learner experiences through mastery of problem solving and believes furthermore that learners are then equipped to generate knowledge and opinions of their own (p.123).

As a constructivist theory, radical constructivism advocates the use of language and communication:

“Talking fosters reflections and reflections foster understanding” (von Glasersfeld, 2003, 7:44)
However Simon (1995) states that “we have no way of knowing whether a concept matches an objective reality” (p.5). Radical constructivism demands social interaction for new knowledge to be constructed, but it differs from social constructivism in that the knowledge is constructed socially but remains a subjective construction to the individual. Furthermore, von Glasersfeld (1995b) notes that despite social interaction, it cannot be assumed that a learner has constructed the same meaning as the teacher intended:

“If the meaning of the teacher’s words and phrases has to be interpreted by the students in terms of their individual experiences, it is clear that the students' interpretations are unlikely to coincide with the meaning the teacher intends to convey” (Von Glasersfeld, 1995b, p.182).

This is where discussion with peers can tease out these understandings, although the individual meaning will always remain subjective as you cannot know for certain what is in someone else’s head (von Glasersfeld, 1991). Von Glasersfeld refers to this as viability. As meaning is always subjective, knowledge cannot ever be representative of reality, just a set of concepts which are “viable within the knowing subject’s range of experience” (von Glasersfeld, 1989, p.125).

**The Constructivist Continuum**

Constructivism, radical constructivism, social constructivism and situated cognition epistemologies could all be placed at various stages on the same continuum (see Figure 1) or sliding scale (Perera, 2011), supporting Rogoff’s conclusion that Piaget’s constructivism is a “limited version of social impact
on the individual’s cognitive development” (1999, p.81). A situated cognition perspective would lie at the other end of this scale where environment is everything and where there should be a purpose for learning in any change to that environment (Brown et al., 1989). Despite being on opposite ends of the continuum, radical constructivism and situated cognition hold the same underlying principles that learning cannot be simply transmitted from teacher to learner and that working together with others will support the construction of knowledge for themselves. Sfard (1998) believes “whatever version of constructivism is concerned – the moderate, the radical, or the social – the same dilemma must eventually pop up: How do we account for the fact that learners are able to build for themselves concepts that seem fully congruent with those of others?” (p.7). From a radical constructivist perspective, and indeed any of the constructivist perspectives to some extent, the word ‘seem’ in Sfard’s statement is paramount, in terms of whether reality is objective or subjective.

![Constructivism Continuum](image)

**Figure 1 – A Constructivist Continuum?**

Ironically radical constructivist theory is “subject to its own claims about the limits of knowledge” (Confrey, 1995, p. 195), therefore it is only true to the extent that it allows us to make sense of our experience, its “viability” (ibid), however, this dissertation is primarily concerned with teacher and learner
motivation and changing attitudes as opposed to measuring understanding. This dissertation will focus on constructivism, from the radical constructivist view on ontological reality to social constructivism and situated cognition as progenies on the constructivist continuum (Perera, 2011) to frame and describe the learning in small group work in this research.

**Mixed Ability: A Prerequisite for Effective Group Work?**

Much of the research into small group work in mathematics describes mixed ability as a prerequisite (e.g. Boaler, 1999; Nardi and Stewart, 2003; Nichols, 1996; Whicker et al., 1997), agreeing with Vygotsky’s belief that “what children can do with the assistance of others might be in some sense even more indicative of their mental development than what they can do alone” (Vygotsky, 1978, p.32), by this Vygotsky is referring to the Zone of Proximal Development (ZPD), which is what learners are able to understand through the support of the more knowledgeable other, which in the context of group work would imply mixed ability groupings to provide this support. However mixed ability is rare in secondary mathematics classrooms beyond Year 7 in the UK (Ofsted, 2012), in fact even Boaler’s Phoenix Park have now moved to setting classes a result of “having succumbed to many years of conservative education policies” (Boaler, 2012, p.14).

Dweck’s (2008) *Growth Mindset* considers that ability is not predetermined and can hence be developed. Boaler’s (2013) research shows that individual teachers who adopt a growth mindset as opposed to a fixed mindset over learner ability, still have little control over how learners are grouped as
“Such changes require positive leadership from governments, local authorities, head teachers and heads of department” (Boaler, 2013, p.149). However, this does not necessarily hinder working in small groups from a theoretical perspective: there could be a range of ability within a particular mathematics ability set with learners possessing different mathematical strengths, which could still enable peer-support with a more knowledgeable other. This would however require careful planning of small groupings around learners’ strengths. So perhaps considering the constraints afforded by many schools across the UK, including the author’s school, effective group work could still be achieved with mathematics ability groupings.

**Empirical Review: Cooperation Vs. Collaboration**

**Defining Cooperative and Collaborative Learning**

Wertsch (1979) attempts to clarify Vygotsky’s social constructivism, which he believes had previously been poorly translated, as well as apply the theory. Mercer (2008) claims this research “provided the kind of empirical illustration which is lacking in Vygotsky’s original accounts” (p.2) and believes that subsequent research has confirmed the importance both Vygotsky and Wertsch placed upon discourse in the classroom. Furthermore, Mercer (2008) claims that learners sharing ideas and explaining and justifying their reasoning with their peers is the most productive form of interaction in the classroom and that over time this “can promote the learning and conceptual understanding of the individuals involved” (ibid, p.8).
Cooperative learning is a term used predominantly in the USA as opposed to the term collaborative learning which is used more in the UK (Panitz, 1999) and cooperative learning and collaborative learning are often used interchangeably (McInnerney & Roberts, 2004). For example, although group work is an essential element of Boaler’s research, she seems to make no clear distinction between cooperative and collaborative learning, as has used both terms to describe working together in groups. She uses them interchangeably, using collaborative most often (e.g. Boaler, 2006a; 2006b; 2008), but occasionally refers to cooperative instead (e.g. Boaler, 1997b) with seemingly no distinction between them. There is however a much debated distinction between the two paradigms (Bruffee, 1995; Brody, 1995; Panitz, 1999; Nam & Zellner, 2011). Figure 2 compares the definitions arrived at by some of the key researchers in the development of this field.
<table>
<thead>
<tr>
<th>Researcher</th>
<th>Cooperative</th>
<th>Collaborative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slavin (1987)</td>
<td>• Learners are given instructional methods to support working together to solve problems</td>
<td>• Learners work together but with “no consequences based on group members’ learning” (p.1166)</td>
</tr>
<tr>
<td>Bruffee (1995)</td>
<td>• Designed for younger learners</td>
<td>• Designed for older learners</td>
</tr>
<tr>
<td></td>
<td>• Learners are collectively accountable for the progress of the group</td>
<td>• Individual progress is assessed after collaborative learning</td>
</tr>
<tr>
<td></td>
<td>• Participation is ensured through assigning social roles</td>
<td>• Only one social role (the recorder) which is chosen by the group</td>
</tr>
<tr>
<td>Dillenbourg, Baker, Blaye and O’Malley (1995)</td>
<td>• Division of labour among the participants</td>
<td>• Mutual engagement of participants</td>
</tr>
<tr>
<td></td>
<td>• Each student is responsible for a part of the information required to solve the problem</td>
<td>• Co-ordinated effort to solve the problem</td>
</tr>
<tr>
<td>Panitz (1999)</td>
<td>• Structure of interaction</td>
<td>• Philosophy of interaction</td>
</tr>
<tr>
<td></td>
<td>• Designed to facilitate the accomplishment of a goal through learners working together in groups</td>
<td>• Individuals are responsible for own actions, including learning and respect the abilities and contributions of others</td>
</tr>
<tr>
<td></td>
<td>• Teacher maintains complete control</td>
<td>• Groups assume almost total responsibility</td>
</tr>
<tr>
<td>Johnson et al. (2000)</td>
<td>• Learners work together to achieve shared learning goals</td>
<td>• Develops the skills required for productive cooperative learning</td>
</tr>
<tr>
<td>McInerney &amp; Roberts (2004)</td>
<td>• Learners work or act together as one to achieve a common goal</td>
<td>• Learners work in a group of two or more to achieve a common goal</td>
</tr>
<tr>
<td></td>
<td>• Tendency not to place emphasis on the input of particular individuals</td>
<td>• Each individual’s contribution to the whole is emphasised</td>
</tr>
<tr>
<td>Kutnick et al. (2005)</td>
<td>• Individual learners all work on the same task</td>
<td>• Learners work in conjunction with others or in jigsaw fashion</td>
</tr>
<tr>
<td>Swan (2005)</td>
<td>• Shared goals for the groups and individual accountability for all group members to achieve learning goals</td>
<td>• Used to develop conceptual understanding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Used for solving more complex problems</td>
</tr>
</tbody>
</table>

Figure 2 - Researcher Definitions of Cooperative and Collaborative Learning
Panitz’s definitions appear in this table, although he purposely set out to bring together the definitions of other researchers to define the “holy grail of interactive learning” (1999, p.3). Constructivism was presented in the conceptual literature review as a sliding scale from radical to social to situated, similarly Panitz places the definitions of cooperative and collaborative learning along a continuum “from a closely controlled, teacher-centred system to a student-centred system where the teacher and students share authority and control of learning” (ibid, p.5).

Bruffee’s definition of the two terms supports this moving from cooperative to collaborative claiming “[c]ollaborative learning is designed to pick up where cooperative learning leaves off” (Bruffee, 1995, p.16). This hierarchy of the two terms is further supported by Swan’s (2006) definition of collaborative learning as a means of construction of conceptual understanding. However conversely, in Johnson’s et al’s (2000) definitions, it is implied that collaboration develops the skills required for learners to work cooperatively. Slavin (1987), McInnerney and Roberts (2004) and Kutnick et al. (2005) state similar differences between the two but do not explicitly imply that one is more desirable than the other. Figure 3 summarises the key differences between cooperative and collaborative learning discussed above:

<table>
<thead>
<tr>
<th>Cooperative Learning</th>
<th>Collaborative Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Shared learning goals with individual accountability</td>
<td>• Work together to achieve individual learning goals</td>
</tr>
<tr>
<td>• Assessed as a group during group work</td>
<td>• Assessed as an individual after group work</td>
</tr>
<tr>
<td>• Structured</td>
<td>• More open-ended</td>
</tr>
<tr>
<td>• More teacher control</td>
<td>• Less teacher control</td>
</tr>
</tbody>
</table>

Figure 3 – Cooperative and Collaborative Learning Summary
For the purpose of this study, group work will refer to learners working together to solve problems through both applying prior knowledge and the construction of new knowledge. It will take the definitions of cooperative and collaborative learning as summarised in Figure 3 and will consider cooperative learning as a structural means of achieving the ultimate goal of effective collaborative learning.

Cooperative Learning: Origins and Research

Modern cooperative learning was introduced in the mid-1960s by Johnson and Johnson, building on Deutsch’s (1949) social interdependence theory. Johnson and Johnson (2000) list five major components which are vital to achieving social interdependence: individual accountability; positive interdependence; face to face interaction; taught social skills; and group processing (p. 7). For the next two decades cooperative learning was developed by a number of researchers and a range of methods emerged (see Figure 4).

<table>
<thead>
<tr>
<th>Researcher-Developer</th>
<th>Date</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnson &amp; Johnson</td>
<td>Mid 1960s</td>
<td>Learning Together &amp; Alone</td>
</tr>
<tr>
<td>DeVries &amp; Edwards</td>
<td>Early 1970s</td>
<td>Teams-Games-Tournaments (TGT)</td>
</tr>
<tr>
<td>Sharan &amp; Sharan</td>
<td>Mid 1970s</td>
<td>Group Investigation</td>
</tr>
<tr>
<td>Johnson &amp; Johnson</td>
<td>Mid 1970s</td>
<td>Constructive Controversy</td>
</tr>
<tr>
<td>Aronson &amp; Associates</td>
<td>Late 1970s</td>
<td>Jigsaw Procedure</td>
</tr>
<tr>
<td>Slavin &amp; Associates</td>
<td>Late 1970s</td>
<td>Student Teams Achievement Divisions (STAD)</td>
</tr>
<tr>
<td>Cohen</td>
<td>Early 1980s</td>
<td>Complex Instruction</td>
</tr>
<tr>
<td>Slavin &amp; Associates</td>
<td>Early 1980s</td>
<td>Team Accelerated Instruction (TAI)</td>
</tr>
<tr>
<td>Kagan</td>
<td>Mid 1980s</td>
<td>Cooperative Learning Structures</td>
</tr>
<tr>
<td>Stevens, Slavin, &amp; Associates</td>
<td>Late 1980s</td>
<td>Cooperative Integrated Reading &amp; Composition (CIRC)</td>
</tr>
</tbody>
</table>

Figure 4 - Development of Cooperative Learning (Johnson et al., 2000, pp. 3-4)
Complex instruction has more recently been developed by Boaler (2011), however generally more recent research into cooperative learning has focused more on evaluating the impact of adopting cooperative group structures, particularly on achievement, as opposed to new developments being introduced (see e.g.; Nichols, 1996; Whicker et al., 1997; Johnson et al., 2000; Ashman & Gillies, 2013). According to Johnson et al. (2000), “this combination of theory, research and practice makes cooperative learning one of the most distinguished of all instructional practices” (p.12).

Cooperative learning is a widely researched field, with more than 1200 research studies conducted (Johnson & Johnson, 2009). Much of the research relating to cooperative learning emanates from the USA and focuses on specific interventions to assess the impact on attainment and motivation in learners. Reviewing this amount of research is beyond the scope of this dissertation, however Johnson et al. (2000) carried out a review of their own evaluating 158 reports on social interdependence which I will summarise and critique here. Johnson et al. (2000) looked into several issues surrounding the impact of cooperative learning, including the validation of the procedures, how many cooperative learning methods have actually been evaluated and how effective are the methods in improving achievement. The two cooperative learning methods which came out strongest in their evaluation of the meta-analysis were Learning Together and Academic Controversy, the two methods which Johnson and Johnson developed themselves. In part this could be down to the fact that over a third
of the studies evaluated were their own research papers, which you would expect to meet the criteria of their own evaluation.

Johnson et al. (2000) do however, in the conclusions of their meta-analysis, state the need for “[m]ore studies conducted by independent investigators” (p.15). They claim that researcher-developers’ evaluations of their own cooperative learning methods are potentially biased due to the vested interest the researcher-developer has in selling the resources and training and express the need for the next generation of researcher-developers who “subject their formulations to rigorous empirical evaluation” (ibid, p.13).

Whicker et al. (1997) had actually already provided an independent evaluation for cooperative learning in mathematics, examining student attitudes and motivation as opposed to just attainment. Their review of a number of cooperative learning studies, where learners work together on group goals but with individual accountability, finds that it has been linked to “increases in self-esteem, attendance, time on task, enjoyment of school and classes, and motivation to learn” (Whicker et al., 1997, p.43); indeed their own empirical research evidenced cooperative learning as “an effective instructional strategy for learning advanced mathematical topics at secondary level” (ibid, p.47). Similarly, writing a paper on the effects of cooperative learning on achievement and motivation in geometry as part of his PhD degree, Nichols (1996) could be considered independent. Nichols concludes that his research findings gave “positive indications” (ibid, p.475)
that "cooperative learning can result in increased achievement and motivation to learn" (ibid, pp.474-475).

Collaborative Learning and Rich, Group-worthy Tasks

If we use the summary definitions of cooperative and collaborative learning (see Figure 3), then collaborative learning is the end product which can be achieved through cooperative learning methods. But what is the end point we are trying to reach? Swan (2006) believes that teachers’ reliance on transmission of knowledge is responsible for learners’ perception of mathematics as “a series of unrelated procedures and techniques that have to be committed to memory” (p.162). By taking a more active role in their learning, Swan believes it will transform the mathematics, the learning and the teaching from a transmission orientation to a collaborative orientation, through discussion and exploration to make connections in the mathematics (Figure 5).

![Figure 5 – Transmission and Collaborative Orientations (Swan, 2006, p.162)]
Swan lists eight teaching principles to enable this shift from transmission of knowledge to collaborative learning:

- building on learners’ prior knowledge;
- addressing learners’ common misconceptions;
- using higher-order questioning;
- using cooperative small group work;
- encouraging reasoning;
- using rich, collaborative tasks;
- creating connections between topics;
- using technology appropriately. (Swan, 2006, p.163)

However Swan (2006) recognises that theory without exemplification is difficult to put into practise in the classroom, so developed five types of activity to support the implementation of these principles:

- Classifying mathematical objects
- Interpreting multiple representations
- Evaluating mathematical statements
- Analysing reasoning and solutions
- Creating problems (Swan, 2006, pp.163-164)

*Classifying mathematical objects* could include learners identifying the odd one out from a list (Swan, 2006), which becomes higher-order thinking when learners must find a justification for each item in the list being the odd one out. Any grouping activity (e.g. card sorts) would also facilitate this classification as well as being an activity which would support the *interpretation of multiple representations*, for example a matching activity.
where learners group equations to their corresponding graphs to make connections in the different representation of functions. Formative questioning techniques such as Always, Sometimes, Never True (Swan, 2006) could support the evaluation of mathematical statements. Analysing reasoning and solutions could simply be achieved by presenting learners with worked examples and tasking groups with marking and correcting them or offering multiple methods for learners to compare. In creating problems for their peers to solve, learners can explore the structure of the mathematics through investigating “the doing and undoing processes in mathematics” (Swan, 2006, p.169).

Learners working on rich tasks is seen by Swan (2006) as an important condition for achieving collaborative learning, but what constitutes a rich task? Lotan (2003) proposes tasks are either routine or open-ended and the more open-ended the problem the more “group-worthy” (ibid, p.72) the task. Horn (2005) lists four properties which make tasks group-worthy: “They

- illustrate important mathematical concepts;
- include multiple tasks that draw effectively on the collective resources of a [student] group;
- allow for multiple representations;
- have several possible solution paths.” (Horn, 2005, p.219)

The exemplification of Swan’s (2006) activities discussed above could potentially fulfil these four properties.
From this review of cooperative and collaborative learning, this dissertation will take the view that cooperative learning can provide the structure for teachers to introduce group work (Panitz, 1999) into the mathematics classroom, by maximising participation (Bruffee, 1995), teambuilding (Slavin, 1987) and sharing responsibility for learning and progress (Swan, 2005). The ability for learners to construct new knowledge and apply existing knowledge through collaborative learning (Swan, 2005) will be viewed by this dissertation as the ultimate aim of group work in mathematics. Collaborative learning will be the outcome of the structured cooperative group work (Bruffee, 1995), where learners can work on complex and challenging rich, group-worthy tasks (Swan, 2006; Horn, 2005) with minimal support from the teacher (Panitz, 1999).

**Establishing Conceptual and Empirical Links**

Johnson et al. (2000) believe that the success of cooperative learning in general is as a result of how it relates to a wide range of social science theories, particularly cognitive developmental learning theories in the field of psychology, including those of Piaget and Vygotsky. In fact Johnson et al. (2000) further believe that “almost any teacher can find a way to use cooperative learning that is congruent with his or her philosophies and practices” (Johnson et al., 2000, p.3). So can the theories of Piaget and Vygotsky be used to define cooperative and collaborative learning respectively? As stated in the conceptual section of this literature review, Piaget believed cooperation was key for discussion to aid cognitive development, however was his intended meaning of cooperation the same
as the definition(s) of cooperative learning above? Mercer (2008) states that Vygotsky’s theory of social constructivism has already been applied to collaborative learning, a view supported by Slavin (1987), however if the teacher gives up all control over the groups as in Panitz’s (1999) definition of collaborative learning, would the more knowledgeable other have to come from mixed ability groupings?

Group dynamics, whether mixed ability or not, need to be considered in terms of the effects made by the composition of groups (Trautwein et al., 2006). For example, could learners’ social standing or perceived academic ability affect how they participate? There is evidence to show that cooperative learning techniques can overcome some of the issues relating to social standing, for example Aronson and Bridgeman (1981) found that the Jigsaw technique overcame some of the boundaries in racial segregation in the USA. Trautwein et al. (2006) found that the attainment composition of groups does make a difference to how learners perceive their own mathematical ability and their confidence in that ability and Bennett and Cass (1989) found that higher attaining learners were more likely to have their contributions listened to than lower attainers. If perceived mathematical ability affects how learners contribute in lessons and then perhaps working in ability groups could minimise this effect.

**Reciprocity in Group Work**

Boaler’s and Staples’ (2008) research into Railside School in the USA looked at the Complex Instruction approach in practice where mathematics
classrooms at the school were multidimensional, roles were given to group members, praise was given to affirm competence in all group members and learners were taught to be responsible for each other’s learning. This resulted in learners seeing the reciprocal potential in collaborative learning, as they “talked about their enjoyment of helping others and the value in helping each other” (Boaler and Staples, 2008, p.633), that is there is learning potential not only from getting support from a fellow group member but also in explaining mathematics to others, fulfilling Piaget’s conditions of achieving equilibrium between partners (Rogoff, 1999).

This value in the reciprocity of group work was discussed as early as 1962 by Bruner (in Hoyles, 1985) and is echoed in Hoyles’ (1985) use of a “social interaction perspective” (p.212) to define understanding in mathematics as “the ability to:

- form a view of the mathematical idea
- step back and reflect upon it
- use it appropriately and flexibly
- communicate it effectively to another
- reflect on another’s perspective of the idea
- incorporate another's perspective into one's own framework or challenge and logically reject this alternative view” (ibid)

These abilities could be considered a prerequisite for achieving Swan’s (2006) eight principles for implementing collaborative learning, so these are perhaps the skills which cooperative learning techniques need to develop to
make the transition from cooperative to collaborative. However how can these skills be developed in learners?

**Cognitive Elaboration Perspective**

The “cognitive elaboration perspective” (Slavin et al., 2003, p.183) considers the ability of learners to explain, rephrase information and build on prior knowledge. Elaboration strategies could range from as simple as paraphrasing and summarising information, to as complex as deriving understanding of new concepts from known facts and contrasting related concepts (Weinstein et al., 2011). However the “active processing involved in using elaboration strategies is what is key to learning” (ibid, p.139) through forming “meaningful connections between what the learner is trying to learn and their prior knowledge, experience, attitudes and/or beliefs” (ibid, p.137). The ability for learners to communicate their mathematical understanding effectively to their peers and incorporate another’s perspective into their schema, as required in the social interaction perspective (Hoyles, 1985), could be developed through a cognitive elaboration approach. Furthermore supporting learners to form connections in their mathematical understanding is key to collaborative learning (Swan, 2006). Several researchers have developed frameworks for developing elaboration skills, including Yager et al.’s (1995) Structured Oral Discussion, Dansereau’s (1988) Scripted Cooperation and King’s (1994) Guided Peer Questionning. All these techniques have one thing in common: providing learners with structure to achieve effective small group work.
Jigsaw and the Mathematics Classroom

Aronson’s (1978) Jigsaw Classroom consists of forming small home groups and each member of the group breaking off into a different expert group to learn a new concept or solve part of a wider problem. The learners then return to their home groups to put the pieces together. Slavin (1989) believes this increases motivation and interest in what other group members have to contribute as “the only way students can learn other sections than their own is to listen carefully to their teammates” (p.235). However Slavin (1989) also concedes that just because the discussion has taken place, understanding is not guaranteed. In the Jigsaw technique, as all learners are assessed individually on the entire content (Blaney et al., 1977), teachers are able to assess individual understanding. Research evidence has shown Jigsaw to improve the way group members interact (Slavin, 1985) and has been shown to have a positive impact on self-esteem (Blaney et al., 1977). More recent research indicates that learner outcomes are improved through the use of the Jigsaw technique as opposed to more traditional forms of instruction (Artut and Tarim, 2007; Johnson et al., 2000), however Webb (1989) believes that the overall effectiveness of learning in groups depends on the level which learners are able to elaborate on their explanations. This agrees with Rohrbeck et al. (2003) who found that the effectiveness is dependent on a learner’s competence at tutoring. Learners may master their expert topic but be unable to explain it to others or indeed learn the other content from their home group members, which although the individual assessment in the Jigsaw technique will expose, the technique itself will not
resolve the issue as learners “require specific development of skills for discourse” (Cohen, 1994, p. 7).

**Think-Pair-Share and the Mathematics Classroom**

In this technique, the teacher poses a question or problem and the learners first think about it individually, then they share their ideas with their partner, and finally share their ideas with the rest of the group, developing their ideas at each stage, which Kagan terms a “concept development strategy” (1989, p. 14), that is a technique which generates ideas and understanding through promoting thought and reflection. Think-Pair-Share is well known in both collaborative and cooperative techniques (see e.g. Li and Lam, 2005; Boston, 2002) and the technique was first introduced by Lyman (1981). The strategy allows learners’ individual ideas to form before building on them socially (Carrs, 2007) and it “compels them to explain their thoughts to one another” (von Glasersfeld, 1995b, p. 190), linking to the constructivist perspective. Von Glasersfeld states two main advantages of learners explaining their thinking, firstly communicating ideas verbally requires a degree of reflection on their own and others’ thinking and secondly learners will often listen more intently to their peers than the teacher (ibid), perhaps as they are more open to something which they know their contemporaries understand already. Nevertheless, new learning can only be constructed if learners have the skills required to explain, question and hence elaborate their understanding to their fellow group members. As with Jigsaw, these skills first need developing in learners.
Kagan Structures and the Mathematics Classroom

In Kagan’s structured approach to cooperative learning, small groups of four mixed ability learners work as a team, which aims to “maximize peer tutoring and positive modelling” (Kagan, 2008, para.10). In groups of four, learners can easily work in pairs and then share their ideas with the rest of the group. Kagan (2008) claims that learner participation is increased with his cooperative learning structures compared to whole class question and answering sessions (ibid). The teacher becomes the facilitator listening in to the small group discussion and as a result “hears the thinking of the low-achieving and middle-achieving students, not just the high achievers” (Kagan, 2008, para.12) so is able to assess a larger proportion of learners in lesson time. In terms of time management, Kagan admits that there is an increase in workload for teachers to learn the structures, but believes that “once teachers know the structures, teaching is easier” (ibid, para.14).

Kagan lists four principles which underpin his structures and links them specifically to cooperative learning theory:

1. The learning task promotes teamwork and students experience themselves as being on the same side;
2. Each student is held accountable for their individual contribution;
3. Students participate about equally; and
4. Many students are engaged at once. (Kagan, 2008)

Furthermore, he claims they are “designed to meet the more demanding criteria of equal participation and maximizing simultaneous interaction” (Kagan, 2001, p.3). However the structures also link with the constructivist
epistemological stance taken in this dissertation, particularly Vygotsky’s
social constructivism as they are also “designed to regulate task difficulty to
keep students in the zone of proximal development” (Kagan, 2001, p.5).
Kagan believes by allowing learners to work in small groups on problems
which they could not do alone, they provide mediation for each other.
Furthermore he believes that this “mediated learning allows students to
progress smoothly through the zone of proximal development so they learn
to do alone that which previously they could do only with help” (ibid),
however this could be viewed as a somewhat simplistic understanding of the
concept of the ZPD.

The structures also correspond with other theories on the constructivist
continuum, for instance situated cognition theory:

  Situated perspectives suggest that the behaviours and practices of
  students in mathematical situations are not solely mathematical, nor
  individual, but are emergent as part of the relationships formed
  between learners and the people and systems of their environments.
  (Boaler, 1999, p.260)

The natural, real-life interaction context in which the structures engage the
learners in discussion and communication has the potential to build these
relationships and to help them “see themselves as equal status members in
a community of learners” (Kagan, 2001, p.8). Furthermore, Kagan believes
this can help “sidestep the transference gap” (ibid, p.6), that is they acquire
skills which can be applied to various situations.
Kagan’s cooperative learning structures were first developed in the 1980s and are now used in schools worldwide (Kagan, 2003). But what is the empirical evidence to support the usage of the structures? Of the 158 studies selected for Johnson et al.’s (2000) meta-analysis, not a single one investigated Kagan’s cooperative learning structures, perhaps as Kagan frames his research on positive interdependence which may not have completely met the prescribed criteria of social interdependence for inclusion, however of the researched based evaluations found from this systematic review of Kagan Structures, only one (Maheady et al., 1991) was actually published before the meta-analysis.

A research team at the State University of New York has since published a series of independent and peer reviewed papers on Kagan’s Numbered Heads Together (see Appendix 1) structure (Maheady et al., 2002; 2006; Haydon et al., 2010), which showed that student attainment was higher than when traditional whole class teaching was employed (e.g. Maheady et al., 2006). Kagan (2014) used this series of research studies to calculate the average positive effect size for Kagan Structures at 0.92, indicating an increase from the 50th to the 82nd percentile (Kagan, 2014). This means that you would expect the average person in the experimental group to score higher than 82% of the control group (Coe, 2002). In Johnson et al.’s (2000) meta-analysis only one cooperative method produced an effect size larger than this, which was Learning Together, suggesting that Kagan’s structures perform in line with the more extensively evaluated cooperative techniques, although it should be noted that the four studies used to calculate Kagan’s
effect size is much smaller than the number of studies used for some of the cooperative techniques in Johnson et al.’s (2000) meta-analysis, which calculated average effect sizes from as little as one study to as many as 57 studies on a single cooperative learning technique.

However a gap in the empirical research to date seems to be an independent evaluation of a wider range of Kagan’s structures and the effect of combining the structures. This gap in the research is especially true for their use in mathematics at secondary school level where only one empirical evaluation was found by the author (Van Wetering, 2009) on the Kagan website, so the independent nature of this research is unclear. Van Wetering’s research was an action research study conducted with her own classes to evaluate the effects of using the structures on both learner attainment and learner attitudes to group work. Van Wetering compares her class averages with the control group of the previous cohort’s attainment and the cooperative structures approach outperformed the traditional teaching methods in all examinations, however some of the differences between the class averages are very small and could be attributed to other factors, for example in the composition of the two cohorts.

Despite there being an expectation to use Kagan’s structures in the author’s school to develop the use of group work in lessons, there has been little evidence of its implementation in mathematics lessons. Through informal discussions with mathematics staff at the school, this is in part due to the fact that they find it hard to adapt the generic structures to mathematics teaching.
From an internet search of the terms *Kagan* and *mathematics*, a variety of activities were found using a selection of Kagan Structures for paired and group discussion in mathematics. This search enabled the shortlisting of ten structures (see Appendix 1). This variety of structures could support Boaler’s (1999) stance for solving problems in a range of ways and in a broader environment to allow knowledge to be applied in alternative contexts.

Kagan’s structures seem to naturally fit with the social interaction perspective with regards to the reciprocity of group work. Kagan emphasises that although the lower attaining learners benefit most from the approach, the “gains are not purchased at the expense of the high achieving students — all students benefit” (Kagan, 2008, para.10), suggesting learners appreciate that explaining to their peers has value in strengthening their own understanding. However, the cognitive elaboration perspective could also be addressed, for example if the coaching hints in Quiz Quiz Trade or Inside Outside Circle (see Appendix 1) offered alternative ways of approaching the problem, then scaffolding for elaboration could be achieved. Similarly, Collective Memory (See Appendix 1) could be used to support learners in describing small details to their peers. These tasks would perhaps offer a starting point for teachers and learners to develop cooperative learning in a structured way with scaffolding explanations, which in turn would contribute to Hoyles’ (1985) social interaction perspective, with the hope of ultimately contributing to the collaborative behaviours described by Swan (2006). If Kagan structures could offer a starting point for developing the cooperative behaviours, then perhaps these skills could be practised further through
Think-Pair-Share and Jigsaw before groups work more independently on Swan’s five types of collaborative activities and other rich, group-worthy tasks. This would structure the transition from cooperative to collaborative learning.

**Barriers for Teachers in Effective Use of Group Work**

Johnson et al. (2000) describe cooperative learning as “one of the most remarkable and fertile areas of theory, research, and practice in education” (p.2), however effective group work strategies have not had sufficient impact on English secondary schools (Kutnick et al., 2005) where learners spend “a lot of their classroom time in the presence of other pupils, but with no clearly defined learning purpose that engaged them collaboratively” (ibid, p.364). In Kutnick et al.’s (2005) research across English, mathematics, science and humanities in 47 secondary schools, planning for meaningful group work was not evident. Kutnick et al. (2005) found that even when teachers planned for group work just a third of teachers provided support for learners to develop the skills to optimise learning in this manner.

Tinzmann et al. (1990) believe that simply rearranging the desks allows learners to take more active roles in the classroom. However, teacher buy-in is also vital to the success of implementing cooperative learning effectively (Sapon-Shevin and Schniedewind, 1991) as the results of empirical research in this field could be affected if the teacher were not committed to using group work (Dotson, 2001).
Panitz (1997) lists eleven barriers for teachers using collaborative learning techniques in the classroom:

- Loss of classroom control
- Lack of teacher confidence
- Concerns over content coverage
- Lack of ready-made resources
- Teachers’ egos, wanting to perform
- Uncertainty how to assess individual progress when working in groups
- Concern being observed as unexpected outcomes are more likely to arise
- Learner apathy and resistance to thinking for themselves
- Lack of familiarity with cooperative learning techniques and classroom management
- Lack of teacher training in collaborative teaching methods
- Large class sizes and inappropriate classroom setup (ibid)

The third bullet point above is supported by von Glasersfeld (1995b) who claims that a common barrier for teachers and leaders in schools is the fear that spending too much time on group work in lessons will not allow the necessary content to be covered, however he believes the research of Cobb on teaching arithmetic (Cobb et al., 1993) has shown this is not the case. Furthermore Swan (2006) states it is “better to aim for depth than for superficial ‘coverage’” (p.163)

Panitz (1997) suggests policy changes which need to take place for collaborative learning to be more widely and effectively used. However,
could the structured approach of cooperative learning, help to overcome some of these barriers as “[c]ooperative learning is actually a generic term that refers to numerous methods for organizing and conducting classroom instruction” (Johnson et al., 2000), that is it can be tailored to not only suit the needs of the learners but also the policy constraints of the individual institution.

Many of the cooperative learning group formations designate specific roles for each team member (Bruffee, 1995). However is this always suited to solving problems in the mathematics classroom? The theory of Complex Instruction claims that the assignation of roles is appropriate for mathematics learning, for example facilitator, team captain, recorder/reporter or resource manager (Boaler and Staples, 2008; Cohen and Lotan, 1997). While the assignation of roles can be used as a tool to ensure all group members are participating (Boaler and Staples, 2008), it does not guarantee that all group members will progress in the learning of mathematics and assessing individual progress becomes a concern for teachers (Panitz, 1997). Boaler and Staples (2008) cite a number of ways teachers in their research have addresses those issues, including administering both group and individual assessments and to ask individuals follow up question once a problem had been solved as a group.

Dillenbourg’s et al.’s (1996) definition of cooperative learning (see Figure 3) supports the Jigsaw technique where each member of the group has a particular task to work on and then they come together to put those together,
by each group member explaining their learning to the others. This increases participation without assigning roles. Kagan (1994) offers hundreds of practical structures for teachers to use in their classrooms, many of which do not require this assignment of roles, however there is a lack of research evidence on their individual quality and little guidance for teachers as to which structures are most suitable for use in their classroom (Panitz, 1997), particularly as Kagan (1994) offers generic structures which are not explicit for how to apply them in a mathematics context. This sentiment is echoed by Johnson et al (2000) who claim teachers “have very little guidance as to which specific cooperative learning methods will be most effective in their situation” (Johnson et al., 2000, p.4). Kagan’s Cooperative Learning Structures exemplify this, as with hundreds of structures to choose from, how do we know which lend themselves particularly well to the learning of mathematics? Many teachers are unlikely to take the risk to randomly try a general structure, since one of the barriers for using small group work is teacher confidence (Panitz, 1997).

The research questions set out in the introduction aim to investigate how teachers’ attitudes to implementing group work in mathematics can be improved. Learner enjoyment and motivation are important factors in improving participation and engagement in lessons (Kagan, 2003), however if mathematical learning is not taking place, then group work is not worthwhile (Cohen, 1994). As previously discussed, mathematical discourse does not always equate to developing mathematical understanding, therefore strategies need to be in place to structure that support for learners’ to
develop their cognitive elaboration to maximise the construction of knowledge.
Chapter 2
Research Design

This chapter outlines the action research methodology and research methods used in the empirical research for this dissertation. Limitations of these methods and potential threats to the validity and reliability of the results are also considered. Links are made back to the literature review to formulate a structured approach to introducing group work in the action research and an analysis rationale is outlined. Finally sampling methods and ethical considerations are discussed.

Methodology

As stated in the introduction, this dissertation aims to answer the following questions:

1. What are teachers’ perceptions of the barriers to group work in mathematics?
2. Does the use of structures for group work change teachers’ perceptions?

The methodology needs to be appropriate to the research questions being explored (Gorard & Taylor, 2004). As a practitioner researcher, the primary interest is in the barriers for teachers using group work in the author’s own school context, so an action research study of the author’s school is most appropriate. The second research question lends itself particularly well to
the action research approach, however the first research question also fits within this framework as it is a necessary step within the process of bringing about the desired change in attitudes towards group work.

1. **What are teachers’ perceptions of the barriers to group work in mathematics?**

   The first research question is addressed through an interpretive study as it is very much the teachers’ perspectives in which this research is interested. The data needed to be collected is teachers’ personal views about group work to ascertain both directly and indirectly the barriers they face to ensuring group work is conducted and managed effectively.

2. **Does the use of structures for group work change teachers’ perceptions?**

   Small-scale action research is particularly appropriate for this research question because the overall intentions are to improve mathematics teachers’ current perspectives on group work with the ultimate hope of improving learners’ experiences in mathematics lessons. A selection of Kagan structures (see Appendix 1) will be piloted to select a few structures to create a phased structured approach to introduce group work for participant teachers in the main action research study. The first phase will aim to increase learner engagement and participation through collaborative structures, so learners’ opinions from the pilot study will be collected and analysed in order to create a shortlist, based on structures which learners have positive attitudes towards. Following the action
research, teachers’ opinions need to be collected to make a judgement on whether the structures for group work have brought about the desired change. The collection of learners’ opinions and examples of small group discussions will attempt to triangulate any findings.

The research questions in this study also fit with the cyclic approach associated with action research (Coghlan and Brannick, 2005):

**Planning** – This will include collecting teachers’ attitudes to group work to determine the barriers. In addition to this, a small pilot study will test the research instrument for the collection of learners’ opinions and will also trial the techniques discussed in the literature review to facilitate group work.

**Acting** – At this stage, training will be given to all mathematics staff at the author’s school on the cooperative and collaborative learning techniques identified in the literature review, followed by joint planning with participant teachers. The participant teachers will trial group work techniques over the course of a school term using a three-phased approach from simple cooperative structures to more open-ended collaborative tasks.

**Observing** – Informal observations will be made of participant classes to capture some of their small group discussions and interactions during each of the three phases. Particular focus to be given to the cooperative and collaborative learning behaviours exhibited in these discussions.

**Reflecting** – The cycle continues by collecting teachers’ opinions on their current thoughts on group work and whether they felt the phased approach had any impact on their participant class or indeed any other classes they teach. Finally the findings and conclusions on the analysis of this data will
be shared with the mathematics department at the author’s school, which can then be used in future departmental planning to continue the action research cycle.

All the research questions are to be investigated through inductive reasoning with the author open to new and unexpected themes occurring as opposed to deductively testing hypotheses. Inductive reasoning fits with the constructivist epistemological framework, in particular the radical constructivist view of ontological reality as it is open to epistemic uncertainty.

**Combined Methods Approach**

Due to the diverse nature of the type of data collection required to address each research question, it will be necessary to use a combined methods approach (Gorard & Taylor, 2004), more commonly referred to as a mixed methods approach where there are both quantitative and qualitative methods for testing the relationships between the variables (Kerlinger in Cohen et al., 2007).

For the first research question, qualitative semi-structured interviews with four members of mathematics department staff will be conducted individually, recorded and transcribed. Interviews allow the researcher to probe deeper into the participants’ thoughts (Silverman, 2006). These interviews will be semi-structured to ensure the key points are explored but that flexibility is maintained (Robson, 2002) so questions can be adapted if deemed appropriate. This flexibility allows unexpected themes to surface (Zhang &
Wildemuth, 2009), which could well change the focus of the research questions. To achieve the semi-structured approach, an interview schedule (Robson, 2002) was produced (see Appendix 2) with prompt questions to probe deeper where required (Kajornboon, 2005). The interviews were chosen to be conducted individually so less experienced staff would not be anxious about their existing knowledge and current practice compared to more experienced or more senior teachers. However a limitation of this could be that in a one to one interview the interviewee might just say what they think the interviewer wants to hear, so to minimise this potential threat to validity (Cohen et al., 2007), all interviewees will be assured of the non-judgemental nature of the interviews and that anything they say will remain confidential and they will remain anonymous (BERA, 2011).

The interview questions focus on the teachers’ attitudes to group work (Miller & Glassner, 2004), when they are likely to use it in their lessons, for which type of classes, ability, topic etc. If they are not currently confident in using small group work in class, the interview structure will probe what the barriers are. In order to address the remaining research questions, the last section of the semi-structured interview will be to ask each teacher to identify upcoming topics for the selected class for the author to prepare small group activities. A possible issue with these interviews could be that because only four teachers will be interviewed, the data collected may not reflect the opinions of all the mathematics teaching staff at the school. To minimise this, a range of experience and teaching styles will be purposively chosen in the sample of teachers with whom to conduct this research. Another issue with interviews
is that it is very time consuming to convert the recordings made in the interviews into transcript form (Britten, 1995). Furthermore there is a potential issue with bias in the analysis and interpretation of interview data, even if in transcript form, as the researcher may seek out themes which support the research questions and ignore others which perhaps negate them (Johnson, 1997).

To address the second research question a phased and structured approach to implementing group work will be developed following the pilot study. The author, in collaboration with the participant teachers where possible, will create mathematics specific activities to trial with their participant class. During this stage in the action research cycle, the author will make informal non-participant observations of some of the small groups’ discussions in lessons to collect qualitative data of their mathematical discourse, as epistemic actions, which construct knowledge, are most likely to be observed in a social setting (Herschkowitz et al., 2001). This dialogue will be analysed in terms of the cooperative and collaborative behaviours, as outlined in the literature review, displayed by the learners. In particular the following behaviours will be looked for in these observations:

**Cooperative Behaviours**

The following cooperative behaviours exemplify the definition of cooperative learning concluded from the literature review, that of maximising participation, teambuilding and sharing responsibility for learning and progress:
• Learners work together to achieve a common goal (Johnson et al., 2000; McIninnerney & Roberts, 2004)
• Learners ask their peers for help (Johnson et al., 2000)
• Many learners are engaged at once (Kagan, 2008)
• A shared responsibility for learning is demonstrated (Bruffee, 1995)

Collaborative Behaviours

As collaborative learning has been defined as the outcome of successful structured group work, the cooperative behaviours above would be expected to be demonstrated alongside the following behaviours required to work collaboratively on complex tasks with minimal support from the teacher:

• Learners offer alternative approaches in explanations and explain their reasoning (Mercer, 2008)
• All learners’ input to discussion is valued by their peers (Panitz, 1999)
• Learners demonstrate intrinsic motivation to solve problems in groups (von Glasersfeld, 1995)
• Learners demonstrate a coordinated effort to solving problems with mutual engagement and participation (Dillenbourg et al., 1996)

It was decided to take written field-notes on key elements of learners’ discussions as opposed to audio recording the learners, as the presence of an audio recording might stifle the discussion (Swann, 1994). Furthermore on an audio recording it could be difficult to ensure the right learner is matched to each voice and in listening back the audio, non-verbal
communication would not be observable (ibid). A video recording would potentially overcome this, but it was felt due to the low self-esteem of many students at the school, a video recording could restrict the discussion even more than an audio recording (ibid). It could be argued that the presence of the author listening to the discussion would also affect the discourse as it is almost “impossible to maintain a strict separation between your role as an observer and your usual role” (ibid, p.28), however the decision was made in conjunction with the participant teachers that the author’s presence would have less impact than an audio recording. A limitation of this method is not everything from the discussions are able to be captured, since small group discussion “flows very rapidly” (ibid, p.31) and there is potential in observational bias as observations are “subjective in interpretation” (Burton et al., 2008, p.97), that is the researcher may focus on comments which support the research questions rather than being open to other themes in the data. The effects of these limitations will need consideration in the interpretation of the discourse (Swann, 1994).

Following the intervention, all participant learners will complete a questionnaire (Appendix 3) to provide quantitative data on learners’ perspectives. These questionnaires will investigate learners’ confidence, perception of their progress and their attitudes to the small group structures trialled. A questionnaire as opposed to interviews here will allow feedback from a large number of the learners (Rea & Parker, 2012). This methodological triangulation between teacher interviews, researcher observations and learner questionnaires, should ensure that data is collected
“from as widely different perspectives as possible” (Denscombe, 2007, p.135) in terms of the wider impact of the structured approach to implementing group work in mathematics.

Of course the participants, for example, may have just enjoyed doing something different in their mathematics lessons, rather than positive responses to the questions being directly attributable to group work, which could be considered a limitation. To address the validity of the questionnaire it must be asked if it measures what it is intended to measure (Hartas, 2010). Therefore it is of particular importance to ensure the respondents know that they are giving their opinions on the structure of each activity, not the content. For example, Quiz Quiz Trade may have been used to solve problems involving percentages, however the participants are feeding back in terms of the structure of the technique to support their peers to construct new knowledge or apply existing knowledge, not to whether they enjoyed learning about percentages. It is difficult to ensure all respondents understand each question, particularly considering they are school-aged (Lewis & Lindsay, 2000). To help overcome these issues, the teachers were encouraged to use each structure more than once with their class to enable the structure to be separated from the content and the learners were reminded what each of the cooperative structures were before completing the questionnaire. A further limitation is that the participants will might offer “social desirable answers” (Hartas, 2010, p. 258); that is they could respond how they think the teacher or the author would like them to respond. To minimise this threat to validity the participants were assured anonymity.
(BERA, 2011) and the questionnaires were also completed in silence, under “exam-like conditions” (Francis, 2000, p. 29), so that respondents would give their own opinions and not be swayed by another participant.

Finally to complete the investigation of the second research question, the participant teachers will take part in a post-intervention interview to assess how the three-phased approach supported both them and their classes in implementing group work and evaluate the impact of the action research. A semi-structured interview schedule was again used (see Appendix 4) to allow for flexibility.

**Pilot Study**

Before the acting stage of the action research cycle, the ten shortlisted Kagan structures were piloted with the author’s Year 9 class and a pilot questionnaire (Appendix 5) was used to collect feedback. The questionnaire was based on a questionnaire used in Van Wetering’s (2009) research to collect learners’ attitudes to group work and was devised to include generic questions about learners’ attitudes to group work as well as their attitudes to the piloted techniques. Hence it served two purposes: firstly to get an insight into the structures to which learners respond positively in order to further shortlist the cooperative learning structures from the literature review to use in the main action research study. Secondly it enabled a pilot of suitable questions for the learner questionnaire, to gain information on whether these questions could be understood by respondents and whether the response scales were appropriate (Hartas, 2010). The response scale used was a
simple four point Likert scale of strongly disagree, disagree, agree and strongly agree. This was chosen to force the participants to give either a positive or negative response (Garland, 1991). The structures with the largest proportions of positive responses will be selected for the main part of this study.

The research needs to be replicable to ensure reliability (Bashir et al., 2008), so one week after completing the initial questionnaire, the pilot class were given the same questionnaire again to assess if learners respond to the questions in the same way as before. To minimise bias, no further group work was conducted between the two occasions of completion of the questionnaire.

Following the pilot, some of the questionnaire items were refined (see Appendix 6). For example two questions were very similar so they were separated and the former was reversed to enable some triangulation of the responses to assess whether the participants respond as expected even if questions are phrased differently (Black, 1999). This also tests the validity of the questionnaire; that is to check if participants are reading each question and not just succumbing to the “temptation just to mark all of them the same” (ibid, p.229) by responding positively to everything if they like group work.
Three-Phased Approach

Kutnick et al. (2005) found that only a minority of teachers provided support for learners to develop the skills required to work in groups and the cognitive elaboration perspective highlighted the difficulty learners have in explaining their thoughts to one another (Slavin et al., 2003). It is hoped that a structured approach to group work from cooperative to collaborative learning activities can address both these issues, through scaffolding this development of group skills, to increase teacher confidence in implementing group work and enabling learners to develop cooperative and collaborative learning behaviours. To facilitate this a three-phased approach was devised as outlined in the Figure 6, which sits within the acting stage of the action research cycle.
<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Increasing Participation, Team Building and Developing Elaboration Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td><em>Quiz Quiz Trade</em> (Kagan, 1994)</td>
</tr>
<tr>
<td></td>
<td><em>Collective Memory</em> (Kagan, 1994)</td>
</tr>
<tr>
<td></td>
<td><em>Rally Robin</em> (Kagan, 1994)</td>
</tr>
<tr>
<td>Open-ended</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase 2</th>
<th>Sharing Responsibility of Learning and Applying Elaboration Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td><em>All Write Round Robin</em> (Kagan adaptation)</td>
</tr>
<tr>
<td></td>
<td><em>Think Pair Share</em> (Lyman, 1981)</td>
</tr>
<tr>
<td></td>
<td><em>Jigsaw</em> (Aronson, 1978)</td>
</tr>
<tr>
<td>Open-ended</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase 3</th>
<th>‘Group-worthy’ Tasks to Construct Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>Classifying mathematical objects (e.g. <em>Odd One Out, sorting activities</em>)</td>
</tr>
<tr>
<td></td>
<td>Interpreting multiple representations (e.g. <em>card match activities</em>)</td>
</tr>
<tr>
<td></td>
<td>Evaluating mathematical statements (e.g. <em>Always, Sometimes, Never True</em>)</td>
</tr>
<tr>
<td></td>
<td>Analysing reasoning and solutions (Swan, 2006)</td>
</tr>
<tr>
<td></td>
<td>Rich Tasks e.g. <em>Volume = 216</em> (Boaler, 2002)</td>
</tr>
<tr>
<td></td>
<td>Creating problems (Swan, 2006)</td>
</tr>
<tr>
<td>Open-ended</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6 - Three-phased approach to support teachers to use collaborative learning techniques

The first phase is to support teachers to use cooperative structures which aim to increase participation and to support team building. These are simple structured Kagan tasks which were selected from the pilot study results (see Chapter 3). These structures also aim to begin to develop elaboration skills,
in line with Slavin et al.’s (2003) cognitive elaboration perspective, through providing coaching hints for learners in their explanations to their peers.

The second phase continues to utilise structured techniques to support learners in sharing responsibility for learning through group accountability (Askew and Wiliam, 1995), an important behaviour of cooperative learning (Bruffee, 1995; Johnson et al., 2000; McInnerney & Roberts, 2004). Jigsaw (Aronson, 1978) was also chosen to use in this phase as one of the barriers to group work identified by Panitz (1997) is ensuring that all learners are on task; in Jigsaw, each member of the small group has responsibility to learn and feedback their piece of the overall task which could potentially overcome this barrier.

The third and final phase uses Swan’s (2006) collaborative learning techniques and rich ‘group-worthy’ mathematical tasks in accordance with Horn’s (2005) conditions to develop cooperative learning behaviours. At each stage in the above plan, the structures are intended to aid progression from routine to more open-ended problems (Lotan, 2003).

**Analysis Rationale**

An empirical approach will be used to investigate the effectiveness of the three phases in overcoming the barriers for teachers in using group work effectively. Transcripts from the pre-intervention teacher interviews will be analysed using a simple descriptive coding framework (Miles & Huberman, 1994) for thematic analysis to draw out emerging themes (Delamont, 2002).
of teachers’ current perspectives on group work. A similar approach is used in the post-intervention interviews to allow any new themes to emerge following the intervention. The analysis of the post-intervention interviews will allow the structures to be evaluated in terms of how they develop cooperative and collaborative learning from the teachers’ perspectives.

The data analysis software SPSS is used to analyse the quantitative questions from the learner questionnaire, through producing frequency tables to compare proportions (Muijs, 2010) in students’ opinions on group work in general as well as the specific cooperative structures trialled with the classes. This is made possible through the use of Likert scales where each response is able to be converted to a number in order to treat the data quantitatively. Generally these were four-point Likert scales as previously discussed, however the pilot study found that questions relating to learners’ mathematical understanding required a five-point scale to allow for a neutral response if participant learners felt unable to comment on any perceived difference.

If the outcomes from the qualitative post-intervention teacher interviews correspond with the quantitative data from the learner questionnaires then greater confidence can be had in the validity of the findings (Cohen et al., 2007). To make this comparison, the teacher interviews will need to be compared with their corresponding class’ feedback.
The test-retest of the questionnaire with the pilot class will investigate whether participants responded similar on each occasion, to consider the reliability of the questionnaire, as the aim of this triangulation is to verify “the repeatability” (Stake, 2005, p.454) of the findings. It should be noted however that the reliability calculated is only for the pilot as a whole; it cannot be verified whether individuals responded similarly on both occasions as a result of the anonymity given.

Due to the small amount of dialogue collected from the small groups’ discussions, thematic analysis of the classroom observations was not possible, however examples of the discourse are incorporated in Chapter 5 where the dialogue supports the findings from the literature review, interviews and questionnaires and adds triangulation in terms of results from different sources which are in agreement (Mathison, 1988). The qualitative comments from the final question on the learner questionnaire (Appendix 3) will also be used in this manner. Both these qualitative forms of data should also to give more depth to the quantitative analysis (Creswell et al, 2006), both in terms of the quality of group discussion and the learners’ perspectives.

**Sampling Methods**

To attempt to maximise the validity of the study, a purposive sample of classes was selected in the hope of being as representative of the Federation as possible (Cohen et al., 2007). The sampling method employed was partly convenience sampling in the first instance to select
Teacher W (TW) and Teacher X (TX) and classes who were taught mathematics during the author’s non-contact or AST allocated time, to minimise cover implications. Following this selection however the sampling became more purposive, as Teacher Y (TY) and Teacher Z (TZ) were purposively selected for the following reasons: They both have very little experience of using group work in lessons and they were keen to be involved in the study to for their own professional development. This teacher buy-in is crucial according to Sapon-Shevin and Schniedewind (1991). More importantly in terms of sampling, TY and TZ both taught classes which if added to the convenience sample, created a wider range of gender, age and attainment of learners in the total sample (Denscombe, 2007), which although does not guarantee representativeness, does attempt to maximise it.

It should be noted that in-class support and observations were not possible with TY and TZ due to the author’s teaching commitments at these times, which will need to be taken into account in the analysis of the results, however they were involved in all the other aspects of the action research cycle.

Once a suitable team of teachers were selected then a purposive sample of their classes for such a small sample was more appropriate than random sampling. To maximise the representativeness, proportions of age groups of learners in the school were calculated to compare with the distribution of age groups in the sample (Robson, 2002). Year 11 were not included in the
calculations due to leaving school in the summer term when the action research took place. Year 10 had work experience for two weeks so were not chosen in the sample as the time to work with these classes on the structures would be limited. The classes selected were as follows:

- Year 7 Boys (middle attainers)
- Year 7 Boys (higher attainers)
- Year 9 Boys (lower attainers)
- Year 9 Girls (lower attainers)
- Year 9 Girls (middle attainers)

As the author’s Year 9 class had worked on these group structures in their mathematics lessons, they were included in the sample. The reasoning behind this and the implications of this decision are discussed after Figure 7, which shows the proportions of each group in the sample compared to the proportions of those groups in the whole school.

<table>
<thead>
<tr>
<th></th>
<th>Number of students in Federation</th>
<th>Proportion of school</th>
<th>Number of participants in sample</th>
<th>Proportion of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Year 7 - 8</td>
<td>231</td>
<td>23.0%</td>
<td>58</td>
<td>46.0%</td>
</tr>
<tr>
<td>Female Year 7 - 8</td>
<td>213</td>
<td>21.2%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Male Year 9 - 10</td>
<td>271</td>
<td>26.9%</td>
<td>21</td>
<td>16.7%</td>
</tr>
<tr>
<td>Female Year 9 - 10</td>
<td>291</td>
<td>28.9%</td>
<td>47</td>
<td>37.3%</td>
</tr>
<tr>
<td>Total Male</td>
<td>502</td>
<td>49.9%</td>
<td>79</td>
<td>62.7%</td>
</tr>
<tr>
<td>Total Female</td>
<td>504</td>
<td>50.1%</td>
<td>47</td>
<td>37.3%</td>
</tr>
<tr>
<td>Total Year 7 - 8</td>
<td>444</td>
<td>44.1%</td>
<td>58</td>
<td>46.0%</td>
</tr>
<tr>
<td>Total Year 9 - 10</td>
<td>562</td>
<td>55.9%</td>
<td>68</td>
<td>54.0%</td>
</tr>
</tbody>
</table>

Figure 7 – Proportions of age and gender in the sample compared with the population
The sample is representative of the population in terms of age, with very similar proportions of younger and older learners in the sample as in the whole school, however due to the constraints which required convenience sampling, it was not possible to work with a teacher of a Year 7 or Year 8 girls’ class. As a result the gender split in each age group in the sample is not representative of the proportions of males and females in the Federation. After the pilot study, the author’s Year 9 class followed the same phased approach for structured group work as the other participant classes and completed the final revised questionnaire in line with the other classes. Without the author’s Year 9 class in the sample, the proportion of girls in the sample would only be 18.3% compared to 50.1% for the school, with the addition of this class, girls are still not represented at KS3, however the overall proportion of girls in the sample rises to 37.3%. While this is by no means an exact stratified sample in terms of age and gender, it is closer to the whole school proportions than with the author’s Year 9 class omitted. This gender split causes implications for the generalisability of the findings of this research (Cohen et al., 2007) which will be discussed in more depth in Chapters 4 and 5. It is generally not recommended for the pilot respondents to complete the final questionnaire (ibid) as their responses may be affected by previous versions of the questionnaire. To take this into account in the analysis of the results and to minimise the effect of the gender split, some results will be calculated separately for males and females to compare the differences in their responses to group work.
Ethical Considerations

All research will be carried out in accordance with BERA (2011) guidelines. Ethical approval was granted by the Centre for Education Studies at the University of Warwick for this research (Appendix 7). The Executive Principal of the Federation gave consent to conduct the research in the two schools including, in loco-parentis, consent to observe teacher-learner and learner-learner discourse in lessons and conduct the learner questionnaire (BERA, 2011). Prior consent of students and their parents was not obtained for classroom observations as learners were not recorded or filmed and even if they are quoted in the dissertation, individuals will not be identified in any way.

The purpose of the study and how observational data and information given in semi-structured interviews will be used, were explained to the teachers selected to participate in this research. They were informed of the voluntary nature of their participation and their right to withdraw at any time (ibid). They were also assured that any observations would be to capture the conversations between learners and not to grade or judge their teaching of group work. At the start of each lesson, the purpose of the observation was explained to the class. Information at the top of the learner questionnaires also explained the purpose of the study and how information collected will be used confidentially (see Appendix 3). Furthermore, a statement was included in this information highlighting that the return of the questionnaire for the purposes of data collection for this research is voluntary so students had the option to simply not hand it in. The questionnaire was conducted in
lesson time so that it could be assured as much as possible that the students understood this information.

The confidentiality of the research was explained to the teachers and that to maintain anonymity they would be referred to as Teacher X etc. Likewise learners will be referred to as Student A etc. from any observations recorded so that individual learners will not be identifiable. Furthermore, no space for names has be given on the learner questionnaires to ensure anonymity (Cohen et al., 2007) and questionnaires will be collected in anonymously in a large envelope.
Chapter 3

Results Analysis and Findings

This chapter presents the findings drawn from the analysis of the results collected from the action research. It first presents the results from the pilot study which shaped the three-phased approach to structured group work and the test-retest results to test the reliability of the questionnaire. It then reveals the themes which emerged as barriers to teachers using group work in mathematics from the analysis of the pre-intervention teacher interviews. This is followed by the findings from detailed quantitative analysis of the learner questionnaires, including the findings from analysing the differences in responses, in terms of gender, age and attainment. Finally, the strengths and barriers of the phased approach are presented from the thematic analysis of the post-intervention teacher interviews.

Pilot Study Results

By grouping the strongly disagree and strongly agree categories with disagree and agree respectively for the questions relating to specific cooperative structures, it was clear to highlight which tasks were enjoyed by the majority of the pilot group from highest percentage agreement (see Figure 8). Enjoyment was considered relevant in the pilot of the structures as a positive attitude from the learners is closely linked to intrinsic motivation.
(Nov et al., 2010) which von Glasersfeld (1995) states is required for collaborative problem solving. Learners’ demonstrating engagement and participation in the first phase through enjoyment of the structures could have a positive effect on teachers’ concerns about implementing group work.

<table>
<thead>
<tr>
<th>Task</th>
<th>N</th>
<th>% Disagree</th>
<th>% Agree</th>
<th>% Missing</th>
<th>% Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have enjoyed Rally Robin</td>
<td>24</td>
<td>0.0</td>
<td>100.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed Collective Memory</td>
<td>24</td>
<td>16.7</td>
<td>83.3</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed Think-Pair-Share</td>
<td>24</td>
<td>16.7</td>
<td>83.3</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed All Write Round Robin</td>
<td>22</td>
<td>20.8</td>
<td>79.2</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed Showdown</td>
<td>24</td>
<td>33.3</td>
<td>66.7</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed Inside Outside Circle</td>
<td>24</td>
<td>37.5</td>
<td>62.5</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed Quiz Quiz Trade</td>
<td>24</td>
<td>41.7</td>
<td>58.3</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed Rally Coach</td>
<td>24</td>
<td>54.2</td>
<td>45.8</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed Find someone who...</td>
<td>23</td>
<td>50.0</td>
<td>45.8</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed Mix and Match</td>
<td>20</td>
<td>41.6</td>
<td>41.7</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I have enjoyed Numbered Heads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 8 – Pilot Group Perspectives of Cooperative Tasks

Rally Robin came out the highest with all respondents indicating a positive attitude to the structure. Collective Memory and Think-Pair-Share were next favoured with a large majority of participants in agreement, then All Write Round Robin and Showdown. All these tasks had at least three quarters of the pilot group giving positive responses.

Although Showdown had the fifth highest percentage agreement, it was decided that Quiz Quiz Trade should be used in the main study instead of Showdown as although 37.5% were not favourable about this task, in lesson observations on three separate occasions with three different members of teaching and senior leadership staff, the class were noted to be highly engaged in mathematical discussion during activities using this structure.
Furthermore, the literature review discussed the need to support learners in their elaboration skills, which is scaffolded for learners in Quiz Quiz Trade, but not in Showdown.

As discussed in the research design in Chapter 2, the pilot study questionnaire was administered a week later to compare the reliability of the research instrument in terms of test-retest. No further group work was trialled in this time to ensure that their opinions on group work had not been influenced further, ensuring that the retest was simply investigating whether participants would respond similarly on different occasions. The largest difference in the percentage agreement from the first to the second test was 5.0%, which is a difference of only 2 respondents, one of whom could be attributable to the change in total responses for that question between the two occasions. Two statements had no change in the percentages of positive responses from the test to the retest. Therefore all the generic group work questions were used in the main action research as a result of this reliability from the test-retest.

<table>
<thead>
<tr>
<th>Test</th>
<th>N</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>23</th>
<th>23</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage Agreement</td>
<td>95.8</td>
<td>95.8</td>
<td>91.7</td>
<td>83.3</td>
<td>87.5</td>
<td>82.6</td>
<td>78.3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Retest</th>
<th>N</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage Agreement</td>
<td>91.7</td>
<td>91.7</td>
<td>91.7</td>
<td>83.3</td>
<td>91.7</td>
<td>79.2</td>
<td>83.3</td>
<td></td>
</tr>
</tbody>
</table>

| Difference in Percentage Agreement | 4.1 | 4.1 | 0.0 | 0.0 | 4.2 | 3.4 | 5.0 |

Figure 9 – Test-Retest Comparisons for Reliability of Research Instrument
Following the test-retest of the original pilot questionnaire, some of the questions about general group work were changed. The most notable changes were splitting up questions Q_p8 and Q_p9 from the original questionnaire:

Q_p8. I feel I have a better understanding of mathematics when I work in a group

Q_p9. Being in a group has helped me become more successful in mathematics

This was in part down to the fact they are very similar, so splitting up the questions and then reversing question Q_p8 (Q_rp4 in the refined pilot questionnaire, see Appendix 6) to triangulate results:

Q_rp4. I feel I have a better understanding of mathematics when I work on my own

Interestingly, this question scored a percentage agreement of 82.6% and 79.2% on the test and retest respectively both indicating a positive attitude to group work, with respect to their success in and understanding of mathematics, however when that question was reversed in the refined pilot, although the percentage agreement dropped to 62.5% (see figure 10), it would be expected to be below 25%.

<table>
<thead>
<tr>
<th>I enjoy working in a group</th>
<th>I feel comfortable working in a group</th>
<th>I feel comfortable asking my fellow group members questions</th>
<th>I am more likely to ask my group members questions before asking the teacher</th>
<th>I find my group members to be helpful</th>
<th>I feel I have a better understanding of mathematics when I work on my own</th>
<th>Being in a group has helped me become more successful in mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>24</td>
<td>24</td>
<td>23</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Percentage Agreement</td>
<td>91.7</td>
<td>95.8</td>
<td>87</td>
<td>79.2</td>
<td>91.7</td>
<td>62.5</td>
</tr>
</tbody>
</table>

Figure 10 – Responses from Refined Pilot Learner Questionnaire
There are several possible reasons for this: it could be attributed to the need for a ‘don’t know’ response option for questions linking group work to attainment as if participants are unsure they could be choosing almost randomly and as this was the third time the pilot learners had completed the questionnaire some may not have noticed the change in this question. Most importantly however it casts doubt on the validity of this research instrument. This revised question has remained in the main action research study as comparing responses from different groups of learner is still possible, however this refined pilot result will need to be considered when analysing these questions and considering the limitations, particularly in terms of whether understanding and success in mathematics are directly comparable.

Pre-Intervention Teacher Interviews

The transcripts were analysed using a simple descriptive coding framework. As barriers to group work arose they were assigned codes which were used whenever these topics arose again. Following completion of the coding of the pre-intervention interview transcripts, these topics were then grouped into common themes for the barriers facing teachers at the author’s school (see Figure 11). Finally the themes were colour coded on the transcripts.
The concerns which emerged directly as themes from the transcript analysis were classroom management and practicalities, time management and assessment issues. In addition to these it indirectly emerged that teachers’ knowledge of cooperative and collaborative structures were also a possible barrier as well as teachers’ prior experience of both traditional teaching through transmission of knowledge from teacher to learner which teachers

<table>
<thead>
<tr>
<th>Barriers to Group Work</th>
<th>Code</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learner behaviour</td>
<td>LB</td>
<td></td>
</tr>
<tr>
<td>Students off task</td>
<td>OFF</td>
<td></td>
</tr>
<tr>
<td>Classroom control</td>
<td>CC</td>
<td></td>
</tr>
<tr>
<td>Classroom layout</td>
<td>ROOM</td>
<td>Classroom management and practicalities</td>
</tr>
<tr>
<td>Seating</td>
<td>SEAT</td>
<td></td>
</tr>
<tr>
<td>Eye line to board</td>
<td>EYE</td>
<td></td>
</tr>
<tr>
<td>Time needed to cover syllabus</td>
<td>COV</td>
<td>Time management</td>
</tr>
<tr>
<td>Time needed to plan for group work</td>
<td>PLAN</td>
<td></td>
</tr>
<tr>
<td>Preparing for group work</td>
<td>PREP</td>
<td></td>
</tr>
<tr>
<td>Time to get around to support each group</td>
<td>SUP</td>
<td></td>
</tr>
<tr>
<td>Group work slows pace of lesson</td>
<td>PACE</td>
<td></td>
</tr>
<tr>
<td>Students might just copy from others</td>
<td>COPY</td>
<td>Assessment issues</td>
</tr>
<tr>
<td>Objectives</td>
<td>OBJ</td>
<td></td>
</tr>
<tr>
<td>Shared responsibility</td>
<td>SHARE</td>
<td></td>
</tr>
<tr>
<td>Results</td>
<td>RES</td>
<td></td>
</tr>
<tr>
<td>Teacher preferences</td>
<td>TP</td>
<td>Impact of prior experience and teacher knowledge</td>
</tr>
<tr>
<td>Learner preferences</td>
<td>LP</td>
<td></td>
</tr>
<tr>
<td>Pair work is easier</td>
<td>PAIR</td>
<td></td>
</tr>
<tr>
<td>Bad experience of group work</td>
<td>BAD</td>
<td></td>
</tr>
<tr>
<td>If it isn’t broken…</td>
<td>FIX</td>
<td></td>
</tr>
<tr>
<td>Effective group work is dependent on the class</td>
<td>TYPE</td>
<td></td>
</tr>
<tr>
<td>Lack of training</td>
<td>TRA</td>
<td></td>
</tr>
<tr>
<td>Knowledge of structures</td>
<td>STR</td>
<td></td>
</tr>
<tr>
<td>Knowledge of roles</td>
<td>ROLE</td>
<td></td>
</tr>
</tbody>
</table>

Figure 11 – Emerging themes from Teacher Interviews
deemed successful, as well as their prior experience of ineffective group work.

**Learner Questionnaires**

In total from the five classes involved in the action research, 126 questionnaires were collected in out of a possible 141. Due to the method of completion of the questionnaires in class, all participant learners who were present in school at the time each teacher conducted the survey handed in their questionnaire, giving a response rate of 89.4% which is considered high (Cohen et al., 2007). Due to some missing responses, not all 126 respondents completed every question but all the questionnaires were over 50 per cent complete so were considered to have enough completed for the purposes of this analysis (ibid). The response rate for each question, N, has been included in the frequency tables.

Questions Q3, Q4, Q6, Q7 and Q8 measure learner attitudes to group work:

- Q3. I enjoy working in a group
- Q4. I feel comfortable working in a group
- Q6. I feel comfortable asking my fellow group members questions
- Q7. I am more likely to ask my group members questions before asking the teacher
- Q8. I find my group members to be helpful

In the same way as for the pilot study data, the strongly disagree and strongly agree categories were combined with disagree and agree respectively for the analysis of frequencies (see Figure 12).
I enjoy working in a group
I feel comfortable working in a group
I feel comfortable asking my fellow group members questions
I am more likely to ask my group members questions before asking the teacher
I find my group members to be helpful

<table>
<thead>
<tr>
<th>N</th>
<th>126</th>
<th>126</th>
<th>126</th>
<th>125</th>
<th>126</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Disagree</td>
<td>8.7</td>
<td>7.1</td>
<td>15.1</td>
<td>16.7</td>
<td>11.9</td>
</tr>
<tr>
<td>% Agree</td>
<td>91.3</td>
<td>92.9</td>
<td>84.9</td>
<td>82.5</td>
<td>88.1</td>
</tr>
<tr>
<td>% Missing</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.8</td>
<td>0.0</td>
</tr>
</tbody>
</table>

| % Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Figure 12 – Learner attitudes to working in a group

All the questions relating to learners’ attitudes to group work had a high majority percentage agreement with the highest proportion of positive responses coming from the learners’ enjoyment and comfort working in a group. The least positive attitudes related to asking questions to their fellow group members, which had the largest proportion of disagree responses, although over 82% were still in agreement that they were comfortable to ask questions in their groups and more likely to ask their group members questions than the teacher.

Q5 and Q9 relate to learners’ perception of the impact on their understanding and success in mathematics as a result of working in a group:

Q5. Being in a group has helped me become more successful in mathematics
Q9. I feel I have a better understanding of mathematics when I work on my own

The percentage agreement for learners believing that group work has helped their mathematical success was 46.8%. The percentage of learners who
disagreed that they understood mathematics better when they worked alone was 44.4%. The purpose of reversing Q9 was to help assess the validity of the questionnaire, which although was not answered as expected in the pilot study, is strongly supported by the percentage responses in the main study as highlighted in Figure 13, where the categories are grouped similarly to the previous questions, but with the addition of the neutral category.

![Table](image)

Figure 13 – Learner perspective of impact on understanding of mathematics as a result of working in a group.

In terms of gender (see Figure 14), both males and females responded very similarly to the likelihood of asking their group members questions before asking the teacher, although the biggest difference between genders was how comfortable they feel asking their fellow group member questions with a difference of over 6%.
Age made little difference to whether learners felt comfortable working in a group (93.1% for younger learners and 92.6% for older learners). Where age does appear to have an effect, is on learners’ perception of the impact of group work on their understanding of mathematics: 51.5% of older learners compared to 41.4% of younger learners, a much bigger difference than between males and females with just a 2% difference (see Figure 14).

The percentage agreement varied most greatly when comparing ‘ability’ groupings (see Figure 15). Learners with above average attainment in mathematics for their age, were more likely to enjoy and feel comfortable working in groups, however below average attainers were most likely to ask their group members questions before asking the teacher. It was average attaining learners who were most likely to believe their understanding of mathematics had improved as a result of group work as opposed to the lower
attaining learners, which Kagan (2008) claims learn the most in a cooperative learning environment.

![Figure 15 – Effect of learner attainment on attitudes to group work](image)

Learner responses for Q16, which invited participants to elaborate on any area of group work they had experienced this term will be used in the discussion in Chapter 4 as anecdotal evidence as the response rate for this more open-ended question was low and many of the comments did not add anything more to the closed responses. Similarly as the observational evidence was limited, this will not be analysed here, but will be discussed in Chapter 4 where the observations support the discussion.

**Post-Intervention Teacher Interviews**

Due to unforeseeable circumstances, Teacher X was unable to complete the action research cycle. The author was able to complete the three-phased intervention with the class in order to conduct the questionnaires with the Year 7 middle ability boys, however because TX had missed the second and
third phases of the action research cycle and due to absence from school, a post-intervention interview was not conducted with this teacher.

The other three teachers involved in the action research were interviewed, recorded and transcribed in the same way as the pre-intervention interviews. Figure 16 summarises the strengths and barriers of the three phases which were reported in these post-intervention interviews.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Strengths</th>
<th>Barriers</th>
</tr>
</thead>
</table>
| 1     | • Engaging  
      • Learners’ enjoyment  
      • Confidence building  
      • Time-efficient  
      • Availability of resources  
      • Easy to plan  
      • Team building  
      • Develops strategy  
      • Support in explanations  
      • Increase in participation  
      • Increase in mathematical discourse between learners | • Explaining the structures initially to learners  
      • Assessing all learners’ understanding  
      • More for revision than new learning |
| 2     | • Engaging  
      • Sharing knowledge  
      • Reinforcing understanding when explaining to others  
      • Everyone involved  
      • Learners work with different people | • Keeping learners on task for longer periods  
      • Difficult to give control over to learners  
      • Some learners found explaining to their peers difficult  
      • Some learners prefer to work alone  
      • Assessing all learners |
| 3     | • Challenging and rewarding tasks  
      • Learners working more independently | • Time to prepare resources  
      • Some learners dominating small group |

Figure 16 - Strengths and barriers of the three phases to introduce group work
The following themes across these strengths and barriers emerged:

- Increased Engagement and Participation
- Increased Teacher Confidence
- Developing Group Skills
- Developing Elaboration Skills

The first two points above emerged as strengths. Elements of the second two bullet points emerged as strengths, however other factors relating to these themes were also cited by participant teachers as barriers. Some off the assessment, time and classroom control concerns which emerged as themes from the pre-intervention interviews remained an issue for individual teachers but were addresses by the action research for others. However all three teachers reported positively on the phased approach to introducing group work in the mathematics classroom:

**TW:** I would definitely feel more confident about using it now.

**TZ:** I think it’s given me more confidence and ways to approach it. Different ideas which I’d never tried before.

**TY:** Students don’t have that much experience explaining things to each other so they find it difficult and then they disengage because they’re not getting that much out of it. So I think the phased approach is really useful.
Chapter 4

Discussion

This chapter will discuss the findings presented in Chapter 3 in relation to the conceptual and empirical literature reviews and how these findings support the research questions for this dissertation. This will first be discussed in terms of the four themes which emerged as barriers to effective small group work in mathematics which address the first research question, linking those themes to previous research. For each of these four themes the evidence will be considered for how the action research element of this study overcame these barriers to address the second research question. It will then consider the evidence which links the group work which took place to the constructivist continuum. Finally it will discuss the themes which emerged as strengths and barriers from the three-phased approach to developing group work and how cooperative and collaborative behaviours were displayed to assess the impact of the action research.

The Barriers: Agreement in the Research

The findings from the pre-intervention interviews support the majority of barriers to group work found from previous research. Figure 17 maps the themes which emerged from this action research and ten of Panitz’s (1997) potential barriers. Panitz’s eleventh barrier, that of teachers' egos and
wanting to perform, did not arise from the interviews, however this is perhaps more personal for teachers to openly admit to as a negative character trait.

<table>
<thead>
<tr>
<th>Barriers to Group Work Theme</th>
<th>Panitz’s (1997) Barriers</th>
</tr>
</thead>
</table>
| Classroom Management & Practicalities | • Loss of classroom control  
• Lack of teacher confidence  
• Lack of familiarity with cooperative learning techniques and classroom management  
• Large class sizes and inappropriate classroom setup  
• Concern being observed as unexpected outcomes are more likely to arise |
| Time management | • Concerns over content coverage  
• Lack of ready-made resources |
| Assessment issues | • Uncertainty how to assess individual progress when working in groups |
| Impact of prior experience teacher knowledge | • Learner apathy and resistance to thinking for themselves  
• Lack of teacher training in collaborative teaching methods |

Figure 17 – Comparison of emerged themes and Panitz’s (1997) barriers

**Classroom Management and Practicalities**

A common concern within this theme was teachers’ confidence in terms of classroom control. The perception for some teachers was that classes working in silence equated to better learning, which was mainly attributed to keeping them on task:
TX: I like control; I worry about children going off task.

TZ: My Year 10 girls just can’t be trusted not to talk off topic so I tend to have to get them to work in silence, it’s really difficult to let them talk but not talk about…boys, social lives…

The comment by Teacher Z above implies that successful small group work is dependent on the class involved, for TZ it was dependent on age and behaviour. In fact all four participant teachers believed that successful small group work, including pair work, was dependent on the class:

JD: How often would you say you have learners working in pairs?

TW: I would say…probably depends on the group.

TZ: Maybe one lesson a fortnight. Depends on the group, some of them a little bit more.

However the type of class where teachers used group work as a pedagogic strategy was different for different teachers. For TY it was attributed to the relationship the teacher had with the class:

TY: It depends on the group. I think some groups are more naturally inclined toward group work than others.

JD: What type of groups would you say? Is there a type of group?

TY: It’s difficult to explain. It’s difficult to explain because it’s not necessarily an ability thing, it’s more of like an attitude thing I think, or it depends on my relationship with them a little bit I think.
Both Teacher Y and Teacher Z believe that sometimes, although implementing group work with lower attaining learners can be more difficult, they are the type of learner who benefits most from the strategy:

*JD: Do you find it easier to do with the lower ability, younger students?*

*TY: No, I find it more challenging, but then they learn more from doing it so that compensates for the fact that it’s a bit more tricky.*

*TZ: Year 10 boys [TZ has a low attaining class] need to support each other so I often get them to do things with partners.*

This corresponds to Kagan’s (2008) assertion that it is the lower ability learners who benefit most from his cooperative learning techniques, however Kagan advocates a mixed ability learning environment which was not a possible condition for this action research. Learners’ perceptions in this empirical review do not agree with TY and TZ nor do they corroborate Kagan’s assertion, as the below average attainers were the least likely to believe that being in a group had helped them become more successful in mathematics and the most likely attainment group to feel they have a better understanding of mathematics when working alone. Furthermore this category of learner had the highest proportion of negative responses in their attitudes to group work in all but one question relating to attitude. These negative responses could be attributed to the lower attaining learners’ abilities to explain their understanding to their peers (Blumenfeld et al., 1996). The exception was where below average attainers were the most likely to ask their group members for help before asking the teacher, however this perhaps just as much exposes the limitation of the question as the response is relative to another variable.
Despite positive feedback from the post-intervention teacher interviews in terms of engagement and participation, for Teacher Z classroom management remained an issue:

TZ: The barriers were control of the students, it works for a while keeping them engaged but then you often start to lose them and then it’s making sure everyone is still on task then I try to interrupt it and control it too much.

Participant learners from TZ’s class corroborate that classroom management may still be an issue:

“The class go a bit over the top on noise”

“Sometimes it gets too loud and it starts getting hard to concentrate”

This is perhaps not surprising as five out of the eleven barriers to implementing group work listed by Panitz (1997) can be linked to concerns over classroom management (see Figure 18) so there are more elements to overcome in classroom management than the other three themes. However Teacher Z is new to the profession where classroom management issues are common (Muijs & Reynolds, 2005).

**Time Management**

In line with Panitz’s (1997) barriers, time management was a concern for Teacher Y at the start of the action research:

TY: Planning group work requires a lot more thought because I have to think about who I’m going to put with who and how I’m going to change the room up and things like that, so it just means that those lessons take longer to plan.
Furthermore, it emerged that higher attaining learners may experience less group work in mathematics than other learners, as there was not enough perceived gains in using group work with this type of learner compared to the amount of teacher preparation required:

TY: *Group work I find requires a lot more work and planning on my side and for the groups that I think are pretty strong, I think the sort of marginal benefits you get from putting them into groups isn't that much* [compared to whole class teaching methods].

However the learner questionnaires showed that over three times the number of learners who felt they had a better understanding of mathematics when working alone, believed that working in a group had helped them become more successful in mathematics. Above average attainers are the most likely to respond positively to all except one question relating to attitude to group work and the exception, which was the likelihood to ask group members questions before the teacher, was only 0.8% less than the most likely category.

However Panitz (1997) states one of teachers’ concerns is the lack of ready-made resources. The phased approach, particularly the first phase, helped to overcome some of these concerns over the time required to plan for group work:

TY: *In the first phase, they were very time efficient activities… you get a lot out of it for a small input, that’s what I liked.*

TZ: *The strengths was probably the availability of resources, it wasn’t hard to plan it.*
However, although this was certainly the case for the structures used in the early phases, it was felt that if specific activities are not readily available then time is still an issue in the later phases of the structured approach to produce these:

*TY:* The later collaborative stuff is stuff that I have only really done with my [participant] Year 9 class, just because to create those resources is quite difficult.

Teacher Y has been unable to experience an impact of the third phase beyond his participant class due to the lack of resources available.

**Assessment Issues**

Assessment was the least cited theme to emerge from the pre-intervention teacher interviews, only being discussed by Teacher W. This does not necessarily mean that assessment is not an issue, just that teachers in the author’s school do not perceive it as a major barrier. This could be down to the fact that until teachers come to implement group work they will not discover the potential assessment issues, particularly considering that assessment is a weak aspect of mathematics teaching generally (Ofsted, 2012). So perhaps teachers do not see it as any bigger barrier than assessing individual progress in a more traditional lesson.

Where assessment was mentioned it was more in relation to whether there was equal contributions by all small group members as opposed to assessing learners’ understanding:
TW: I find it quite hard to work out that all four members have equally contributed to the task rather than two lead it and two agree, or one sit back completely and not really be as involved.

This sentiment is echoed by this learner in his qualitative response on the learner questionnaire:

“I never copy when I work alone.”

The issue of assessing that all learners are involved is discussed further in the Increased Engagement and Participation section below, however assessment in terms of marking remained an issue after the intervention:

TW: It’s a great team building activity [Rally Robin], but the way that it works it’s very hard in a class environment to actually ascertain as to whether what’s been written down is correct or just nonsense!

Impact of Prior Experience and Teacher Knowledge

From the pre-intervention teacher interviews it emerged that the impact of teachers’ own learning preferences may dictate their teaching styles:

JD: How often would you say you have learners working in small groups?

TW: Very rarely.

JD: Is there any reason?

TW: I don’t like doing it myself. I don’t like working in groups, I’d rather just get on with it and do it myself.
However the learner questionnaires showed that all categories of learner were more likely to believe that working in groups improved their mathematical understanding than working alone.

Sometimes teachers may know all the theory and agree with the benefits, but do not have the necessary tools to put that into practice:

*TX*: I think there are benefits if it's done correctly. I think it allows the strong to help the weak. I think it allows students to shine when they wouldn't previously. It develops social skills; they're going to be working in the real world soon where they are going to be interacting with their peers, so it's good practice.

*JD*: So based on all of those benefits why would you say you're very rarely using it?

*TX*: I don’t know how to do it effectively.

In the post-teacher interviews, all three teachers found the phased approach to structured group work was helpful in putting the theory into practice:

*TW*: It was a class which I hadn’t done much group work with at all so being able to have the phases to introduce them to it was really helpful.

*TZ*: Yeah definitely. Made it easier for me to know how to approach it and where to start.

*TY*: I think there does need to be a phased approach, because I think if we went straight into the collaborative stuff, you’d get the kind of teething problems that I had before I started.
Solving Problems on the Constructivist Continuum

The post-teacher interviews suggest that the action research project created a context for situated learning in the participant classes and those classes starting to develop as communities of learners (Lave, 2011) solving problems together:

TY: They are seeing the things I give them more as problems to solve rather than exercises to get done.

TW: [They] have definitely now become more independent of me. So I have noticed generally they have helped each other out on their tables and have been happy to explain to each other what’s going on, rather than 5 or 6 girls all waiting for me to help them, they have definitely looked to their peers for help first before nagging at me.

This ease of working with their peers is also evidenced by the quantitative data from the learner questionnaires and could be regarded as a necessary step to creating Boaler’s “social arena” (1999, p. 279). This social element to solving problems will hopefully enable participant learners to transfer knowledge (Boaler, 1999) over a period of time to a range of situations, however there is not the evidence in this action research to evidence that here.

There was evidence however of group members acting as Vygotsky’s (1978) more knowledgeable other, through supporting their peers to achieve more than they could do alone in their ZPD for that particular moment in time:
SS: You’re confusing me!

SQ: That’s the highest [points to 4] and the range is three so the lowest must be one.

SS: Oh because range is biggest take away smallest?

SQ: Yes.

Student S understood how to calculate the range but was unable to apply it in this collaborative problem solving context without the support of SQ. However this only supports the benefit of the more knowledgeable other in pair work, which in the pre-intervention teacher interviews was perceived as easier to implement in lessons than groups of three or four, in terms of equal participation. There was evidence that there were benefits to working in small groups other than pair work in terms of developing elaboration skills as illustrated in the following discourse:

SA: It’s prime, I don’t know what that is.

SB: It can only be divided by one and itself

SA: I still don’t get it

SB: You know, number 7 doesn’t appear in any other times table other than 1 and 7.

SC: So 1x7=7 and 7x1=7 but no other numbers.

SA: Like 9 isn’t prime because 3 goes in?

SB: Yeah.

A cooperative behaviour illustrated in both these excerpts is learners asking their peers for help (Johnson et al., 2000). However in small groups as opposed to pairs, there is the added benefit here that between SB and SC, different ways of approaching the problem are offered to SA, thereby displaying Mercer’s (2008) collaborative behaviour of offering alternative
approaches. By interpreting her understanding through giving an example and justifying that example, there is evidence that SA has constructed the concept of a prime number through the support of her peers and which she was not able to do alone, again supporting the social constructivism perspective. A similar excerpt further illustrates the scaffolding that small groups can offer with regards to alternative approaches:

SJ: *I eliminated these two people because one of the suspects didn’t know that x equals 6.*

SK: *I don’t get it.*

SJ: *I worked backwards so 15 take 9 equals 6.*

[SK looks confused]

SL: *Look, if you put 6 into that [points to x + 9], you get 15.*

SK: *Oh yes, I get it.*

[SK goes on to correctly solve the next problem unaided]

SJ and SL display collaborative behaviours by offering alternative ways of approaching the problem, through either substitution or inverse operations, which together give the scaffolding required in Slavin et al.’s (2003) cognitive elaboration perspective. This comment from a learner questionnaire suggests that learners appreciate the alternative approaches to problem solving that collaborative learning can provide them:

“It helps me understand when having different ways of solving things”

However although there is evidence that the discussion between SJ, SK and SL seemed to scaffold the explanation, as knowledge is a construct which is subjective to the individual (von Glasersfeld, 1991), SK’s understanding cannot be guaranteed from a radical constructivist perspective. This is
particularly the case here as, although SK seemed to apply the knowledge to the next problem, she did not articulate her understanding of either method. This is further illustrated by the following discussion:

*SE:* *Is that a short line?*

*SG:* Yes.

*SF:* *I got 15 for the shorter side but the longest is 12mm.*

*SE:* *You need to take away because it’s a shorter line you’re trying to find so you still square both and square root, but you take them away instead of add.*

[SF goes on to complete the problem alone]

SF appreciates that her answer cannot be correct, and by completing the problem she demonstrates Kagan’s perspective of the ZPD that her peers have supported her to do alone what she could not do before (Kagan, 2001), however her understanding of why she needs to subtract cannot be guaranteed from a radical constructivist framework, particularly on the evidence of this discussion.

**Increased Engagement and Participation**

The strengths of the first phase of *Increasing Participation, Team Building and Developing Elaboration Skills* have a common theme of engaging learners:

*TZ:* *Strengths was that it was really engaging […] They would ask if we were doing group stuff today and then be really glad if we were.*
From evaluating the author’s class working on the structures, Quiz Quiz Trade and Rally Robin were effective structures for the collaborative behaviour of engaging many learners at once (Kagan, 2008).

As well as engaging learners, TW also believed the structures to have a positive effect on their class’ confidence:

*TW*: *I think it helps to build confidence; everyone has to be involved, you can’t dip your go or just sit back and let everything around you happen and the competition element of making sure all your answers are correct definitely helps to encourage the students to participate mathematically with it.*

This comment made by a member of TW’s class supports this perceived increase:

“*[I] have gained confidence learning*”

From TW’s point of view, this gain in learner confidence has resulted in an increase in learner participation, in terms of engaging in mathematical discourse:

*TW*: *They have a lot more confidence now in sharing their ideas. I think they’ve now understood that they don’t necessarily have to work with the same people all the time; moving round and working with other people in the group can work as well and they’ve definitely gained in confidence to have mathematical conversations and put out their ideas, knowing that it could be right, it could be wrong, it could be half right, it could then lead onto the right ideas. I think they’ve probably become a lot more independent and less hands up “Miss, Please”.*
Developing Group Skills

The phased approach was designed to support learners in developing the skills required for working in groups (Slavin et al., 2003; Kutnick et al., 2005) and the post-intervention teacher interviews showed that the teachers felt that the structures in the phased approach supported that development:

TW: *I would say they are tasks that really helped introduce working as a team, as a group.*

TZ: *I think the Collective Memory was good for kind of strategy; someone had to take the lead and designate who was going to try and remember what so communication I guess as well.*

Collective memory was also observed with the author’s class as an effective structure for developing the cooperative behaviour of working together to achieve a common goal (Johnson et al., 2000; McInnerney & Roberts, 2004). However the aim is not solely to develop team building skills, as stated earlier if mathematical learning is not taking place it is not a worthwhile task in a mathematics lesson (Cohen, 1994). Other comments evidenced that from the teachers’ perspectives, learning was taking place:

TZ: *That’s more team work [Rally Robin] but also more mathematical as they are sharing their knowledge of mathematics with one another, helping each other correct maths problems and come up with new maths questions, reinforcement of their understanding and helping other people get up to the same level, so I think they were really sharing their knowledge there.*

TW: *I would say there is potential for learning there [Quiz Quiz Trade] as students are encouraged to help each other out and are structured and there*
is an end point of showing understanding on the questions before being able to move on.

However these developed group skills are the teachers’ perceptions. Although observations were made which evidence cooperative and collaborative behaviours, no starting point was measured to evidence how the structured approach developed these skills.

**Developing Elaboration Skills**

On the whole, the phased approach was seen by the participant teachers as a useful way of beginning to develop learners’ explanation skills as required by the cognitive elaboration perspective (Slavin et al., 2003):

*TY: Students don’t have that much experience explaining things to each other so they find it difficult and then they disengage because they’re not getting that much out of it. So I think the phased approach is really useful.*

*TW: Because the structure is on the cards [Quiz Quiz Trade]; the help, the hints are on the cards, then it gave them a starting point for their explanation, which I think had it just been the question and an answer, maybe they then wouldn’t necessarily be very good at explaining how to get from one to the other. But with the help and the hints that are on the cards, I think that definitely gives them some structure and some support in explanations.*

However the evidence indicates that the action research did not allow enough time for this development to move from the structured support given in Quiz Quiz Trade for example. When the teachers moved into the
second phase, some learners were still unable to articulate their understanding to the peers:

TY: I think it might be worth spending some lessons training the kids on how they can communicate their ideas or something like that to make it more efficient, because I really like the structure [of Jigsaw], but it didn’t work so well.

This is perhaps the case in the following excerpt, where although they were supporting each other, they worked on the questions almost individually, not displaying the cooperative characteristics of working together or fostering a shared responsibility for learning. In addition only a simple procedural method is offered as opposed to elaborating on their reasoning:

SE: Is it Pythagoras’ theorem? We all know how to do it, we revised it yesterday?
SF: Yes.

[Students calculate independently]
SG: Oh I know what I’ve done, I forgot to square them.
SH: Wait, I’m confused.
SG: You need to press this button first then the number.
SH: Oh yes.

The discussion enabled SH to go on to solve the problem, but there is no evidence that SH has developed the concept of Pythagoras’ theorem in their schema as a result of this low level discussion.

When one member of the group has the ability to offer an explanation and take the role of the more knowledgeable other however, they do not
necessarily know that their peers need, or indeed want, that explanation unless their peers have the confidence to ask them to explain:

\[
SM: \text{ How many numbers are there? [Writes 4, 4]} \\
SN: \text{ Why have you written that?} \\
SM: \text{ I don’t know how many numbers there are but 4 is the mode so there must be at least two fours.} \\
SP: \text{ You just need to explain sometimes!}
\]

The learner questionnaires indicate that this could be particularly an issue for girls who felt less comfortable asking questions of their fellow group members than boys. If learners do not have the confidence to ask their group members for support then the cooperative behaviours of learners asking their peers for help (Johnson et al., 2000) and working together towards common goal (Johnson et al., 2000; McInerney & Roberts, 2004) are not achieved and teachers’ concerns over copying could become a reality.

Learners’ confidence to ask their peers for support also relates back to the learners’ standing in the group and whether they feel they are listened to by their peers (Bennett & Cass, 1989). The observational data does not indicate that this was an issue, for example in this discussion, Student Q, a stronger member of the class in terms of both attainment and confidence, took control, but Student R, a lower attaining learner within the class also gives input and is listened to by her group members:
SS: How does that work if it’s out of 25?
SR: It all adds up to 25 but each one is out of 5.
SQ: There are five people doing five tests so 25 in total, not the test out of 25.

[...] 
SR: You have the mode? That means you have the mean and median because they’re all the same.
SQ: No, but….oh yeah, well done darling!

This demonstrates the collaborative behaviour of all learners’ input being valued by their peers (Panitz, 1999). Teacher W believes that the reason learners’ perceived mathematical ability by other members their small groups was not an issue in the action research was due to the group work being a different way of learning for all the learners:

TW: It slightly took them all out of their comfort zone, that actually they were all happy for someone to be saying something so it wasn’t all just up to them.

This seems to not correspond with Trautwein’s (2006) assertion that group dynamics plays a role, however this research would need to be carried out over a longer period of time to ascertain whether this phenomenon of all contributions being valued regardless perceived ability within the class, would continue once learners were more accustomed to this way of working.

There was evidence from the post-teacher interviews of the more open-ended tasks in the third phase producing collaborative learning:
TY: The main thing is it’s really challenging so I don’t think many kids would know how to do it [a rich, problem solving activity] purely on their own because you need lots and lots of ideas, so tasks like that where it’s very challenging and it’s also quite rewarding to get the answer because it’s quite challenging. The kids also realise that they can’t do it on their own as there is so many different pieces of information and I think they learn more, but they also develop a bit of a passion for working in teams because that’s a real example of where you need to work in a group to achieve a complex goal.

Teacher Y is describing collaborative behaviours here through mutual engagement and coordinating their efforts (Dillenbourg et al., 1996) without the need for teacher control (Panitz, 1999). These collaborative behaviours which TY describes also suggest that these learners are showing intrinsic motivation perhaps made possible through the learners learning to solve problems on their own (von Glasersfeld, 1995).

**Increased Teacher Confidence**

The post-intervention teacher interviews revealed that the action research had a direct impact on the teachers’ pedagogy:

TZ: I taught my kids in rows for the first two terms, so having them in groups now, and I think I’ve got them in the right groups, I’ve changed them round a few times to get the right balance on each table. I think now we’re at a place (at the end of term!) that I’m more willing to try stuff with them definitely and they know the expectations and are getting used to the idea of doing it.
TY: If it was incorporated as part of a regular scheme of work then I can see my role would definitely change to more of like a group facilitator.

Furthermore, the engagement of the learners appears to have influenced teachers’ confidence in implementing group work as a result of the action research:

TZ: I think it’s probably helped with the engagement of some of the students definitely. I was doing it with the top set and they all like maths anyway but I think now that I’ve done it with them, who I know I can trust more than some of my other classes, I’ve got the confidence to do it with some of my weaker classes who I think would get more benefit from it.

The Importance of a Variety of Methods

This dissertation has predominantly focused on the active, participatory nature of learning, whether cooperative or collaborative. The participants started the action research cycle with a limited experience of group work and reservations to use it in mathematics lessons. As a result of the action research teachers have noticed an increased engagement and participation in mathematical discussions with they believe has supported learning. Sfard (1998) uses the terms *acquisition metaphor* and *participation metaphor* to differentiate between two types of learning. Although not entirely mutually exclusive, Sfard describes the participation metaphor as the act of community building and communicating, which is an aid to support the acquisition metaphor, that is, the development or construction of knowledge. However she claims that there is the danger that the participation metaphor is taken to mean that all learning should be cooperative learning and hence
many interpret all teacher instruction as negative. Sfard (1998) warns that “too great a devotion to one particular metaphor and rejection of all others can lead to theoretical distortions and to undesirable practical consequences” (p.5). According to Nune et al. (2009), further research is needed to find “the characteristics of mathematics teaching at higher secondary level which contribute both to successful conceptual learning and application of mathematics” (p.10).

This issue was raised with the participant teachers, where they felt that the cooperative structures and collaborative activities better supported the application of mathematics and problem solving as opposed to being a platform to learn new conceptual knowledge:

TZ: The activities we were doing were a lot reinforcing what they know and taking it to a problem solving level, looking at something and thinking how do I solve that? They’ve got the skills because I’ve already taught them it. Working out how to apply them was more what they were learning rather than learning a new specific maths skill.

This seems to support that teachers should not rely on one just one of the acquisition and participation metaphors; as cooperative and collaborative learning methods alone may not necessarily contribute to both conceptual learning and applying mathematics.
Limitations of the Research

The potential threats to the validity and reliability of results and the limitations of this research have been discussed throughout the dissertation, however the biggest flaw in the research design was the questionnaire as a valid research instrument. The questions were based on Van Wetering’s (2009) questionnaire to collect learner attitudes as they were simply phrased and straightforward to understand, however there was too much focus on enjoyment. Although enjoyment is important in increasing engagement and participation (Kagan 2003), enjoyment on its own does not necessarily imply learners are engaged, they may just enjoy the chance to chat with their peers. Furthermore even if enjoyment could be linked to engagement, it is not possible to know if learners can separate the cooperative structure from the mathematical content in evaluating that enjoyment. The impact of how each teacher explains a task is a further dimension to this limitation of using enjoyment as a measure.

Other issues with the questionnaires, included the reversed question, which did not make an explicit link between understanding and success in mathematics, the difference between the two is subjective. Furthermore the reversal of the question threw doubt on the validity of the questionnaire in the pilot study, that is, could the responses for other questions also be different if reversed? For these reasons the data collected from the learner questionnaires has limited use in providing evidence for this research. The most reliable use is in making comparisons across different groups (e.g. gender, class) in the questions relating to attitudes to group work. Less
confidence can be had in making generalisations across the school and in comparing learners' perceived impact of group work on their mathematical understanding.
Chapter 5

Conclusions

This dissertation set out to investigate the barriers teachers face in introducing group work into the mathematics classroom and whether a structured approach to group work could change teachers’ perceptions. The literature review found that a continuum from radical constructivism to situated cognition could describe the complexities of learning in groups, through social interaction and creating a problem-solving environment in the classroom. By comparing and contrasting both cooperative and collaborative group work techniques, a definition was formed describing how the cooperative behaviours of participation, teambuilding and sharing responsibility (Bruffee, 1995) for learning are a prerequisite for higher-level collaborative behaviours such as mutual engagement (Dillenbourg et al., 1996) and intrinsic motivation (von Glasersfeld, 1995). From these frameworks, a structured, phased approach to group work was developed and investigated empirically through an action research study.

The biggest barriers for teachers using group work in mathematics in the author’s school were found to be classroom management and practicalities; time management; assessment issues; and the impact of their prior experience and teacher knowledge. These concerns agree with previous research in this area (Panitz, 1997).
The structured approach supported teachers to overcome some of these issues, particularly in the first phase using the Quiz Quiz Trade, Collective Memory and Rally Robin structures which in the teachers’ opinions, increased participation and developed teambuilding skills. The Quiz Quiz Trade structure was also perceived to give some support to learners in developing their elaboration skills. Teachers found classroom management was not an issue at this stage due to the increased learner engagement and teachers found the structures were time-efficient.

In the second phase, the Jigsaw structure was found to be helpful for sharing responsibility of learning, however for one teacher, the learners had not developed sufficient elaboration skills to explain their understanding to one another. More research is needed therefore into providing more scaffolding for learners in their explanations during this phase.

Conceptual development was observed by the author during these phases, with evidence of learners acting as the more knowledgeable other to help their peers do what they could not do alone (Vygotsky, 1978). However teachers perceived both the first and second phases as opportunities for revision and applying their mathematics as opposed to constructing new knowledge. In the third stage, teachers reported that learners were displaying collaborative behaviours through intrinsic motivation of learners to solve problems in groups, suggesting that they are beginning to act as a community of learners (Lave, 2011).
Some of the issues with classroom and time management resurfaced after the first phase particularly in the third phase with the more collaborative tasks where one teacher found it difficult to keep learners focused on task. However overall, the structures for group work went some way in changing teachers’ perceptions of group work and increased their confidence in using both cooperative and collaborative techniques.
References


Appendix 1 – Kagan’s Cooperative Learning Structures

The following ten structures were shortlisted from an internet search of the terms Kagan and mathematics:

1. Quiz Quiz Trade
   Each member of the class is given a card containing a question and a worked solution to act as coaching notes. The class pair up and take turns to ask each other their question, supporting the other with the worked solution and hints as required. After they have both asked their questions, they then swap cards and find another learner to pair up with. It is hoped by this point the learners understand how to tackle their new question in order to offer support to their next pairing. This gives structure and support for learners to take responsibility in helping their peers to understand, with less reliance on the teacher. The coaching element is key here, however the quality of the coaching hints needs careful consideration to ensure that learners could offer each other effective support.

2. Collective Memory
   Groups of students have to recreate a poster on a particularly topic. In turns they come to the front and look at the poster for 15 seconds, they then return to their groups and must describe in two minutes what they saw while the rest of the group write or draw. Then the next student views the poster for 15 seconds and returns to the group etc. The fact that the person who sees the poster cannot write, forces learners to communicate with one another. While this structure can be used for revision of prior learning it could also be used to construct new knowledge by posing new problems within the poster or putting in errors for learners to identify.
3. **All Write Round Robin**

In silence students take turns to answer a problem in a grid in groups, while watching closely what their other group members are doing. Afterwards they discuss as a group whether they all agree. As it is a team effort, the group must concentrate on all answers given, again encouraging them to explain to each other if mistakes are made, allowing the more able in that topic to be the more knowledgeable other, if they have supported their peer to develop their mathematical understanding further. When the teacher takes feedback however the group should only get credit if any group member can explain any problem. The structure seems particularly suited to tasks which have common errors and misconceptions to promote more quality discussion, for example the order of mathematical operations.

4. **Rally Coach**

In pairs, one learner supports another to answer a first set of questions, then roles are reversed for the second set. The coaching element is key here, however this structure however assumes that one learner can support the other without intervention as it does not provide scaffolding to support the learners to support each other. If neither understands, teacher input will be a necessity to move learning forward.

5. **Rally Robin**

In groups of about four, learners are asked a question which has multiple answers, for example ‘the answer is 4, what is the question?’ Group members take it in turns to write a different answer on the group’s whiteboard with the aim of being the group with the most correct responses. Due to the speed and competitive element between groups, this could be seen more as a team building structure than a learning structure.
6. **Find someone who**…
   Learners have a list of problems and have to find a different person in the classroom who is able to solve each one. They then need to discuss with that learner how to tackle the problem, rather than just the answer. When learners return to their seats, the teacher can ask learners to nominate someone who can answer each question and explain themselves how they arrived at that solution. This structure to tackling problems encourages learners to go beyond their normal groupings to find enough learners to answer and explain. The way feedback is taken by the teacher is crucial though to ensure learners understand the mathematics.

7. **Mix n Match**
   Each learner is given a card and each card has a pair; either an equivalent form or one card has a problem and the other one has a possible solution. Learners mix around the room looking for the match to their card. This structure links to Nune et al.'s (2009) suggestion that learners need to understand relations in mathematics, here relationships in terms of equivalence can be discussed.

8. **Showdown**
   All members of the group write their answer to a given problem on their mini-whiteboard. When teacher calls out “Showdown”, the group reveal their answers. If all are correct they can be awarded maximum points, if not they must coach the incorrect responders to get some points once the incorrect responder can explain the correct answer. The better the more knowledgeable learners coach the others, the more likely they are to receive full marks for the next problem. The fact that those who understand must coach those who do not understand not just to know the answer but to be able to apply it to a similar problem could prevent the correct responders just telling the answer.
9. **Inside Outside Circle**

This structure has the same problems with coaching hints as Quiz Quiz Trade. The difference is half the class stand in the inner circle facing out and the other half stand in the outer circle facing in. The teacher says for example “move 3 places to the right” and learners then ask their questions to whoever ends up opposite. This has similar benefits to Quiz Quiz Trade, however learners do not decide who to pair up with, potentially enabling more diverse discourse.

10. **Numbered Heads Together**

Each learner in the group is allocated a number. A question is posed and the class must discuss the answer ensuring all in the group understand. The teacher then calls on a number to explain their answer to the rest of the class. Learners are perhaps more likely to share their ideas and ask their fellow group members for support as they do not know who will be called upon to explain their ideas.
Appendix 2 - Pre-Intervention Teacher Semi-Structured Interview Schedule

“Thank you for agreeing to work on the development of group work with your class. Your comments are confidential, so you will not be identified in the dissertation even if your comments are used in the write up. You have the right to withdraw at any time.

Section 1 – Current approach to group work

Prompts

How often do you have learners working in pairs?
How often do you have learners working in small groups?
What do you think are the benefits to group work?
Do you use any particular activities which are specifically for pairs or groups?
Do you prepare pupils for working in groups? If so, how?
How do you set out your tables? What is your reasoning behind this?
Do you notice any change in pupil behaviour when working in groups?

Section 2 – Cooperative Learning Structures

Prompts: Can you name any Cooperative Learning Structures? (e.g. Kagan Structures or similar)

Which of these have you used in your mathematics teaching?
In your opinion, what are the benefits of this technique?
Are there any drawbacks to this technique?

Which (if any) of the following structures do you know? Which have you used?

- Quiz Quiz Trade
- Collective Memory
- All Write Round Robin
- RallyCoach
- RallyRobin
- Find someone who...
- Think Pair Share
- Find my rule
- Mix n Match
- Showdown
- Inside Outside Circle
- Numbered Heads Together

Section 3 – Identification of Topics

Prompts: Is there a particular topic you would like to explore through group work?

What topics are coming up in April, May and June for the class?
Appendix 3 – Final Learner Questionnaire

The purpose of this questionnaire is to find out about your experiences and opinions of the small-group activities used in your mathematics lessons. It is anonymous, so please do not write your name on it. The findings will be used to support a study on the use of group work in mathematics.

Completing the questionnaire is voluntary and the information you are asked to give does not identify you or your teacher. If you have any questions please send me an email (jdenton@******) or find me in person in WU06 in the **** building.

1. What is your gender? (Please tick)
   - Male ☐
   - Female ☐

2. Which year group are you in? (Please tick)
   - Year 7 ☐
   - Year 8 ☐
   - Year 9 ☐
   - Year 10 ☐
   - Year 11 ☐

For questions 3-15, please tick the box to show whether you strongly disagree, disagree, agree or strongly agree with each statement (some questions have a ‘neither agree nor disagree’ option):

3. I enjoy working in a group.
   - Strongly Disagree ☐
   - Disagree ☐
   - Agree ☐
   - Strongly Agree ☐

4. I feel comfortable working in a group
   - Strongly Disagree ☐
   - Disagree ☐
   - Agree ☐
   - Strongly Agree ☐

5. Being in a group has helped me become more successful in mathematics
   - Strongly Disagree ☐
   - Disagree ☐
   - Neither Agree nor Disagree ☐
   - Agree ☐
   - Strongly Agree ☐

6. I feel comfortable asking my fellow group members questions
   - Strongly Disagree ☐
   - Disagree ☐
   - Agree ☐
   - Strongly Agree ☐

7. I am more likely to ask my group members questions before asking the teacher
   - Strongly Disagree ☐
   - Disagree ☐
   - Agree ☐
   - Strongly Agree ☐

8. I find my group members to be helpful
   - Strongly Disagree ☐
   - Disagree ☐
   - Agree ☐
   - Strongly Agree ☐

9. I feel I have a better understanding of mathematics when I work on my own
   - Strongly Disagree ☐
   - Disagree ☐
   - Neither Agree nor Disagree ☐
   - Agree ☐
   - Strongly Agree ☐
10. I have enjoyed Quiz Quiz Trade

Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

11. I have enjoyed Collective Memory

Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

12. I have enjoyed All Write Round Robin

Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

13. I have enjoyed Rally Robin

Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

14. I have enjoyed Think Pair Share

Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

15. I have enjoyed Jigsaw

Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

16. Please use this space to add anything which you would like to say about the group work in mathematics you have experienced this term:

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

Thank you for taking the time to fill out this questionnaire. Please return this form to either your form tutor, the admin office or directly to me in the envelope provided by 30 June 2014.
Appendix 4 - Post-Intervention Teacher Semi-Structured Interview Schedule

Section 1 – Developing from Cooperative to Collaborative

- Describe your understanding of what constitutes a cooperative or collaborative approach?

- Did you find the structures effective in implementing group work?
  Prompts: 
  - In what way?
  - What types of group work did the different tasks produce?

- In your opinion what were the strengths and barriers of the first phase (Collective memory, Rally Coach and Quiz Quiz Trade)?
  Prompts:
  - Did the simple structures in the first phase to increase participation (e.g. involvement of all pupils in doing mathematics and discussing mathematical concepts)?
  - Do you think this was as a result of the group structures or just that it was a new way of working?
  - What learning do you think took place?

- In your opinion what were the strengths and barriers of the second phase (All Write Round Robin, Think Pair Share and Jigsaw)
  Prompts:
  - What learning do you think took place?
  - What do you think was different compared to phase 1?
  - During small group discussion, how can you be sure that all group members understand?
  - Do you feel that all group members were listened to by their peers

- Do you feel the first two phases have made you and your class more prepared for more open and rich tasks?
  Prompts:
  - In what way?
  - Has the relationship between you and the class changed in any way?

Section 2 – Impact of Intervention

- Have your opinions on using group work changed since the start of the summer term?
  Prompts:
  - If so, how is this reflected in your practice?
  - Describe any impact beyond the participant class?
Appendix 5 – Original Pilot Learner Questionnaire

The purpose of this questionnaire is to find out about your experiences and opinions of the small-group activities used in your mathematics lessons. It is anonymous, so please do not write your name on it. The findings will be used to support a study on the use of group work in mathematics.

Completing the questionnaire is voluntary and the information you are asked to give does not identify you or your teacher. If you have any questions please send me an email (identon@*******) or find me in person in WU06 in the **** building.

1. What is your gender? *(Please tick)*
   - Male □  Female □

2. Which year group are you in? *(Please tick)*
   - Year 7 □  Year 8 □  Year 9 □  Year 10 □  Year 11 □

For questions 3-21, please tick the box to show whether you strongly disagree, disagree, agree or strongly agree with each statement:

3. I enjoy working in groups.
   - Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

4. I feel comfortable working in groups
   - Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

5. I feel comfortable asking my group members questions
   - Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

6. I am more likely to ask my group members questions before asking the teacher
   - Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

7. I find my group members to be helpful
   - Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

8. I feel I have a better understanding of mathematics when I work in a group
   - Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

9. Being in a group has helped me become more successful in mathematics
   - Strongly Disagree □  Disagree □  Agree □  Strongly Agree □
10. I have enjoyed Quiz Quiz Trade
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

11. I have enjoyed Collective Memory
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

12. I have enjoyed All Write Round Robin
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

13. I have enjoyed RallyCoach
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

14. I have enjoyed RallyRobin
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

15. I have enjoyed Find Someone Who
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

16. I have enjoyed Think Pair Share
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

17. I have enjoyed Find the Rule
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

18. I have enjoyed Mix n Match
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

19. I have enjoyed Showdown
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

20. I have enjoyed Inside Outside Circle
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

21. I have enjoyed Numbered Heads Together
   Strongly Disagree □ Disagree □ Agree □ Strongly Agree □

Thank you for taking the time to fill out this questionnaire. Please return this form to either your form tutor, the admin office or directly to me in the envelope provided by 30 June 2014.
Appendix 6 – Revised Pilot Learner Questionnaire

The purpose of this questionnaire is to find out about your experiences and opinions of the small-group activities used in your mathematics lessons. It is anonymous, so please do not write your name on it. The findings will be used to support a study on the use of group work in mathematics.

Completing the questionnaire is voluntary and the information you are asked to give does not identify you or your teacher. If you have any questions please send me an email (jdenton@*******) or find me in person in WU06 in the **** building.

1. What is your gender? (Please tick)
   Male ☐ Female ☐

2. Which year group are you in? (Please tick)
   Year 7 ☐ Year 8 ☐ Year 9 ☐ Year 10 ☐ Year 11 ☐

For questions 3-21, please tick the box to show whether you strongly disagree, disagree, agree or strongly agree with each statement:

3. I enjoy working in a group.
   Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree ☐

4. I feel I have a better understanding of mathematics when I work on my own
   Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree ☐

5. I feel comfortable working in a group
   Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree ☐

6. I feel comfortable asking my fellow group members questions
   Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree ☐

7. I am more likely to ask my group members questions before asking the teacher
   Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree ☐

8. I find my group members to be helpful
   Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree ☐

9. Being in a group has helped me become more successful in mathematics
   Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree ☐
10. I have enjoyed Quiz Quiz Trade
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

11. I have enjoyed Collective Memory
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

12. I have enjoyed All Write Round Robin
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

13. I have enjoyed RallyCoach
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

14. I have enjoyed RallyRobin
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

15. I have enjoyed Find Someone Who
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

16. I have enjoyed Think Pair Share
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

17. I have enjoyed Find the Rule
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

18. I have enjoyed Mix n Match
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

19. I have enjoyed Showdown
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

20. I have enjoyed Inside Outside Circle
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

21. I have enjoyed Numbered Heads Together
   Strongly Disagree □  Disagree □  Agree □  Strongly Agree □

Thank you for taking the time to fill out this questionnaire. Please return this form to either your form tutor, the admin office or directly to me in the envelope provided by 30 June 2014.
Appendix 7 - APPLICATION FOR ETHICAL APPROVAL

Name of student: Joanne Denton

Course: MSc Mathematics Education

Dissertation/Project title: Making Small Groups Work: Overcoming Barriers to Collaborative Learning in the Mathematics Classroom

Supervisor: Andrea Pitt

Participants: (if children, specify age range) AND ATTACH A COPY OF YOUR CRB CLEARANCE

Four mathematics teachers and 4 classes from Years 7 to 10 (Aged 11-15)
- Four mathematics teachers from The Federation of Glenmoor School and Winton Arts and Media College to be pre-interviewed (semi-structured) and then joint plan of upcoming lessons using structured group activities.
- Approximately 120 students from Years 7 to 10 (aged 11-15) will be in the observed lessons working on the group tasks. All participating students to complete a questionnaire, but they will be given the opportunity to choose for it not to be included in the dissertation analysis.

Consent - will prior informed consent be obtained?
From participants? YES
From others? YES

Explain how this will be obtained. If prior informed consent is not to be obtained, give reason:
- Consent will be obtained from the Executive Principal to conduct the study and give consent for the students to be observed and given questionnaires in loco-parentis.
- Teachers selected will be explained of the purpose of the study and how observational data and information given by them in semi-structured interviews will be used. They will be assured of the voluntary nature and confidentiality of participation.
- Prior consent of students will not be obtained for lessons as they are not being filmed or identified in any way, although I will verbally explain to each class the purpose of my observations. Information at the top of the student questionnaires will explain the purpose of the study and how information collected will be confidentially used. There will be a statement informing that the return of the questionnaire is voluntary so students can simply choose not to hand it in. The questionnaire will be conducted in class so that I can be assured that the students understand this information.

Will participants be explicitly informed of the student’s status? YES
**Confidentiality**

Will confidentiality be assured? YES

How will confidentiality be ensured?

Teachers will be referred to as Teacher X etc. in the write up. Students will be referred to as Student A etc. from any observations recorded. No space for names will be given on the questionnaire sheet to students. Questionnaires will be collected in anonymously in a large envelope.

**Protection of participants**

How is the safety and well being of participants to be ensured?

- Participant teachers will be assured that any observations are to capture the conversations between students and not to judge or grade their teaching.

Is information gathered from participants of a sensitive or personal nature? NO

If yes, describe the procedure for

a) ensuring confidentiality

n/a

b) protecting participants from embarrassment or stress

n/a

**Observational research**

If observational research is to be carried out without prior consent of participants, please specify

a) situations to be observed

- Lesson observations will be with prior consent of teachers but only notification of students.
- Student-student and student-teacher dialogue will be scribed.

b) how will privacy and cultural and religious values of participants be taken into account?

- No names or identifiable features given in the write up.

Signed (Student): J L Denton Date: 17/03/2014

Signed (Supervisor): A M Pitt Date: 18/3/14

Action: Once both you and your supervisor have signed this form take it to your course administrator. If there are any queries, these will be logged and the form sent back to you for amendment and resubmission. Otherwise the form will be signed by your course leader and you will be able to collect a signed copy from your course administrator. The signed copy should be included as an appendix into your assignment/thesis.
COURSE LEADER TO COMPLETE

☐ Approved

☐ Approved with modification or conditions — see below

☐ Action deferred. Please supply additional information or clarification — see below

Course Leader Name: Andrea Pitt

Signed: A M Pitt Date: 18/3/14