CO-OPERATIVE LEARNING AND GENDER IN MATHEMATICS EDUCATION

A case study in a Malawian secondary school

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ABSTRACT

Gender differences in mathematics education have persisted in many countries despite the substantial research undertaken to understand the contributing factors and the many intervention efforts adopted to address the issue. Recent gender reformists have drawn attention to mathematical instruction as a strategy for improving girls' learning of mathematics. In this regard co-operative learning has been consistently recommended as a strategy that has the potential to address gender equity in the mathematics classroom. While most studies have shown that co-operative learning strategies have positive effects on students' learning of mathematics, it has also been shown that such benefits are attained when certain conditions are in place. However, the conditions under which co-operative learning can be most beneficial for all students have not yet been clearly established. Further, little is known about the feasibility of implementing a co-operative learning approach in developing countries since the bulk of research in this field has been conducted in "developed" countries.

The present study was designed to investigate the above issues in a Malawian secondary school context. It was exploratory and focused on (i) the feasibility of implementing a co-operative learning approach for mathematics teaching in Malawian secondary schools, and (ii) the likely benefits of co-operative learning for students, especially girls. Data were collected in three phases. The data in phase one were collected through a questionnaire sent to 15 mathematics teachers in Zomba urban secondary schools. Phase two comprised a teacher development workshop. Main data were collected in phase three extended over a period of three months. During this period, one female mathematics teacher and 120 Form 3 (year eleven) students she was teaching in a co-educational secondary school in Zomba Urban– Malawi were investigated. The study was qualitative involving interviews and classroom observations of the students and the teacher. Data consisted of field notes, transcripts of tape recorded interviews with the students and teacher, recorded informal conversations with the students and teacher, students' written journals and questionnaire responses of students.

The results from classroom observations revealed that all students preferred co-operative learning over the traditional question/answer teaching approach because of the learning benefits it offered them. A major finding was that peer interaction significantly contributed to the students' learning of mathematics. The peer interaction during co-operative learning activities stimulated elaboration, an awareness of knowledge gaps and inconsistent reasoning. The girls gained confidence, actively participated in discussion, showed an understanding of concepts and reported that they found mathematics less difficult as a result of their involvement in the co-operative learning approach. The findings also suggest that the question/answer approach might have contributed to the students' negative attitude towards mathematics.

The present study also highlights some of the issues that need to be carefully considered if co-operative learning were to be implemented on a larger scale and longer term in Malawi. Preliminary results gathered through the questionnaire and the teacher development workshop revealed that even though the teachers viewed co-operative learning to be beneficial for the students' learning of mathematics (especially for girls), it was not a major part of their current instructional practice. They mostly taught mathematics using an expository teaching approach, their use of co-operative learning being limited to revising and practicing mathematics.

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Bless the Lord all my soul and all that is within me bless His Holy name
Psalm 103:1

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Chapter One

Introduction and Background

1.0 Introduction

Over the past thirty years, gender inequities in mathematics education have generated a lot of interest and concern amongst educators and researchers in many parts of the world. This concern has led to extensive research on the issue, the production of several international journal special issues devoted to gender and mathematics (e.g. Mathematics Education Research Journal Volume 9, Number 3, 1997, Special Issue: Gender and Learning Settings), special conferences on the topic such as the one sponsored by the International Commission on Mathematical Instruction held in Sweden in 1993, and the publication of books of collected papers on the topic such as those edited by Burton (1990) and by Rogers & Kaiser (1995).

These research efforts and publications have seen a shift of focus from the documentation of sex differences in mathematics achievement and participation, to providing likely explanations for the differences observed, and identifying the effectiveness of various intervention strategies. However, despite these efforts, the problem of gender differences in mathematics still exists in much the same form that it did in the 1970's (Fennema, 1996). This has led many education researchers to realise that the issue of gender and mathematics is very complex and that there is a need for a broader research approach (Fennema, 1996; Solar, 1995; Boaler, 2000). Recent gender reformists, especially those influenced by feminists' notion that boys and girls have different ways of knowing, have drawn attention to mathematical instruction as a strategy for addressing gender imbalance in mathematics (Becker, 1995; Rogers, 1995; Solar, 1995). This study is part of this search and considers co-operative learning as an approach that might improve the mathematics learning of girls in Malawi.

Although co-operative learning has been extensively researched, relatively few studies have isolated gender as a factor for investigation. Much of the literature on co-operative learning has focused on the academic, attitudinal, and social-interactive effects of co-operative learning (see Davidson, 1990; Springer, Stanne & Donovan, 1999). Further, most of the studies have been conducted in the developed countries, and largely at elementary level. The few studies that have isolated gender as a factor affecting achievement in co-operative learning have only done so as part of broader studies, and usually as an after thought (e.g. Busato, Ten Dam, Van Den Eeden & Terwel, 1995). Thus, the possible gender-specific processes and interactions within co-operative learning groups with a focus on gender have seldom been investigated, certainly not in Malawi. Consequently, this study sought to explore in detail the experiences of three Form 3 classes, comprising 48 girls and 102 boys, during co-operative learning mathematics lessons in one secondary school in Malawi.

The remainder of the chapter outlines:

1.1 Background to Malawi.

1.2 Government's efforts to address gender imbalance in education

1.3 Status of girls' education in Mathematics in Malawi

1.4 Aim of the study and the research question

1.5 Overview of the thesis

1.1 Background to Malawi

Demographic information

Malawi, formerly called Nyasaland, is a land-locked developing country situated in Southern Africa. It borders Tanzania, Mozambique and Zambia, and has a land area of 118,484 km^2. It has a population of about 9.8 million people of which 51% are female, 46% are aged under 15 years, and 89% live in the rural areas where the prevalent occupation is subsistence farming. Malawi has a literacy rate of about 39%, which is lower than the average of 47% for countries in Sub-Saharan Africa (Malawi Government & United Nations, 1993). Illiteracy among women is about 75%.

Politically, Malawi gained independence from Britain in 1964. For 30 years, Malawi was ruled by Dr Hastings Kamuzu Banda under a one-party government. In 1994, following national and international pressures for political reform, a multiparty government was elected.

By economic and social standards, Malawi is a poor country, its gross national product per capita income being $116 per year (as measured by UNICEF standards in 1988). Its economy is based on agriculture, the main export crops being tobacco and tea. Malawi's social and economic development plans are supported mainly through donor aid, notably from the International Monetary Fund and the World Bank.

In Malawi, as in other developing countries, education has long been recognised as the catalyst that assists economic development through its provision of the manpower requirements of the economy (Ministry of Education and Culture, 1985). Since the greatest shortages in manpower are in agriculture and industry, there is an emphasis on Mathematics and Science which together with English and Chichewa (vernacular language) form the four compulsory subjects in Malawian schools. The official language is English and it is used as a medium of instruction in the schooling system from year three.

Historical background of formal education in Malawi:

Western education was introduced in Malawi in the late 19th century by the Christian missions. These missions included: the Universities Mission to Central Africa (1862; 1885), The Livingstonia Mission of the Free Church of Scotland (1875), The Blantyre Mission of the Established Church of Scotland (1876), the Zambezi Industrial Mission (1892), and the Roman Catholic Mission from 1902 (Hauya, 1993). Although each mission had its own curriculum depending on the philosophy of the mission, the common thrust of the curriculum was reading, writing and rudimentary arithmetic. As education development was by mission, all related aspects of control such as teacher training, school inspection and supervision/administration were also unique to each mission. Government's efforts to control education started in 1924 when the Phelps-Stokes Commission was appointed by the government to study the education system in Malawi and draft recommendations for the future. Based on the recommendations of the Commission a Department of Education was formed in April, 1926, and in 1927, the missions adopted new rules that from then on would regulate education. Thus, the period 1926–1927 marked the transition from missionary controlled education to state regulated education in Malawi. A Ministry of Education was formed about thirty years later in September, 1961.

1940 saw the opening of the first secondary school. The curriculum for the school was modelled at the academic-elitist tradition of the English Grammar School. The opening of the secondary school led to the introduction of a public examination at

Standard 6 for purposes of selection to secondary school. From the start, the goal of secondary school education has been to prepare adequate manpower for the civil service and the growing economy. The same rationale saw the University of Malawi established in 1965. A second university, Mzuzu University, opened in April, 1999 and comprised a faculty of education, focused on training secondary school teachers.

The effects of these developments on the education of boys and girls were many, but two are immediately important for the present study. First, with the introduction of a public examination, teaching and learning became theoretical and dictated by examination requirements. Thus, the emphasis on a relevant curriculum for community development which had characterised mission education since 1925 shifted to an alien, British-based content. The irrelevance of the curriculum was reinforced by the majority of the teachers who were Europeans; they were inclined to imitate the school traditions of the British system. The resultant pyramidal structure, in which access to the education system was limited to the minority of the population who survived the selection process, may have negatively affected the morale of many students, especially girls. Another related development concerning access was the government's introduction in the early 1960's of the *Rules of Age Limits* to regulate the school age range between *entry* and *exit* which led to the dismissal of many older pupils (Hauya, 1993). This undermined the developing positive attitude to education of parents and students at a time when many communities were just coming to terms with formal learning. Particularly destructive was the strict enforcement of the rules.

1.2 Government's efforts to address gender imbalance in education

Access, quality and equity for women and men are central to the more recent educational policies that have been pursued by the Malawi Government, as outlined in the *Second Education Development Plan* that spanned the years 1985–1995 (Ministry of Education and Culture, 1985), and in the Policy and Investment Framework for Education for the period 1995-2005 (Malawi Government, 1995). However, Malawi is one country in which gender inequalities in achievement in favour of males still exist at all levels of education from primary to tertiary, and in all subjects including mathematics and languages (the latter being a subject in which international evidence has shown no or little gender differences). In order to alleviate this inequality, the government of Malawi has implemented a number of strategies including:

1. revision of the primary school and teacher training curriculum (1987–1992) to make them more gender appropriate;

2. removal of restrictions with respect to subject combinations that barred some girls from science and technical subjects;

3. implementation of a scholarship programme between 1987 and 1994 by the University of Malawi (with funding from USAID) for female students who opted to study subjects such as Engineering, Mathematics, Physics, Chemistry and Law, subjects not traditionally studied by females in Malawi; and

4. recent upward revision of the quota policy for selection of girls into secondary school from 33% to 50%. (Efforts are still underway to realise this).

In addition, the government is currently implementing a Girls' Attainment in Basic Literacy and Education programme (again with funding from USAID). Under the programme,

(i) the Girls' Attainment in Basic Literacy and Education programme is paying school fees for all girls attending public secondary schools;
(ii) a Social Mobilisation Campaign targeting families and community leaders such as chiefs and religious leaders is being implemented to try to change their attitudes about females in society; and
(iii) the Girls' Attainment in Basic Literacy and Education programme is publishing short biographies of Malawian women in important positions and occupations, especially in the non-traditional fields, in order to provide role models to girls.

The success of the above strategies is reflected to some extent in the increased proportion of girls entering secondary school and university. For instance, female enrolments in the University of Malawi rose from 19% in 1981/82 academic year to 26% in 1994/95. This has been possible by relaxing entry requirements for females, increasing the female student intake and lowering the male student intake. The proportion of girls completing primary has also increased from 27% in 1984 to about 40% in 1994 (Khembo, 1995).

Despite this improvement in the transition rate for females from one level of education to another, the next section (section 1.3) indicates that the available data consistently showed gender inequity in mathematics achievement. Little change in success rates has been achieved through the measures mentioned above, possibly because they were merely aimed at increasing numbers of females without addressing the causes of poor performance or poor persistence. Implicit in these strategies was the argument of fairness— that women constituted 50% of the population of Malawi and must therefore have 50% representation in all subjects at all levels of education. As important as many of these strategies may have been, arguments that focused on fairness alone lose force when females admitted to school were unable to persevere in unfriendly or even hostile pedagogical and classroom environments. The current equity strategies needed to be supported by efforts to provide girls with the necessary learning experiences/activities that would boost their morale, increase their interest and help them to develop better attitudes toward mathematics.

This will require teaching methods which allow active student participation in the learning process. Co-operative learning, the focus of this thesis, is one such method. It constitutes an endeavour to address the equity issue from a pedagogical perspective. Links between these strategies and aspects of feminism are discussed in chapter two.

The government of Malawi is about to review its secondary school curriculum and it is hoped that the results from this study may assist curriculum planners concerning gender issues.

1.3 Status of girls' education in Mathematics in Malawi

The current status of girls' education in Mathematics in Malawi can be summarised as follows:

At primary level, the number of girls and boys enrolling in Year 1 is about equal. However, large enrolment differences are observed from Years 4 to 8 which indicate high drop-out rates for girls. For example, of all pupils who completed primary education in 1996 only 37% of them were girls (Chimwenje, D., 1998). At primary school leaving examinations, boys do better than girls in all subjects with the gender gap being the widest in Arithmetic and in the General Paper (Geography, History and Civics) and narrowest in the languages (Hiddleston, 1990; Khembo, 1991). This is unusual because, internationally, researchers have found that girls usually excel in Arithmetic at primary level.

At secondary school level, the trend for boys' superiority in achievement observed at primary continues, as shown in Tables 1.1 and 1.2 below:

Table 1.1: Percentage Pass rate in Junior Certificate Examination (JCE) by subject and gender for years 1992–1996

Year/ subject		1992	1993	1994	1995	1996	Mean (F-M)
English	M	96.7	95.5	97.5	96.5	97.1	
	F	90.3	87.5	93.1	90.3	92.2	
	F-M	-3.4	-8.0	-4.4	-6.2	-4.9	-5.4
Maths	M	90.4	98.7	87.3	95.1	89.1	
	F	67.7	94.9	65.7	84.5	70.8	
	F-M	-22.7	-3.8	-21.6	-10.6	-18.3	-15.6
History	M	91.2	93.2	90.8	93.6	94.2	
	F	72.2	76.2	76.4	80.8	79.2	
	F-M	-19.0	-17.0	-14.4	-12.8	-15.0	-15.6
Geography	M	93.0	91.8	98.3	92.9	89.3	
	F	73.5	77.4	92.3	80.4	69.8	
	F-M	-19.5	-14.4	-6.0	-12.5	-19.5	-14.4
Biology	M	91.6	91.3	90.0	94.9	94.5	
	F	68.9	72.5	70.4	85.8	77.6	
	F-M	-22.7	-18.5	-19.6	-5.1	-16.9	-16.6
Chichewa	M	97.8	96.2	95.8	93.9	94.3	
	F	95.3	94.7	91.9	90.5	93.2	
	F-M	-2.5	-1.5	-3.9	-3.4	-1.1	-2.5

Adapted from Chimwenje, C (1998)

Table 1.2: Percentage of students obtaining Distinctions and Credits in MSCE examinations in Mathematics for the years 1994 – 1996

Year	Sex	% Grades (1-2) (Distinction)	% Grades (3-6) (Credit)
1994	M:	7.60	32.17
	F:	0.01	12.97
	F-M:	-7.59	-19.20
1995	M:	9.72	29.90
	F:	1.84	13.86
	F-M:	-7.88	-16.04
1996	M:	8.67	19.48
	F:	3.56	15.73
	F-M:	-5.11	-3.75

Adapted from Chimwenje, C. (1998)

Table 1.1 shows that boys achieve better than girls in all subjects. Like primary school, the situation is worse in Mathematics, Biology and some Art subjects. The gender gap is still narrowest in the languages (Chichewa and English). For example, in 1992, the gap in percentage pass rate between boys and girls in Mathematics was about 28 points. It is, however, difficult to speculate from table 1.1 as to whether the trend in the gender gap in Mathematics is getting smaller over time since there is no consistent pattern along the years. For example, in 1993, the gap narrowed to about 4% and then the gap widened again to about 22% the following year.

Table 2.1 shows that there is a gender gap in terms of the proportion of students obtaining top grades—distinctions (grades 1–2) and credits (grades 3–4) in Mathematics. For example, in 1994, 7.6% of the boys obtained distinction grades in Mathematics compared to only 0.01% of the girls. The same pattern continued through 1995 and 1996. This contrasts with the achievement of girls in mathematics in a number of other countries. For example, in New Zealand, the proportion of girls obtaining top grades (1–3) in Mathematics is much higher than that of the boys (Harker, 2000); while in the United Kingdom, girls now attain the same proportion of grades A–C as boys although gender differences still exist amongst students obtaining A grades (Boaler, 1998). Given these comparisons, it seemed important to investigate whether co-operative learning might improve the learning of girls in Mathematics in Malawi, thus helping to redress inequity in mathematics achievement via a pedagogical strategy.

The choice of co-operative learning pedagogy was influenced by some recent research findings (Adedayo, 1999; Rogers, 1995; Wood & Sellers, 1997) which suggested that co-operative learning had considerable potential for promoting a learner-friendly classroom climate and enhancing achievement (discussed in chapter 3).

1.4 Aim of the study and the research questions

This study aimed to investigate the gender related effects of co-operative learning among Form 3 students studying mathematics in a Malawian secondary school. The main research question was very open, indicating the exploratory nature of this study. It was: "What are the effects of co-operative learning on boys and girls in secondary school mathematics?" It also aimed to investigate the following questions:

1. What is the teaching approach commonly used for mathematics teaching in secondary schools in Malawi?

2. What are the students' mathematical experiences in such a teaching approach?

3. What are the teachers' views about and current use of cooperative learning?

4. How did the selected teacher implement cooperative learning approach?

5. What effects did the use of cooperative learning have on the boys' and girls' learning of secondary school mathematics?

It was expected that data from the study would provide some information about (i) the feasibility of implementing a cooperative learning approach for mathematics teaching in Malawian secondary schools, (ii) the likely benefits of cooperative learning, and (iii) the conditions under which cooperative learning could be most beneficial for all students in a Malawian secondary school context. Such information could be of value to government policy makers, curriculum planners, teachers, and educators.

1.5 Overview of thesis

The thesis is structured into eleven chapters. After this introductory chapter, the theoretical framework and assumptions that inform the study are described and discussed in the next chapter. Chapters 3 and 4 critically review the literature on gender and mathematics, and co-operative learning respectively, while chapters 5 and 8 outline the research design and description of the research setting respectively. In chapters 6, 7, 9 and 10, results and data analyses are reported—chapter 6 reports on the questionnaire findings of secondary school teachers' beliefs about co-operative learning, while the teachers' experiences during the teacher development workshop are reported in chapter 7. The findings from the classroom observations are reported as two individual case studies, each one focusing on one teaching approach used by the teacher. Finally, conclusions, recommendations, limitations and implications for future research are given in chapter 11.

Chapter two

Theoretical framework

2.0 Introduction

The research into co-operative learning reported in this thesis is theoretically based on social constructivism and feminism. This chapter outlines the meaning given to, and the rationale for, the 'theoretical framework' as used in this thesis. It includes a discussion on how the researcher's background, beliefs and assumptions, and prior knowledge influenced the choice of theory. The chapter concludes with a discussion on the ideas of social constructivism and feminism and their relationship with the present research.

2.1 Theoretical framework

Understanding amongst researchers as to what constitutes a theoretical framework varies (Bogdan & Biklen, 1992; Zevenbergen & Begg, 1998). In this study, the term "theoretical framework" is used in the most general sense to refer to the beliefs and assumptions held by the researcher. This definition encompasses the three types of frameworks—theoretical, practical and conceptual—that often appear in the literature (Zevenbergen & Begg, 1998). Like many other postmodern feminists (Jones, 1992), I consider that exposing my own assumptions and biases that shape my world view is important if my work is to be accessible to and contestable by a wide range of people. I also subscribe to the view that making one's theoretical framework explicit is not only good practice for feminist research but for any research because it provides structure and coherence to the research project. When a researcher is aware of her/his theoretical base, the collection and analysis of data is consciously guided by such theory (Bogdan & Biklen, 1992; Zevenbergen & Begg, 1998). Furthermore, this study is conducted from a constructivist stance which claims that what is known cannot be separated from the knower. Thus, making the researcher's theoretical framework explicit allows for the content of the thesis to be understood in the context of the perspectives and assumptions by which it was shaped. This increases the validity of the research.

2.2 The Researcher's Background

Consistent with the constructivist view that what is known cannot be separated from the knower, this section aims at making the researcher's background explicit. Since graduating from the University of Malawi in 1988, I have worked as a pre-service teacher educator of secondary school mathematics teachers. Consequently, I have always been keen to find effective teaching strategies that can be used by secondary school mathematics teachers. While writing my master's thesis on gender and mathematics (Chamdimba, 1994), I was overwhelmed with the evidence on the striking differences between the achievements and participation rates of boys and girls in mathematics. Since then, 'gender and mathematics' has become a major area of concern to me and I have presented papers on this subject at various conferences. I concluded in my masters thesis that the teaching method commonly used in Malawi secondary schools probably disadvantaged girls in that it encouraged girls to seek less of the teachers' time than boys, and might implicitly promote boys' dominance over the limited resources in mathematics. Thus the desire to explore the experiences of girls and boys in a co-operative learning environment builds on my masters thesis. Such an approach is an alternative to traditional methods of teaching, and may help overcome the problems associated with such methods.

2.3 Researcher's beliefs and assumptions

I began this study with a belief that any strategy that is aimed at improving the education of girls in mathematics must be based on an understanding of how girls and boys learn mathematics. Social constructivism and feminist theory seemed to offer a theoretical base on which I could fit my perceptions of how boys and girls learn mathematics, so these ideas were used as the guiding theoretical framework for the present study. The design of the study was also influenced by insights gained from extensive reading of the literature on gender and cooperative learning (chapters three and four respectively).

2.4 Constructivism

Constructivism is a philosophical perspective on knowledge and learning. Its ideas can be traced back to the 5th century BC. Several scholars (Jaworski, 1994; Nola, 1997; Salomon, 1997; von Glasersfeld, 1991b) have argued that the current conception of constructivism has been strongly influenced by Piaget's theory of cognitive development.

It is widely recognised that different forms of constructivism exist (Dengate & Lerman, 1995; Nola, 1997; Phillips, 1995). Geelan (1997), for instance, identified six forms of constructivism, namely (i) personal constructivism, (ii) radical constructivism, (iii) social constructivism, (iv) social constructionism, (v) critical constructivism and (vi) contextual constructivism, while at the same time acknowledged that this did not exhaust the possibilities of the field and that different authors may call a particular form by different names. The various forms of constructivism could be viewed as spreading on a continuum between 'those that emphasise on individual cognition' on one end, and 'those that emphasise on social processes' on the other end (Geelan, 1997; Phillips, 1995). However, all variants share the belief that knowledge is actively constructed by the individual learner, rather than conveyed to the learner from an external source. Smith (1997: 106), for instance, noted that in its most popular form, constructivism may be viewed as

> "a commitment to the idea that we construct our knowledge. This means that knowledge is not and cannot be placed inside our heads; rather, we make our own knowledge by selectively using our experiences to create mental structures that form the basis for our knowledge."

That constructivism has been interpreted in many ways is consistent with the constructivist perspective itself; it is to be expected that individuals will construct their own particular meanings for it (Jaworski, 1994; Salomon, 1997). The discussion in this chapter will focus on radical and social constructivism as these are more related to the present study.

Radical constructivism

Radical constructivism was proposed as an alternative to the long-dominant epistemological theory of objectivism. Consequently, radical constructivism is the particular form that gained considerable popularity, especially in the 1980's because it has the appeal of rejecting the behaviourist view of learning (Ernest, 1994). Ernest von Glasersfeld is recognised as the primary exponent of radical constructivism. The definition of radical constructivism proposed by von Glasersfeld (1990: 22–23) asserts two principles, as follows:

1. Knowledge is not passively received either through the senses or by way of communication. Knowledge is actively built up by the cognizing subjects.

2. (a) The function of cognition is adaptive, in the biological sense of the term, tending towards fit or viability;

   (b) Cognition serves the subject's organisation of the experiential world, not the discovery of an ontological reality.

It has been argued that the notion that knowledge is the result of a learner's activity rather than of the passive reception of information has its origins in the thinking of Socrates and Plato (Nola, 1997; von Glasersfeld, 1991a). Nola (1997), in trying to illustrate Socrate's constructivist view of knowledge and learning, provided a description of the dialogue Socrates had with a slave boy who patently did not know the answer to the geometrical question 'What is the length of the side of a square double the area of a given square the side of which is 2 metres long' and who then came to know what the correct answer was. When the boy thought that the answer was 4 m, Socrates asked the boy to work out the area of two squares whose sides were 2m and 4m long instead of telling him that the answer was wrong. Part of the dialogue included:

> "You see Meno that I am not teaching him anything, only asking."

> " Now notice what, starting from the state of perplexity, he will discover by seeking the truth in company with me, though I simply ask him questions without teaching him. Be ready to catch me if I give him any instruction or explanation instead of simply interrogating him on his own opinions."

Nola argued that in being opposed to didactic teaching and learning of reasons which underpinned knowledge, Socrates demonstrated a view that students do not acquire knowledge through picking up bits of information didactically conveyed to them. This view of learning is widely accepted by all constructivists. But von Glasersfeld considered the acceptance of this view alone without the ideas embedded in the second principle to be trivial.

Thus, in von Glasersfeld's view, the key issue that distinguishes radical constructivism from other versions is the second principle—the concept of knowledge as an adaptive function. According to von Glasersfeld (1991a: xiv–xv), it simply means that:

> "the results of our cognitive efforts have the purpose of helping us to cope in the results of our experience, rather than the traditional goal of furnishing an "objective" representation of a world as it might "exist" apart from us and our experience."

Von Glasersfeld (1991a) noted that some scholars have interpreted this perspective about knowledge as a denial of reality. However, he (von Glasersfeld ,1995; 1991a; 1991b), explained that this is not to deny the existence of an objective world but rather to emphasise that we cannot know anything of a reality beyond experience. This claim about knowledge is based on Vico's school of thought that posits that we do not have access to a 'God's-eye' privileged view of the universe (Hardy & Taylor, 1997; Nola, 1997; von Glasersfeld, 1991b). For Vico, as cited in von Glasersfeld (1991b: 15):

> "in order to know something, one had to know how and out of what it was made. Hence, God alone can know the real world, because it was He who created it; the human knower, analogously, could know only what humans have constructed."

Several scholars (Hardy & Taylor, 1997; Jaworski, 1994; von Glasersfeld, 1995) have argued that radical constructivism is directly derived from Piaget's theory of cognitive development.

Piaget's theory asserts that knowledge construction occurs through cognitive adaptation in terms of a learner's 'assimilation' and 'accommodation' of experience into 'action schemes' (Jaworski, 1994). His theory is based on the central tenet of evolutionary biology that each organism regulates itself in its environment in order to ensure its survival (Nola, 1997). In light of this hypothesis, the process of equilibration or self-regulation is a fundamental factor in Piaget's theory of cognitive development. The child must assimilate new data into the concepts he has formed and accommodate data that does not fit. According to him, learning is not simply imposed by environmental forces. The child takes an active role in his own learning. He actively constructs models of the world using the mental processes of which he is developmentally capable. He wrote,

> "all knowledge is tied to action, and knowing an object or an event is to use it by assimilating it to an action scheme... " (Piaget, 1967, cited in von Glasersfeld, 1995: 56).

When a child receives new information that does not fit with what he or she already knows, his or her equilibrium with the outside world is upset. Such perturbation can lead to active adjustments of the learner's schemata through accommodation thereby setting up a new equilibrium. Accordingly, most constructivists (van Boxtel, van der Linden & Kanselaar, 2000; Wood, 1999) consider learning to have occurred when the learner has resolved a perturbation by reorganising previous knowledge.

In line with Vico, Piaget's perspective of knowledge was that:

> "knowledge is not a copy of the environment but a system of real interactions reflecting the autoregulatory organisation of life just as much as the things themselves do"
> (Piaget, 1971, cited in Nola, 1997).

Thus, according to von Glasersfeld, the revolutionary aspect of radical constructivism lies in the assertion that knowledge cannot and need not be "true" in the sense that it matches ontological reality; it only has to be viable in the sense that it fits within the experiential constraints that limit the cognizing organism's possibilities of acting and thinking (von Glasersfeld, 1989: 162).

Criticisms of radical constructivism

Some of the criticisms of radical constructivism have focused on its:

- neglect of the social dimension
- lack of connection to teaching
- denial of the possibility of knowing the ontic world
- overlooking that language can communicate shared meaning.

Criticism one: Social dimension

One major criticism of radical constructivism focused on its neglect on the role of the social dimension in the construction of knowledge. It is claimed that radical constructivism portrays the learner as an individual, isolated, rational being, rather than as a social participant. For example, in reviewing the book *Radical Constructivism* by von Glasersfeld (1995), Smith (1997: 110) wrote,

> "Glasersfeld has been remarkably consistent in portraying this picture of the informationally isolated, adaptive individual learner for nearly 30 years."

This view of individualistic learning has been challenged by several scholars (Cobb, 1994; 1995; Phillips, 1995). Cobb (1994) argued that the radical constructivism's emphasis on learning as an individual experience is inconsistent with some findings from cultural studies that demonstrated relative homogeneity of intellectual practices in subject-matter areas among different cultural communities. According to his view, knowing is intrinsically social. An individual reorganises his or her experience as the learner participates in and contributes to the development of practices established by a local community, including the mathematical practices established by the teacher and students in a particular classroom (Cobb, 1995). He argued in his earlier writing (Cobb, 1994) that mathematical learning is both a process of active individual construction and a process of enculturation into the mathematical practices of the wider community.

In response to this criticism, several scholars (Hardy & Taylor, 1997; Smith, 1997; von Glasersfeld, 1995) have argued that the criticisms of radical constructivism's neglect of the social dimension of learning are unwarranted in that radical constructivism does not deny the social component of learning. Hardy and Taylor (1997: 140), for example, cited some of von Glasersfeld's work to illustrate that radical constructivism does identify the social as an indispensable component of the learning process.

> "von Glasersfeld maintains that 'Every individual's abstraction of experiential items is constrained (and thus guided) by social interaction and the need of collaboration and communication with other members of the group in which he or she grows up' (von Glasersfeld, 1991). Von Glasersfeld argued further that social interaction is both the most frequent source of perturbation (von Glasersfeld, 1989) and the most powerful method for testing the viability of one's constructions (von Glasersfeld, 1991, 1993). Hence, 'it is precisely the social aspect (of one's environment) that furnishes the key to the solidification of the individual's experiential reality' (von Glasersfeld, 1989)."

Despite the acceptance by radical constructivists of the powerful influence of the social component in the construction of knowledge, some scholars (Cobb, 1995; Hardy & Taylor, 1997; Phillips, 1995) have, nevertheless, argued that the radical constructivist learning model does not provide an adequate explanation of how the socio-cultural and the personal components of learning interact. Phillips (1995), for example, argued that since teachers, parents, siblings, atoms, molecules and so forth are part of the realm external to the knower that radical constructivist are so skeptical about, it is difficult to see how an explanation of the social influence in the learning process could be made without facing problems of consistency.

Given my focus on classroom interaction, in this thesis, I take the social constructivist perspective of learning which characterises the learning process as both an individual and social activity (Cobb, 1995; Driver & Scott, 1995).

Criticism two: Lack of connection to teaching

A constructivist model of learning is often criticised for its lack of provision for a teaching model (Hardy & Taylor, 1997; Nola, 1997). For constructivists, there are no direct connections between teaching and learning. Since the teacher's knowledge cannot be conveyed to the students, the teacher's mind is inaccessible to the students and vice versa (Sierpinska & Lerman, 1996). Matthews (1997) argued that this failure by the constructivist learning theory to provide clear advice on how to teach the content of science [mathematics] is a serious one and exposes a fundamental theoretical problem for constructivism, given the necessity for any science [mathematics] programme to teach the content of science [mathematics]. He (Matthews, 1997: 12) wrote:

> "if knowledge cannot be imparted, and if knowledge must be a matter of personal construction, then how can children come to knowledge of complex conceptual schemes that have taken the best minds hundreds of years to build up? Many science [mathematics] educators are interested in finding out how, on constructivist principles, one teaches a body of scientific [mathematical] knowledge that is in large part abstract (...), removed from experience (...), has no connection with prior conceptions (...), and is alien to common-sense, and in conflict with everyday experience, expectations and concepts?...How all of this is to be taught without teachers actually conveying something to pupils, is a moot point."

Despite the emphasis in the literature that constructivism is a perspective on knowledge and learning but does not dictate specific forms of teaching (Begg, 1994; Sierpinska & Lerman, 1996; von Glasersfeld, 1991), many educationists have derived a number of teaching approaches from constructivist ideas. Such examples include: the Investigative approach by Jaworski (1994); and problem solving approach by Wheatley (1991). Although there are variations in the nature of these approaches, there seems to be general agreement that viewing mathematical knowledge as a learner activity requires a shift in the teacher's role from imparting or transmitting knowledge to creating a learning environment conducive to children constructing their own mathematics. In his answer to the question, "what are the implications of constructivism for a theory of instruction?" von Glasersfeld (1993) replied that there are many. He explained that adhering to a constructivist view of learning might involve some of the following,

- teachers getting some idea of the students' prior knowledge
- valuing students' answers or ideas because that is what makes sense to them
- asking students how they arrived at an answer
- focusing on the process of arriving at an answer rather than on the answer.

Criticism three: *Knowing the ontic world*

The radical constructivist view that knowledge cannot and need not be "true", in the sense that it matches ontological reality, has been criticised for attempting to justify knowledge in terms of its relation to an ontological world (Nola; 1997; Smith, 1997; Thomas, 1994). Thomas (1994), for example, argued that having a viable notion of a piece of the world is to know that piece of the world. He suggested that the meaning of knowledge ought to be redefined to refer to some standardized shared understanding called official knowledge— against which a piece of supposed knowledge could be marked right or wrong accordingly as it agrees or disagrees with official knowledge. Nola (1997) and Thomas (1994) argued that the notion of being able to know that an idea is true or false is important in education because by knowing that "a theory is correct, it can be a spur to someone to start learning the theory" (Nola, 1997: 79).

Criticism four: *Language and shared meaning*

Radical constructivism has also been criticised for its assertion that language does not have the capacity to convey shared meanings. From a radical constructivist perspective, one cannot use language to package and convey meanings, concepts or knowledge to a recipient who unpacks the exact meanings, concepts or knowledge that one endeavoured to communicate (Hardy & Taylor, 1997; von Glasersfeld, 1991). This view is expressed when Von Glasersfeld (1991: xiv) wrote:

> "Language frequently creates the illusion that ideas, concepts, and even whole chunks of knowledge are transported from a speaker to a listener.... Perhaps the best way to dismantle the illusion is to remember or reconstruct how one came to form the meanings of words and phrases when one was acquiring language in the first place. Clearly it could only be done by associating bits of language one heard with chunks of ones' own experience— and no one's experience is ever exactly the same as another person's....This may serve to remind us—especially when we act as teachers — that new concepts and new knowledge cannot simply be passed to another person by talk, because each must abstract meanings, concepts, and knowledge from his or her own experience.... it does mean that we can never rely on langauge to 'convey' knowledge as though it were something like food that can be handed from one to another."

The view that knowledge is not a commodity that can be communicated is readily agreed to by most scholars but the controversy surrounds the idea that shared understanding cannot be reached (Cobb, 1994; Hardy & Taylor, 1997; Nola, 1997). Nola (1997), for example, argued that the idea that meaning cannot be shared undermines the possibility of common scientific knowledge of how the world is. According to Wheatley (1991: 10), "to know is to understand in a certain manner, a manner which can be shared by others who join with you to form a community of understanding." Wheatley explained that viewing mathematical knowledge as a learner's activity in a social setting implied that meaning could be negotiated and consensus reached as learners shared their ideas with peers. Similarly, Jaworski (1994) argued that notions of viability and fit were as applicable to sharing of meaning as they were to construction of knowledge. She explained that while accepting that what the hearer creates was his/her own perspective, successful communication depended on this being close to the perspective of the speaker. In this thesis I take the social constructivist perspective that learners co-construct their knowledge as they share their ideas with peers, both in small groups and within the classroom community (Wheatley, 1991).

Social constructivism

Social constructivism is a theory of learning which acknowledges that both social processes and individual construction of meaning have central and essential parts to play in the learning (Ernest, 1994; van Boxtel, et al, 2000). It is widely believed that social constructivism was proposed as an attempt to reconcile the individual aspect of learning with the social aspect of learning— an aspect which was perceived to be neglected by radical constructivism (Cobb, 1995; Ernest, 1994). The ideas of social constructivism have their roots in disparate theoretical frameworks including Piagetian, Vygotskian, fallibilist social theories, and cultural theories (Ernest, 1994; Cobb, 1994). Consequently, a variety of forms of social constructivism exist. Further, different titles referring to similar aspects of social constructivism have been adopted by different authors, or even the same authors. Cobb (1995), for example, stated that they called their version of social constructivism 'the joint approach' in their Cobb and Bauersfeld (1995) publication, and the 'emergent perspective' in their Cobb, Jaworski, & Presmeg (1995) publication. He explained that the emergent perspective draws on both radical constructivism and interactionism theories. Thus, from an emergent perspective, mathematical learning is viewed as both a process of active individual construction and a process of enculturation into the mathematical practices of wider society (Cobb, 1994). In the mathematics classroom, the individual construction of meanings takes place in interaction with the culture of the classroom while at the same time it contributes to the constitution of this culture (Cobb & Bauersfeld, 1995).

The perspective adopted in the present study is one of a belief in individual construction of meaning as the students interact with each other and with the teacher in the classroom environment. In some ways it therefore draws upon both radical constructivism and on Vygotsky's view of individual "cognition as mediated by social interaction" (Abreu, 2000: 3). Vygotsky (1978) claimed that cognitive development was the result of the gradual internalisation and personalisation of processes originally experienced in social interaction (Ritchie & Carr, 1997). This suggests that Vygotsky considered social interaction as influencing individual construction. A central concept of Vygotsky's theory of learning was the 'zone of proximal development' defined as 'the zone between what a student can do on his or her own and what the student can achieve while working under the guidance of an instructor or in collaboration with more capable peers'. Several scholars have noted that past interpretations of Vygotsky's zone of proximal development tended to focus on how experts can scaffold novices to extend their zone of proximal development. Brown and Renshaw (1999) argued that this interpretation tended to highlight a one-way transfer of information from an expert to the novice. It has been suggested that interaction between peers with incomplete expertise can create a collaborative zone of proximal development in which students are able to coordinate their different perspectives in order to achieve progress (Goos, 2000).

Social constructivism in this research

Research done from a social constructivist perspective implies developing methods of investigation consonant with social constructivist ideas. Ernest (1991: 72) identified two key features of social constructivism as follows:

> *First of all, there is the active construction of knowledge, typically concepts and hypotheses, on the basis of experiences and previous knowledge. These provide a basis for understanding and serve the purpose of guiding future actions. Secondly, there is the essential role played by experience and interaction with the physical and social worlds, in both the physical action and speech modes. This experience constitutes the intended use of the knowledge, but it provides the conflict between intended and perceived outcomes which lead to the restructuring of knowledge, to improve its fit with experience.*

These features are evident in the present research. What is reported in this thesis represents the researcher's interpretation of boys' and girls' construction of mathematical knowledge as they interacted with the teacher and their peers, based on the researcher's classroom observations from the position of an 'insider'. The whole research process was shaped and directed by the researcher's reconstruction of her day-to-day classroom observations and experiences. Interpretations of observations were used to inform the next day's activities. Since individuals' prior experiences vary, the researcher was aware that these interpretations were likely to vary between participants and the researcher. This acceptance of inter subjectivity has attracted criticism about the validity of constructivist research (Hammersley, 1993). In addressing this criticism, the researcher has made an effort to provide a detailed account of the contexts in which the interpretations were made.

2.5 Feminist theory

Feminism is defined as the frame of reference within which individuals, women in particular, build their actions in order to transform the social division of the sexes (Solar, 1995). Although all feminists probably share the common assumption that women suffer certain disadvantages in comparison with men, their analyses of the situations in which they find themselves and their strategies for addressing these situations can vary. This has resulted in a variety of feminist theories (Leder, Forgasz, & Solar, 1996; Mura, 1995; Wilkinson, 1997). Mura (1995), for example, distinguished between three different types of feminism which she called:

- feminism of equality
- radical feminism
- feminism of difference

Feminism of equality

Feminism of equality (also classed as 'liberal feminism' by Forgasz, Leder & Vale, 2000) advocates equality between men and women in all social, political and economic systems. Feminists in this area demand that "women occupy 50 per cent of all political offices as well as all military, religious, academic, managerial, judicial, and other offices" (Mura, 1995: 156). They attribute women's low participation rates to the discriminatory conditions women experience, and advocate programmes that would ensure equal participation between men and women. The government strategies for achieving gender equity in Malawi outlined in chapter one fit this perspective in that they focused on increasing female participation rates. In the field of mathematics education, this approach is representative of studies that viewed gender differences in mathematics as the consequence of inadequate educational opportunities, social barriers, or biased instructional methods and materials; the approach advocated the removal of these barriers and, if necessary, the resocialisation of females to achieve gender equity (Forgasz et al, 2000; Leder et al, 1996; Mura, 1995). This view is similar to what Forgasz et al (2000) and Leder et al (1996) have described as the 'assimilationist' and 'deficit model'. Forgasz et al (2000: 306) characterised the 'assimilationist' and 'deficit model' as:

> "largely uncritical acceptance of the male norms of performance, participation, and approach to work as optimum and standards to be attained by all students. Females were assumed to have the same characteristics, motivations, and educational aspirations as males. Females were considered deficient."

Radical feminism

Radical feminists refuse to define themselves in relation to men. They identify patriarchy as a social, political and economic system that oppresses and exploits women individually and collectively, sexually and economically. Issues of power relationship, dominance, liberation and empowerment of women are at the focus of radical feminism. In the field of education, Mura (1995: 158) wrote,

> "radical feminists favour a pedagogy that addresses the subject of women's oppression and liberation explicitly in the classroom. In line with radical thinking, this pedagogy seeks to minimize hierarchical relations between teachers and students, empowering female students, and forcing male students to give up their dominance in the classroom."

Studies that analyse interactions in terms of oppression and dominance, power relationship between boys and girls in the classroom, and that advocate an inclusive pedagogy of liberation are some of the examples cited as being done from a radical feminist position (Mura, 1995; Forgasz, et al, 1996).

Feminism of difference

Feminists with a difference perspective accept that women and men are different. Unlike feminists of an equality persuasion and radical feminists, they insist on recognition of difference. Researchers in this area maximize and celebrate sex differences. "They assert that women have their own ethics, their own way of knowing and their own language" (Mura, 1995: 156). Feminists of difference promote the idea of the complementarity of the sexes and ask that women be allowed to engage in activities separate and different from men, but that these activities be equally valued and rewarded. The approach is characteristic of what Forgasz et al (2000) called the 'pluralistic model' and 'social justice model'. Examples in this field include the work of Belenky et al (1986) that identified women's different ways of knowing and Carol Gilligan's (1982) book *In a Different Voice*. Both feminists of difference and radical feminists criticize the feminism of equality approach because it identifies women and femininity as the problem and implies that women need to be given the opportunity to be more like men if they are to succeed (Leder, 1995).

Another perspective for classifying feminist views was given by Wilkinson (1997). She distinguished five different types of feminist theoretical traditions, categorising them as:

(i) **The mismeasure of women**— those that refute the studies of mainstream researchers who have consistently omitted women from their samples, or mismeasured women.

(ii) **The problem is oppression**— those that contend that women's inferiority is simply an index of women's oppression, arguing that women's short-comings arise from gender-related motives, fears or concepts which lead them to act against their own best interests.

(iii) **Women are different and superior**— those that agree that women are different from men, but argue that women's characteristics are superior, rather than inferior to men.

(iv) **Mental health is unrelated to gender**— those that argue that women are neither inferior nor superior to men, and therefore comparison of the sexes is unacceptable. They argue that being male or female is not a central determinant of one's functioning; rather, the major determinant is the ability to deploy one's abilities according to the situation.

(v) **These are wrong questions**— this group, which is influenced by a social constructionism framework, argue that sex/gender should no longer be theorized as 'difference', but reconceptualised as a principle of social organization, structuring power relations between the sexes.

Similarities between the two categories are clear. For example, 'the problem is oppression' perspective is similar to radical feminism in that both emphasise issues of power and dominance; the 'women are superior' view is consistent with the tenets of feminism of difference.

My use of the word feminism in this thesis is a broad one that encompasses several different feminist perspectives. For instance, the very idea that this research is about redressing the gender imbalance in mathematics education is in itself a typical *feminism of equality issue*. On the other hand, the choice of co-operative learning as a strategy that caters for individual learning styles has characteristics of *feminism of difference* in that it supports the view that boys and girls learn differently. Similarly, one can easily identify ideas of *radical feminism* in this research. For example, the use of small cooperative learning groups within a class as a teaching approach that may help overcome the problems of boys' dominance over resources (see section 2.2), proceeds from a *radical feminist* standpoint which analyses classroom interaction in terms of oppression and dominance.

Feminism in this research

Research done from a feminist perspective is mainly concerned with collecting data that truly reflects women's experiences, data that can be used to improve women's status in one way or another (Duelli-Klein, 1980; Reinharz, 1992). To this effect, the present study can be considered to have been conducted from a feminist perspective since the purpose of this research was to explore the experiences of girls in a co-operative learning class with the aim of improving girls' learning of mathematics. Duelli-Klein (1980) emphasises that not all research on women qualifies to be called feminist research and goes on to describe some of the criteria feminist methods should meet (derived from 'truly feminist scholarship' in Germany). These are that such research methods must:

- not only document women's life histories but motivate them to work for change (consciousness-raising process),
- promote collective perception of the women's situation (conscious subjectivity),
- allow for inter subjectivity; that is, the researcher must constantly compare her work with her own experiences as a woman and a scientist and share it with the researched, who then will add their opinions to her research, which in turn might change it again,
- allow for women studying women in an interactive process without the artificial object/subject split between researcher and researched,

- and have an inherent obligation to try to maintain honesty between researcher and researched.

The issue of whether there is a research approach called *feminist method* is still under debate. Most writers (Banister, Burman, Parker, Taylor, & Tindall, 1994; Hardings, 1987; Morgan, 1981; Reinharz, 1992) are of the opinion that most qualitative methods such as interviews, participant observation, and ethnography are applicable to feminist research. Other writers claim that what identifies feminist research is a commitment to a focus on representing the experiences of women, reflexivity in which the researcher takes her own experiences seriously and incorporates them into her work (Roberts, 1981), and a relatively intimate and non-hierarchical power relationship between the researcher and the researched (Oakley, 1981). Maintaining such a relationship could, however, pose challenges to researchers researching in countries such as Malawi which value respect for authority.

In this research, the researcher's commitment to issues of reflexivity and her efforts to develop an intimate relationship with the participants are discussed in chapter five. Consistent with the feminist commitment to representing women's experiences, data that emerged from observations and interviews are presented using the participants' own words whenever possible.

2.6 Compatibility of social constructivism and feminist perspectives

The ideas of social constructivism seem to be consistent with the feminist perspective of how women come to know. One of the major influences in the feminist research of women's development of knowledge comes from a study of an all-female sample by Belenky et al, (1986). From this study of 'Women's Ways of Knowing', Belenky et al found that women tended to be connected knowers. Their study involved only female subjects. In a study involving male and female career mathematicians at university level, Burton (1999) found that both females and male mathematicians were connected knowers and preferred collaboration in their work. Several feminist researchers (e.g. Jacobs & Becker, 1997; Rogers, 1995) have used the knowledge derived from Belenky et al's *Womens' Ways of Knowing* to suggest pedagogical strategies, usually referred to as 'feminist pedagogy', that facilitate using connected teaching to reach girls. Jacobs and Becker (1997) considered that pedagogical strategies that facilitate connected knowing should:

(i) include experiences that enable students to actively build on their intuitive understanding, thus, providing insights into the reasons for such study,

(ii) include use of writing in mathematics to help students develop their own voices and move away from the authority of the teacher, allowing them to listen to and learn from others' reasons and ideas, and encouraging them to value process, not just the correct answer,

(iii) encourage cooperative learning to develop the students' voice and ability to learn autonomously, and

(iv) develop a community of learners, that is, an environment where the teacher and the students in the class are there to learn together and from each other.

Solar (1995) reviewed some feminist pedagogies and noted that they were all based on the four principles of speech (rather than silence), active participation (rather than passivity), empowerment (rather than powerlessness), and inclusion (rather than omission). These principles shared the ideals of social constructivism in that they emphasised the importance of:

- actively involving the students in their learning,
- using students' own experiences to build knowledge,
- developing the student's voice and ability to learn autonomously,
- the process of knowledge production rather than the product, and
- recognition of the social nature of mathematical activity.

2.7 Summary

This chapter argued that teaching approaches based on social constructivism and feminist theories seem promising for improving the learning of girls and boys. The discussion highlighted diverse forms of both constructivist and feminist perspectives. The different forms of constructivism ranged from those that described learning in terms of individual cognition to those focusing on social processes. The social constructivist perspective that guides the present study views learning as both an individual and social activity. Similarly, it was noted that a variety of feminist theories ranging from the more equalitarian to the more radical perspective have been used to address gender issues. It was observed that the ideals of liberal feminism characterised the current government strategies for equity in Malawi. The chapter argued that the underlying assumption for such perspective was a deficit and assimilationist model in which females were "positioned as victims with deficit aims and desires" (Forgasz et al, 2000: 308). The feminist perspective adopted in this research incorporates the ideals of liberal and radical feminism, together with the feminism of difference. Further discussion of how the theoretical perspectives are manifested in the research methodology is provided in chapter 5.

Chapter Three

Literature Review on Gender and Mathematics

3.0 Introduction

A significant amount of research has been done over the past three decades where the aim has been to improve the learning outcomes of girls in mathematics. As evidence, Leder (1992), in an attempt to provide a possible measure of the prevalence of such research, reported that approximately 10% of the total articles published in the *Journal for Research in Mathematics Education* between 1978 and 1990 had a theme related to gender. Similar results have been reported in a more recent study. Lubienski & Bowen (2000) found that of the 3,000 articles printed in the major international educational research journals during the period 1982–1998, 323 articles pertained to gender. In this chapter I provide a review of such studies, discuss the limitations and strengths of them, and consider new directions for research that may help address the issue of gender and mathematics. The present review focuses on explanations for gender inequity and the resulting interventions that have been used in the past to redress this, as these closely relate to the present study. After a brief overview, I group the explanations under four broad categories: biological, cognitive, affective and sociological variables. I conclude my review by suggesting that the problem of gender and mathematics is a complex issue that requires a broader perspective to investigate and redress it.

3.1 An overview of gender differences in mathematics

The literature on gender differences in mathematics achievement revealed the following developmental trend: there were differences between girls' and boys' achievement in mathematics, particularly on tasks that required spatial skills and problem solving (Friedman, 1989; Maccoby & Jacklin, 1974); these differences increased significantly by age 13 (Kahle & Meece, 1994; Fennema, 1996); the gender gap on mathematics achievement was largest in samples of high performers (Hyde, Fennema & Lamon , 1990; Benbow & Stanley, 1982); the gender gap appeared to be getting smaller over time (Baker & Jones, 1993; Friedman, 1989; Leder, 1992); the Scholastic Aptitude Test-Math scores showed the largest gender effect sizes as compared with other mathematics tests (Hyde et al, 1990), and the size and direction of gender differences varied from one country to another (Baker & Jones, 1993; Hanna, 1989; Hanna, Kundiger & Larouche, 1990). Recent studies in Australia (Forgasz, 2000), New Zealand (Harker, 2000), and the United Kingdom (Younger, Warrington & Williams, 1999) showed that girls now attain the same or better proportion of grades A-C as boys in Mathematics, although gender differences in favour of boys still existed amongst students obtaining A grades in the United Kingdom (Boaler, 1997).

An analysis of the international trend reported above and the trend in Malawi on mathematics achievement (chapter one) revealed several important discrepancies. First, the international trend showed that significant gender differences appeared at the beginning of secondary school and continued to increase thereafter, while studies done in Malawi showed that the gender gap in favor of males was largest at primary and secondary school levels, but reversed at tertiary level. Second, the international trend suggested that the gender gap was getting smaller over time whereas the gender gap in Malawi was not. Another finding was that despite the huge amount of literature on gender and mathematics, few such studies had been done in developing countries.

Findings of persistent gender differences had resulted in a significant number of theories to explain gender differences in mathematics. Interventions based on such theories had been designed to alleviate the documented differences. The next four sections provide a brief review of such theories.

3.2 Biological explanations

Theories based on biological explanations for sex differences in mathematics achievement considered genetic factors (Stafford, 1961), hormonal influences (Broverman, Klaiber, Kobayashi & Vogel, 1968) and brain lateralisation (Buffery & Gray, 1972) to be significant. Stafford's hypothesis was that the genetic determiner for spatial ability (consequently mathematics ability) was sex-linked, being carried on the X chromosome and being recessive. This X-linked recessive gene theory claimed that the genetic makeup of females made them less capable in mathematics than their male counterparts. Similarly, the Broverman hypothesis explained that large amounts of estrogens (female hormones) negatively affected the females' ability in visual-spatial tasks (consequently mathematics). The brain lateralisation theories claimed that females' lack of ability in mathematics was because their brain lateralisation into the left and right hemisphere encouraged verbal ability but not visual-spatial (and consequently mathematical) ability whereas males tended to develop a brain physiology that helped them perform mathematical tasks better than females (Benbow, 1988; Buffery & Gray, 1972). Benbow & Stanley (1982) found from some of their studies that gender differences in mathematics achievement were not accounted for by sex differences in expressed attitudes toward mathematics and mathematics course taking. They then used these findings as evidence that gender differences in mathematics achievement were due to biological differences in mathematical ability between boys and girls.

However, the adequacy of biological explanations has been challenged by many for their inability to explain gender differences or similarities found in mathematics achievement between different countries (Baker & Jones, 1993; Byrnes, Hong & Xing, 1997; Hanna, 1989), and the diminishing of the gender differences over time (Baker & Jones, 1993). For these reasons, such theories are considered of no further value in this study.

3.3 Cognitive theories

Researchers in this area considered the role of cognitive abilities to be important in explaining gender differences in mathematics achievement. Most studies in this group were influenced by the findings of Maccoby and Jacklin (1974) whose findings indicated that developmentally, gender-related differences in some cognitive abilities and mathematics achievement appeared to emerge at roughly the same age, 12-14 years. The underlying assumption in this area of work was that there were gender differences in cognitive skills and that these gender differences in turn influenced performance on mathematics tests. Thus, numerous researchers had suggested that an understanding of the relationship between cognitive abilities and mathematics achievements was likely to be a key in understanding gender differences in mathematics achievement. Consequently, a number of studies had been carried out firstly to identify the specific cognitive skills that predicted differential mathematics achievement between girls and boys and, secondly, to investigate how such skills could be developed in girls to improve their mathematics achievement. The results of such studies seemed to show that gender differences existed to some extent among some cognitive abilities. Females appeared to be superior in verbal ability, manual dexterity, and rote memory, whereas males were supposedly superior in spatial and problem-solving abilities (Battisa, 1990; Casey, Nuttall & Pezaris, 2001; 1997; Fennema & Tartre, 1985; Maccoby & Jacklin, 1974). These results have influenced some researchers to believe that males achieved more than females in mathematics because the alleged "males' abilities" were the ones relevant for mathematics achievement whereas the alleged "females' abilities" were not. Consequently, the majority of studies in this area have focused on the influence of spatial abilities and problem-solving skills in the learning of mathematics.

(a) Spatial skills and mathematics learning

Spatial skills is one of the cognitive abilities that has been extensively studied as a contributing factor in explaining girls' low achievement in mathematics (Casey, et al, 2001; 1997; Cornor & Serbin, 1985; Tartre, 1990; Vermeer, Boekaerts, & Seegers, 2000). Some researchers in this area (Casey et al, 2001; 1997) were influenced by some research findings which showed that the largest advantage for males across grade levels was found in mathematical areas in which spatial skills were beneficial. Others (Connor & Serbin, 1985) explained that spatial skill was an important variable to study because, developmentally, gender related differences in spatial skill performance and mathematics achievement appeared to emerge at roughly the same age.

Despite such associations between spatial skills and mathematics achievement, the literature revealed inconsistent findings regarding the nature and extent of the relationship between gender differences in spatial abilities and mathematics achievement. For example, while some studies provided evidence which showed that spatial ability predicted mathematics achievement for both boys and girls (Casey et al, 2001; 1997), others showed that spatial ability was advantageous for females but not males (Tartre, 1990), or for males but not females (Connor & Serbin, 1985), or that it even debilitated mathematics achievement (Lean & Clements, 1981). For example, Casey et al's (2001) study of grade eight students and Casey et al's (1997) study of the top third college bound students showed that spatial skill measure, when compared to a mathematics self confidence measure, accounted for 74% and 64% respectively, of the total indirect mediational effect between gender and mathematics achievement. Casey et al concluded that by 8^{th} grade, girls' relatively poorer spatial skills contributed to lower scores on mathematics at which boys typically excelled (Casey et al, 2001). On the other hand, a study by Connor and Serbin (1985) showed that the females' spatial abilities were unrelated to their mathematics achievement. Connor and Serbin's conclusions were based on two studies involving seventh and tenth graders in which scores from six visual spatial tests were correlated with scores from mathematics achievement tests for the two grades and for boys and girls separately. The results of the two studies showed higher correlation coefficients for boys than for girls in each grade. Connor and Serbin (1985) concluded from such findings that spatial skill was more related to mathematics performance for males than for females. A study by Tartre (1990) resulted in findings that were contrary to those of Connor and Serbin (1985) and also different from Casey et al's findings. Tartre's (1990) study showed that low-spatial males were not hampered on mathematics achievement by their low level of spatial skills whereas low-spatial females were. Thus, Tartre concluded that spatial skill predicted mathematics achievement for females but not for males. On the other hand some studies have shown that spatial strategies were less efficient than non spatial strategies when solving mathematics problems. For instance, a study by Lean & Clements (1981) showed that students who solved the problems using non visual methods outperformed the students who used visual processes.

The inconsistency in the literature on the relationship between spatial ability and mathematics achievement has been attributed to the fact that neither the domain of skills represented by the term "spatial skill" nor the domain represented by the term "mathematical achievement" is unidimensional. Other scholars have provided research evidence for the view that superiority in spatial skill may not be linked to mathematics achievement because the same problem may be tackled in one way by people with high spatial potential and in another way by people with a different pattern of abilities (Lowrie, 2000). In a later study Lowrie and Kay (2001) have shown that gender had no effect on problem solvers' preference for visual and nonvisual approaches to solving mathematical problems, but task difficulty did. Both boys and girls tended to use non visual methods for solving less difficult tasks and visual methods when solving more difficult problems. Because of such inconsistencies in research findings, it is difficult to attribute girls' low mathematics achievement to inferior spatial abilities.

(b) Problem solving strategies

Research has shown that boys and girls differed in the strategies they used to solve mathematical problems (Byrnes, Hong & Xing, 1997; Byrnes & Takahira, 1993; Fennema, Carpenter, Jacobs, Franke & Levi, 1998; Gallagher & DeLisi, 1994). For example, Carr and Jessup (1997) reported from a study of first graders mathematics strategy use, that while there were no gender differences in the number of correct solutions, there were differences between the strategies used by boys and those used by girls to solve addition and subtraction problems. The girls were more likely to use overt strategies (e.g. counting on fingers or using counters) while the boys tended to use mental strategies. Gender differences in problem solving strategies have also been reported among samples of secondary school students (Byrnes et al, 1997; Byrnes & Takahira, 1993; Gallagher & DeLisi, 1994).

Most studies reported that the strategies used by the boys were more effective for successful problem solving than those used by the girls (Byrnes et al 1997; Byrnes & Takahira, 1993; Fennema et al, 1998). For example, Fennema et al (1998) concluded from a longitudinal study of students' strategies for solving addition and subtraction problems that using invented algorithms (strategies mostly used by boys) in the early grades seemed to provide a foundation for solving the extension problems while using standard algorithms (a strategy mostly used by girls) did not. They argued that because the girls tended to use school taught algorithms whereas the boys were able to invent their own algorithms, it indicated that the girls had not developed an understanding of mathematics to the same degree that the boys had. Their conclusion was based on the finding from a study involving 44 boys and 38 girls as they progressed from grades 1-3; the students who used invented algorithm outperformed those who used standard algorithms on the extension problems. Similarly, Byrnes and Takahira (1993) studied 11th and 12th grade students solving some Scholastic Aptitude Test mathematical tasks, and reported that gender differences in the Scholastic Aptitude Test occurred because the problem solving strategies used by the boys were more effective than those used by the girls. The boys were better at compiling their knowledge into a strategy for solving the tasks than the girls.

Explanations based on gender differences on problem solving strategies have been criticized by many, notably feminist scholars, for assuming that the girls' low achievement in mathematics beginning at adolescence was due to their inferior problem solving strategies (Boaler, 2000; Hyde & Jaffee, 1998). Boaler (2000) argued, for example, that the reasoning that equated standard algorithms use with a lack of understanding was problematic considering that the girls in the Fennema et al (1998) study (and in the Carr & Jessup, 1997 study) had attained equal marks to those attained by the boys despite their differences in strategy use. Indeed, insights gained from some feminist studies (e.g. Belenky et al, 1986) suggested that the differential strategy use by boys and girls may just be reflective of the different preferred styles of learning for boys and girls. A discussion of different styles of learning is taken up further in section 3.7 of this chapter.

3.4 Affective variables

One of the most common explanations for girls' low achievement in mathematics has focused on affective variables (Hyde, Fennema, Ryan, Frost, & Hopp, 1990; Sayers, 1994). Researchers in this area explained that girls had low achievement in mathematics stemmed from the attitudes they developed. Several reviews concluded that there were gender differences in attitude towards mathematics, with girls showing more negative attitudes than boys. In general, most of the studies reported that, compared with boys, girls lacked confidence, had debilitating causal attribution patterns, perceived mathematics as a male domain, and were anxious about mathematics (Hyde et al, 1990; Ho, Senturk, Lam, Zimmer, Hong, Okamoto, Chiu, Nakazawa, & Wang, 2000; Ma & Kishor, 1997; Sayers, 1994; Vermeer et al, 2000). For example, a meta-analysis by Hyde et al of 126 studies showed gender differences in self-confidence (mean effect size =+0.16), mathematics anxiety (mean effect size = +0.16), mathematics as a male domain (mean effect size = -0.90), and general attitudes towards mathematics (mean effect size = +0.13). Hyde et al further found that these gender differences were larger among high school and college students than among younger students, and that such differences were similar in effect size to gender differences in mathematics performance (Hyde et al, 1990). These findings were reiterated in their later meta-analysis study (Frost, Hyde & Fennema, 1994). Findings of females' negative attitudes towards mathematics have also been reported for Australia (Forgasz & Leder, 1996), Netherlands (Vermeer et al, 2000), China and Taiwan (Ho et al, 2000), USA (Casey et al, 2001; 1997), and Zambia (Sayers, 1994).

The causes of the gender differences in mathematics attitude were found to be multifaceted. Researchers have identified parental and societal attitudes (Papanastasiou, 2000; Wong, 1992), and students' classroom experiences (Fisher & Rickards, 1998; Forgasz & Leder, 1996), as being influential in making girls internalize the feeling that they are inferior to boys in mathematics. Jacobs and Eccles (1992) found that mothers' beliefs about their children were gender stereotyped and that this parental belief in turn influenced their children's self-perceptions. Studies that have considered learning environments consider teachers' classroom behaviours to be a factor associated with students' attitudes. Fisher and Rickards (1998) found that the students' attitudes towards mathematics tended to be more positive in classrooms where students perceived greater leadership and helping/friendly behaviours in their teachers, and more negative in classrooms where students perceived their teachers as admonishing and enforcing strict behaviours. Other researchers have compared the effect of single-sex and coeducational classrooms upon students' attitudes (Forgasz & Leder, 1996; Norton & Rennie, 1998; Rennie & Parker, 1997). Students in single-sex schools were found to have more positive attitudes than students in the coeducational schools. For example, Norton and Rennie's (1998) study of grades 8 to 12 in four secondary schools (one private single-sex girls' school, one private single-sex boys' school, one coeducational state high school, and one coeducational private school) in Queensland, Australia, found that boys in the single-sex schools had the most positive attitudes. The attitudes of boys in coeducational schools were similar to girls in the single-sex school, and girls in the coeducational schools reported less positive attitudes on most scales.

The reported gender differences in attitude towards mathematics influenced some researchers to study some affective variables as mediators of gender differences in mathematics achievement (Casey et al, 2001; 1997). However, little consensus existed among researchers regarding the influence of affective variables on gender and mathematics achievement. For example, some studies reported statistically significant effects of affective variables on the learning of mathematics (Casey et al, 2001; Ho, et al, 2000; Ma & Kishor, 1997), while others indicated no relationship between attitude variables and mathematics achievement (Papanastasiou, 2000). Even among those studies that found a significant relationship, there was still controversy regarding the educational implications of the results. For example, some researchers concluded that although statistically significant, the mean effect size for the relationship between attitudes towards mathematics and achievement in mathematics was not strong enough to have useful implications for educational practice (Ma & Kishor, 1997). On the other hand, some researchers (Hyde et al, 1990; Norton & Rennie, 1998) have cautioned against dismissing the effects of affective variables on longer-term learning outcomes, despite the finding that most of the gender differences in mathematics attitudes were small.

One of the explanations for the inconsistent findings regarding the relationship between attitude and mathematics achievement, was that such a relationship existed only with respect to particular mathematics content areas (Casey et al, 1997; Ma, 1999) and for specific affective variables (Ho et al, 2000). Overall, most studies have considered that the students' confidence in mathematics, attribution style, mathematics as a male domain, and anxiety, was important. Some of these studies are reviewed in the next sections.

(a) Confidence in learning mathematics

Confidence in learning mathematics, or the degree to which a person feels certain of his or her ability to do well in mathematics, has consistently emerged as an important component of gender-related differences (Casey et al, 2001; Vermeer et al, 2000). Generally confidence in mathematics has been associated with mathematics achievement (Fennema & Sherman, 1977; Ryan & Pintrich, 1997), with correlation coefficients ranging from 0.3 to 0.4 (Hart, 1989). One of the ways in which self-confidence has been seen to affect mathematics was through its effects on help seeking behaviours that promoted learning (Hart, 1989; Newman, 1990; Ryan & Pintrich, 1997). For example, Ryan and Pintrich (1997) showed that students who perceived themselves as cognitively competent were less likely to avoid seeking help, whereas, students who were unsure of themselves were more likely to feel threatened when asking their peers for help and more likely to avoid seeking help. Hart (1989) found that the mean for public teacher-student interaction was higher for high confidence students than the mean for low confidence students. Ryan & Pintrich explained that students with high confidence in mathematics do not attribute their need for help to a lack of ability and thus are more likely to seek help when they need it (Ryan & Pintrich, 1997). Hart (1989) further found that high confidence students were engaged in mathematics a greater percentage of the time than were low confidence students.

Based on such findings, some scholars have suggested that mathematics self-confidence could be an important variable in understanding gender differences in mathematics (Casey et al, 2001; 1997; Hyde et al, 1990). In general most of the studies have shown that girls had lower self-confidence in mathematics than boys (Casey et al., 1997; Eccles, Wigfield, Harold, & Blumenfeld, 1993; Hyde et al, 1990; Norton & Rennie, 1998; Ryan & Pintrich, 1997), and that the gender differences in mathematics self-confidence emerged as early as first grade, with first-grade boys perceiving themselves as more competent than first-grade girls (Eccles et al.'s, 1993). In some cases, boys were more confident than girls even when their mathematics achievement was similar to that of girls (Casey et al, 1997). Vermeer et al (2000) have further shown that the gender differences in self confidence were more marked for application problems than for computation problems, with girls showing significantly lower confidence for application problems. Ryan & Pintrich's (1997) study of seventh and eighth graders in a city in Michigan, showed that although the girls perceived themselves as more cognitively competent in mathematics ($M = 2.61$) than boys ($M = 2.26$; $t = -3.01$, $p < .05$), the girls were more likely to avoid asking for help from the teacher when they needed it because they felt more threatened by negative reactions from the teachers than were the boys.

Self-confidence has also been shown to mediate gender differences in mathematics achievement in samples of primary students (Vermeer et al, 2000), middle school students (Casey et al, 2001) and high school seniors (Casey et al, 1997). For example, Casey et al (2001) found that self-confidence accounted for 26% of the total indirect mediational effect between gender and mathematics performance.

Despite such consistent findings of girls' low confidence in mathematics, studies of classroom environment have shown that the girls' confidence in mathematics improved greatly in classes which actively involved girls in the learning of mathematics (Boaler, 2000; 1997; Hart, 1989; Rennie & Parker, 1997). A fuller discussion of such studies is given in section 2.7(b) of this thesis.

(b) Attribution style

Closely related to self-confidence is the attribution style, that is, the way in which a student attributes causation for success or failure. According to the attribution theory (Weiner, 1979), the reason students give for academic success and failure can be assessed according to two dimensions: "stable versus unstable" and "internal versus external". These four causes can be classified along the dimensions of stability and locus of control, as illustrated in figure 3.1 below:

Figure 3.1 Schemes of causal factors determining achievement outcome

		Locus of control	
		Internal	**External**
Stability	**Stable**	Ability	Task difficulty
	Unstable	Effort Motivation	Luck

Source: Lorenz (1982: 2)

Scholars in this area have claimed that stability and locus of causal attributions were important because they related to an individual's expectation for performance on future tasks (Fennema, Peterson, Carpenter & Lubinski, 1990; Kloosterman, 1990; Lorenz, 1982).

Some researchers have used attribution theory to suggest that there were gender differences in patterns of attribution styles and that this might have contributed to gender differences in mathematics achievement. A number of researchers who investigated the attribution styles for males and females have reported that there were gender differences concerning the way in which students attributed causation for success and failure (Amit, 2000; Norton & Rennie, 1998; Vermeer et al, 2000). Males tended to attribute their success to stable variables and their failures to unstable variables, while females tended to show the reverse of this pattern. Some studies showed that the gender differences were more marked in application problems than computation problems (Vermeer, 2000). Vermeer et al (2000) found no gender differences in the boys' and girls' attribution style for the computation problems. But with respect to the application problems, girls attributed a bad result more often to lack of ability, and to the difficulty level of the task than did the boys.

It has been widely believed that the reported attribution pattern for girls has a debilitating effect on their learning of mathematics. Many scholars (Fennema et al, 1990; Kloosterman, 1990; Lorenz, 1982) have explained that attributing success to external and unstable variables such as ease of task or luck, or failure to external and stable variables such as lack of ability, was associated with subsequent failure. For example, Lorenz (1982) explained that if a student attributed her/his failure to lack of ability, then s/he would have little reason to expect success in future, since ability was a stable characteristic. On the other hand, attribution of failure to lack of effort does not preclude success in the future, since effort is within an individual's control and can be adjusted to make success possible.

Forgasz and Leder (1996) have, however, noted that a comparison of attribution styles for males and females without providing the context in which such attributions were made was not very revealing. Forgasz and Leder (1996) provided evidence based on classroom observations suggesting that the differential experiences of boys and girls during mathematics learning may have reinforced males' beliefs that their failures were attributable to lack of effort and not to lack of ability, whereas the girls' mathematical experiences discouraged them from attributing their failures to lack of effort. Forgasz and Leder's study showed that for small group tasks, it was usually the girls who did the whole project without the contribution from the boys, and that their teacher was not fully supportive when the girls raised the issue with the teacher. Forgasz and Leder explained that given such a context, the boys were more likely to attribute their failure to lack of effort since their efforts during the group task were minimal. On the other hand, the girls would have attributed failure to causes other than effort.

(c) Mathematics as a male domain

Mathematics considered as a male domain has consistently emerged as having the largest effect size (e.g. -0.90 in Hyde et al's 1990 study) in the literature on gender differences, where boys more than girls believed that mathematics was a male domain. This belief of the masculinity of mathematics has remained consistently strong over time although recent studies (Forgasz & Leder, 1996; Norton & Rennie, 1998) have indicated smaller effect sizes than the one reported by Hyde et al (1990).

However, the interpretation of the consistent pattern of "mathematics as a male domain" has been questioned, for example, by Forgasz and Leder (1999). Forgasz and Leder (1999) provided some recent research evidence which suggested that several items in the often used 'mathematics as a male domain' subscale of the Fennema-Sherman Mathematics Attitude Scales may no longer be valid and that responses to others could no longer be reliably interpreted. Based on four data sources collected in several countries and from various age groups, Forgasz and Leder showed that the assumption underpinning the development of the Male Domain scale, namely that a low score reflected the stereotyping of mathematics as a male domain, was no longer valid. Hence, students' disagreement with an item such as "Girls can do just as well as boys in maths" may have indicated either a belief that boys were better and mathematics was a male domain, or a belief that girls were better and mathematics was a female domain. Forgasz and Fennema have suggested that the scale be revised to reflect the present thinking.

(d) Anxiety towards mathematics

One particular affective factor that has probably received considerable attention within the affective domain has been anxiety towards mathematics. Mathematics anxiety has been often referred to as "the general lack of comfort that someone might experience when required to perform mathematically, or the feeling of tension, helplessness, and mental disorganization one has when required to manipulate numbers and shapes" (Ma, 1999). Many researchers have shown that being anxious towards mathematics results in negative educational consequences including an inability to do mathematics, a decline in mathematics achievement, and avoidance of mathematics courses (Casey et al, 1997; Ho et al, 2000; Ma, 1999). A number of studies that have examined the relationship between gender and mathematics anxiety have concluded that there were differences between males and females in mathematics anxiety, with females showing more anxiety than their male counterparts (Casey et al, 1997; Hembree, 1990; Ho et al, 2000; Norton & Rennie, 1998), the gender difference in mathematics anxiety was smallest for highly selected samples (Hyde et al, 1990), and that the gender differences in mathematics anxiety increased with grade level (Hembree, 1990; Hyde et al, 1990; Ma, 1999; Norton & Rennie, 1998). Such findings have influenced some researchers to believe that gender differences in mathematics achievement were attributable to gender differences in mathematics anxiety. However, the patterns of results from studies that have investigated the relationship between gender differences in mathematics anxiety and gender differences in mathematics achievement were somewhat varied. For example, while Ma (1999) showed that the relationship between mathematics anxiety and mathematics achievement was consistent between males and females, Casey et al (1997) concluded from their study that the differential mathematics anxiety between boys and girls did not lead in any way to gender differences in mathematics achievement. They found that although girls did have higher math anxiety than the boys, this difference did not have any significant impact on how well they performed in mathematics. Casey et al used Felson and Trudeau's (1991) findings that gender differences in math anxiety were part of a more general academic anxiety among girls, to explain their result that anxiety specific to mathematics did not mediate gender differences in mathematics performance. On the other hand, Ma (1999) acknowledged that the relationship between mathematics anxiety and mathematics achievement was dynamic in nature in that it changed dramatically for students with different social and academic background characteristics. Ma cited some examples of past research to illustrate that when students' characteristics were diverse and unique, so were the relationships: mathematics anxiety was shown to facilitate mathematics performance, debilitate mathematics performance, or was quite unassociated with mathematics performance. Casey et al's sample was a group of higher ability college-bound students while Ma's study was a meta-analysis of studies that had reported on students at the elementary or secondary school level. Ma (1999) explained that when the sample comprised gifted students in academic tracks these students were able to control their anxiety and channel it into the task because of their strong self-esteem and high levels of task-related confidence. This possibly explains why high mathematics anxiety was not a debilitator of mathematics achievement for the girls in Casey et al's sample.

Some researchers have attributed the varied findings regarding the relationship between mathematics anxiety and mathematics performance to the diversity of the instruments used for measuring mathematics achievement (Ma, 1999) or mathematics anxiety (Ho et al, 2000; Sassen, 1980). Ma's meta-analysis of 26 studies showed that the relationship between mathematics anxiety and mathematics achievement differed significantly between types of instruments used to measure achievement. The standardized achievement tests tended to report a significantly weaker relationship than those using researcher-made achievement tests and mathematics teachers' grades. Ma's study, however, showed that the relationship was consistent between instruments used to measure anxiety. In contrast, Ho et al (2000) showed that the relationship varied according to the instrument used to measure anxiety. In their study, Ho et al distinguished between the affective and cognitive dimensions of mathematics anxiety. The affective anxiety referred to the emotional component of anxiety such as feelings of nervousness, tension, dread, fear and unpleasant physiological reactions to testing, while cognitive anxiety referred to the worry component of anxiety, which is displayed through negative expectations, and having a preoccupation with self-deprecatory thoughts about an anxiety-causing situation. Examples of questionnaire items testing affective anxiety included: "When I am in math class, I usually feel relaxed and at ease", whereas cognitive anxiety items included: " In general, how much do you worry about how well you will do in school?" Ho et al's (2000) study showed that it was the affective, rather than the cognitive domain of math anxiety that was negatively related to mathematics achievement.

A somewhat different explanation for the allegedly high anxiety among females often reported in the literature has been offered by Sassen (1980). Drawing upon Kegan's (1977) constructivist developmental concept of anxiety and Gilligan's studies of women's structures of knowing, Sassen (1980) argued that the high anxiety attributed to women might well be a reflection of their essentially female way of constructing reality. Kegan defined anxiety as the sense of disintegration which occurs when a meaning-making organism finds itself unable to make meaning. Sassen argued that taking this view of anxiety, as well as Gilligan's (1977) findings that women tended to have a contextual and relational structures of knowing, explained why females tended to exhibit high anxiety. Women brought a relational, contextual structure of knowing to the agree-disagree anxiety questionnaire which they were asked to make sense of within a specific limited time, and thus found they could not accommodate it to this kind of competitive environment; hence the anxiety.

Studies done in Malawi

In Malawi, little work has been published concerning students' attitudes towards mathematics. The exception is a study by Hiddleston (1993). In her study, she considered female subjects in their last year of their secondary schooling before qualifying for tertiary education. The research used a questionnaire which was partly the original Second International Mathematics Study (SIMS) questionnaire on attitude. It had 20 lists of activities which pupils undertook or learnt about in mathematics and for each of the activities, pupils were asked to indicate three things: (a) how important they considered it; (b) how difficult they found it; and (c) how much they liked it. The findings indicated that the girls in Malawi perceived most of the topics in mathematics important but they found them very difficult. Hiddleston interpreted such findings as indicating a greater fear of mathematics amongst girls in Malawi. An ethnographic qualitative study by Davidson and Kanyuka (1992), however, revealed that the reason given by girls for believing that it was more difficult for girls to do well at school than boys was because girls had too many chores to do after school. The girls spent 68 percent of their after school time on domestic chores and child care, whereas boys spent only 37.8 percent. Davidson and Kanyuka also found that the girls often reflected the attitudes of their parents and their teachers— that females were not expected to perform academically at the same level as boys, and that females should pursue careers in which they could use skills associated with nurturance and domesticity. They argued that such stereotyping of attitudes reduced the opportunities that girls had for education in comparison to boys. They further observed that girls were less apt to ask and answer questions in classes, and explained that this was possibly because the Malawian culture expected girls to be shy and submissive. The focus of Davidson and Kanyuka's study was not specific to mathematics attitude but to education in general. A study that specifically compared gender differences in mathematics attitude was conducted in Zambia (a neighbouring country to Malawi) by Sayers (1994).

Sayers' (1994) study comprised a sample of 410 females and 478 males drawn from Grade 8 to Grade 12 students from 35 secondary schools across the country of Zambia. Sayers' analysis of the attitude questionnaire responses revealed a picture of girls being less confident, more nervous, enjoying mathematics less and seeing less use for their mathematics when compared with boys (Sayers, 1994: 397). Sayers further found that these attitudinal differences were found to be much more marked in examination classes, and in classes taught by male teachers.

3.5 Sociological explanations

Researchers in this area have considered that gender differences in mathematics achievement resulted from boys and girls being socialised differently. The socialisation process encouraged boys' superiority in mathematics. This explanation contrasted with those that claimed differences were due to girls' innate disability at mathematics. Sociological explanations varied considerably. For example, while some researchers (e.g. Peters, 1992) suggested that gender differences in mathematics stemmed from differential toys and play behaviours of boys and girls, other researchers (e.g. Baker & Jones, 1993; Ho et al, 2000) attributed the differences to variations in the gender stratification of educational and occupational opportunities in adulthood. Other sociological explanations for the differences included: teachers' differential beliefs and expectations about girls' and boys' abilities in mathematics (Fennema et al, 1990); differences in patterns of teacher interactions with male and female students, school policies, timetabling and examination policies (Burton, 1986); single-sex versus co-education type of school organisation (Harker, 2000; Hiddleston, 1995); the nature of the subject and examination questions (Northam, 1986). Some of these explanations are briefly reviewed below.

(a) Educational and employment opportunities in adult life

Some researchers have explained that girls' low achievement in mathematics was due to their perceiving few opportunities for women in higher education and in the labour market. Baker & Jones (1993) compared mathematical achievement for male and female eighth grade students across 19 countries using data from the Second International Mathematics Study. They found considerable cross-national variation. For instance, seven countries had male advantage, eight countries had no significant differences between the sexes and four had female advantage. Baker & Jones attributed gender variations in achievement among countries to cross-national variations of gender stratification of opportunities. In their study, they found that countries with greater opportunities for women's access to higher education and the labour market had smaller gender differences in mathematics achievement than students from countries with fewer opportunities. Baker & Jones also investigated whether gender differences in mathematics performance had declined over time to match a concurrent trend toward decreasing gender stratification of opportunity within society itself. They compared data for nine countries from the First International Mathematics Study completed in 1964 with data from SIMS completed in 1982 and reported that the gender gap appeared to be getting smaller over time. Ho et al (2000) offered a similar explanation for their differential findings between Taiwanese and the People's Republic of China samples; gender differences were found amongst the Taiwanese sample but no gender differences were found amongst that of the People's Republic of China. They attributed the lack of gender differences amongst the Chinese sample to the one-child policy which they claimed had resulted in improved educational and economic opportunities for women.

The view that fewer opportunities for higher education have an effect on the achievement of girls may partially explain the low achievement amongst students in Malawi. Only a small proportion of students who complete secondary school in Malawi proceed to tertiary level education due to limited places (chapter one). This view, however, did not explain why limited opportunity for higher education and opportunities for jobs in adult life should affect the achievement of Malawian females more than their male counterparts. There must be factors that prevent Malawian females from achieving in mathematics, other than the limited opportunity for higher education.

(b) Differential Coursework View

The differential coursework hypothesis, in its most extreme form, stated that no gender differences in mathematics would be found if females were to take the same number of mathematics courses as males. The hypothesis originated from the fact that some studies found no gender gap between male and female students on Scholastic Aptitude Test mathematics items when students' differences in the number and level of high school mathematics courses studied were taken into account (Byrnes, Hong & Xing, 1997; Pallas & Alexander, 1983; Tate, 1997). Several studies have considered the differential coursework hypothesis as a possible explanation for gender differences in mathematics performance. Byrnes et al (1997) used the differential coursework view to explain their finding of lack of gender differences on the SAT mathematics test among the Chinese sample. Byrnes et al explained that because Chinese males and females took the same mandatory courses in high school, whereas American males took more mathematics courses than their female counterparts, the differential coursework view best explained the finding of their study that gender differences did not emerge among the Chinese sample while significant gender differences were found among the American sample. The differential coursework view has, however, been challenged by some researchers (Benbow & Stanley, 1982) who found gender difference at the seventh-grade level when formal mathematics was similar for boys and girls.

According to the differential coursework argument, no gender differences at primary and secondary school level in Malawi should be expected because mathematics was compulsory at these levels; that is, all students studied the same mathematics courses. But this was not the case; significant gender differences were found at both the primary and secondary school levels (Chimwenje, 1998; Khembo, 1991), although the gender gap in mathematics closed at tertiary (Hiddleston & Nicolson, 1994)— a period when students opted for different mathematics courses. The differential coursework hypothesis did not seem to explain the gender differences in mathematics in Malawi. It might be that boys and girls had different experiences in the mathematics classrooms and that these differences led to gender differences in their performance.

(c) Differential teacher-student interaction pattern

Considerable research has examined teacher-student interaction patterns in mathematics classrooms (Chionidou-Moskofoglou & Papadopoulos 2000; Howe, 1997; Leder, 1990; Rennie & Parker, 1997; Wickett, 1997) to determine explanations for gender differences in mathematics achievement. This research has assumed that girls' low achievement in mathematics resulted from teachers' differential behaviours towards boys and girls. Findings from such studies have mostly shown that in mathematics classrooms, a disproportionate number of quality and quantity teacher-student interactions occurred with boys, and that boys tended to dominate resources and classroom discourse. For example, Chionidou-Moskofoglou & Papadopoulos (2000) found from their classroom observation study involving 10 university student-teachers and six (3 boys and 3 girls) high achieving 11-12 years old sixth graders in a Greek primary school that the teachers initiated many more interactions with the boys than with the girls (129 v 62 times), asked many more mathematics questions of boys than of girls (47 v 11 times), positively reinforced boys many more times than girls (22 v 4 times), but tried to offer help many more times to girls than to boys (22 v 7 times). Gender differences in teacher-student interactions had also been found in some studies of American classrooms (Hart, 1989; Wickett, 1997), and Australian classrooms (Leder, 1990; Rennie & Parker, 1997). In the United States, for example, Wickett (1997) found from her study that the boys were more likely to be given the first opportunity to answer a mathematics question than girls were. The findings from observation studies reported above were further supported by research done from the students' perspective of their mathematical learning environment. Rennie and Parker (1997) reported that girls perceived that they had less interaction with the teacher for instructional purposes in mixed-gender mathematics classrooms.

A number of explanations have been considered for the differences found between girls' and boys' interactions with the teachers. These include teachers interacting with boys more than girls to avoid classroom disruption and inattention by boys, girls being less assertive than boys, and teachers believing that the class would benefit from the boys' contribution to the class discussion (Hart, 1989; Rennie & Parker, 1997; Wickett, 1997). For example, Wickett (1997:104) wrote:

> "The boys I usually called on first were bright, enthusiastic, verbal, and wriggly. Their behaviour caught my attention, and I think I may have called on them partly to control behaviour. I knew the others— the girls, the first-year students, and the second–language children would wait. I also believed these boys had a lot to contribute to the discussion. Sometimes their comments triggered the thinking of other students."

Feminist scholars have argued that such classroom interaction patterns have resulted in greater opportunities for boys than girls to learn in mathematics. They have argued that offering more help to girls than to boys may have conveyed the message that girls were not as smart as boys so they needed more help from the teacher. However, some evidence suggested that although the findings on gender differences in classroom interaction patterns were consistent, the influence of these experiences on students' attitudes and achievement in mathematics was not yet clear (Hart, 1989; Koehler, 1990). For example, Koehler (1990) found no relationship between the differential treatment of boys and girls and their achievement.

The lack of a relationship between teacher-student interaction and achievement found in some studies may have reduced support for the hypothesis that gender-related differences in mathematics attitude and achievement in favour of male students were mainly the result of teachers interacting with male students more than female students. The findings may, however, have supported some recent research in cognitive developmental theory which have emphasised that it was not the amount of interaction *per se* that was beneficial for the construction of mathematics, but rather the cognitive level of what was being actually discussed (see section 4.5 of this thesis). Most of the studies cited above showed that the majority of the teacher-student interaction with boys were concerned with controlling boys' inappropriate behaviour and not necessarily about mathematics.

3.6 Intervention strategies

The explanations for girls' lower achievement in mathematics reviewed above led some educators to suggest intervention strategies aimed at improving the achievement and retention of girls in mathematics. The interventions were as varied as were the explanations for the girls' low achievement in mathematics. They included:

(1) teaching girls some spatial skills to improve their mathematical problem solving skills (Connor & Serbin, 1985),
(2) helping girls' become less anxious, and more confident through "career fairs" and female role models (Lantz, 1985; Rogers, 1985; Tobin & Fox, 1976),
(3) running special mathematics courses for girls to increase their mathematics knowledge and skills, such as SummerMath (Morrow & Morrow, 1995), and The METRO Achievement programme (Thompson, 1995),
(4) using single sex mathematics classrooms (Forgasz & Leder, 1996; Norton & Rennie, 1998; Rennie & Parker, 1997),
(5) inservice programmes designed to sensitise teachers, curriculum planners, textbook publishers, examination boards, to some gender stereotypic practices believed to affect the girls' learning of mathematics (Stage, Gilliland, Kreinberg & Fennema 1983; Okeke, 1987), and recently,
(6) the use of inclusive instructional strategies and materials (Jacobs & Becker, 1997; Rogers, 1995; Solars, 1995).

Willis (1995) argued that the underlying assumption for most of the intervention strategies listed above was a deficit view of girls. She explained that because most of them focused on changing girls by improving their achievement, attitudes, confidence, self-esteem, or altering their educational and career choices, they may have suggested that there was something lacking or in need of reconstruction in girls. Such approaches for gender reform have been criticised by many (Boaler, 2000; Kaiser & Rogers, 1995; Mayo, 1994; Mura, 1995; Willis, 1995) for assuming that it was girls and women who had to change, while the mathematics itself and the pedagogy used to teach it remained unquestioned. It was not surprising, therefore, that most interventions were found to have either no effect on females' learning of mathematics, or that any positive effect was either temporary or extremely costly (or both), and difficult to implement on a large scale (Kahle & Meece, 1994; Lantz, 1985). Such approaches would not be appropriate for Malawi considering that, economically, Malawi's development plans are supported mainly through donor aid and it would therefore be difficult to sustain such interventions.

3.7 Towards a broader perspective

The studies reviewed above showed that no one explanation of girls' underachievement in mathematics received unequivocal support. This has led an increasing number of educators and researchers to perceive the complexity of the issue, and recognise the need to address it in a holistic manner, that is, to take into account the girls (and boys), the curriculum, the learning environment, the wider social context, and research perspectives from different disciplines (Boaler, 2000; Fennema, 1996). In this study, I concur with the views of researchers who have suggested using pedagogical practices that are sensitive to (the presumed) interests of girls (and boys), their ways of knowing and working, and students' prior experiences, as an important strategy for redressing the problem (Jacobs & Becker, 1997; Solar, 1995). In support of this, several reviewers of intervention strategies have concluded that altering instructional approaches was the most promising intervention strategy (Kahle & Meece, 1994; Lantz, 1985; Leder, Forgasz & Solar, 1996). Examples of such instructional approaches are discussed in the next chapter. In line with this, teaching approaches based on social-constructivist and feminist ideas may have the potential to improve the learning of all students in mathematics. In the remainder of the chapter I discuss why such approaches seem promising in achieving equity for all. In doing this, I discuss (a) how social constructivism approaches the issue of gender from a pluralistic view, and (b) provide evidence from research findings that intervention programmes that have attempted to use instructional methods consistent with the social constructivist and feminist views of learning of mathematics have been successful in improving girls' confidence and achievement.

(a) Social constructivism and the multivariable approach to achieving equity

Past research on gender issues has been criticised because of its tendency to consider just one or two variables at any one time (Boaler, 2000; Fennema, 1996). A pluralistic view of gender issues must accept that several factors impact on students as they are learning mathematics, for example, the nature of students as individuals, students' prior knowledge, students' interest in mathematics content, their preferred style of learning, the way the subject is taught, race, class, power relations and other classroom dynamics, and the wider social context. In a social constructivist learning environment, variables such as these are sure to be addressed.

Social constructivism accepted that learners constructed their own knowledge but that knowledge was developed and influenced by their social experiences and interactions

(Abreu, 2000; Cobern, 1998). The use of classroom pedagogy that reflected the social-constructivist's views of how students learned mathematics seemed to be promising for promoting mathematics for all. For example, Scantlebury (1998) discussed in detail what social constructivism might mean regarding the role of the teacher in the areas of (i) knowledge making, (ii) curriculum making, and (iii) teaching and learning, for those concerned with gender issues in science. Very broadly, Scantlebury explained that from a constructivist perspective, teachers were required to reflect upon and re-construct (a) their perceptions of gender-role stereotypes and how these perceptions may influence their differential treatment of girls and boys in the classroom, (b) their own curricula to determine if class materials reflected the precepts of a gender-laden education rather than being gender-sensitive, and (c) their teaching practices to include the students' different preferred learning and teaching styles. Although Scantlebury's discussion was mainly based on science education, her arguments regarding knowledge making, curriculum making and teaching and learning in an enhanced gender-sensitive classroom climate apply equally to mathematics education.

Social constructivism and knowledge making

Current scholarship in mathematics education has provided insights regarding the conflict between women's ways of knowledge making and the traditional way of knowing in mathematics. The work of Belenky et al (1986) has been particularly illuminating in this area. Their work showed that many women had a relational, connected approach to knowing where personal experience, intuition, induction, creativity and context were a major vehicle through which knowing something takes place (Belenky et al, 1986). Buerk's (1985) study revealed that it was this connected dimension of mathematics, often left out of mathematics education, that discouraged women from learning mathematics. Feminist scholars have used this insight to challenge the traditional way of knowing in mathematics for assuming that the only knowledge accepted as valid was that which was based on deductive logic (Becker, 1995; Buerk, 1985). They have argued that such mathematical practices contribute to the difficulties that females had in accessing mathematics knowledge because their ways of organizing and making sense of the world were incongruous with the way mathematics was presented. They have suggested that the mathematics education of all students might be enhanced if the subjective, intuitive, emotive, and creative aspects of knowledge making were also recognized as valuable knowledge for students to acquire (Buerk, 1985; Becker, 1995; Jacobs & Becker, 1997; Rogers, 1995).

The constructivist view of learning provides mathematics teachers with a theoretical framework to recognize and value students' different ways of knowledge making. Constructivism as a theory of knowledge suggests that learners construct their own knowledge of the world in which they live. Because students' schema regarding gender, race, and class are some of the perspectives from which students interpret the world and their role in it (Scantlebury, 1998), accepting a constructivist view of knowledge making would mean that the students' different modes of reasoning (e.g. objective logic as well as subjective intuitive), resulting from their varied perspectives and interpretations of the world, would be recognised and valued.

Constructivism and curriculum making

Feminist critiques of mathematics curricula have drawn attention to the masculine way in which mathematics has tended to be defined, organized and taught (Fennema & Carpenter, 1998). Mathematics has been characterized as unrelated to the interests of girls, has little connection to relationships, placed emphasis on the impersonal and objective, and dealt with things not people (Toomey & O'Donovan, 1997). For example, Toomey and O'Donovan's (1997) case study of Annie showed that, despite being a good mathematics student, Annie decided to drop mathematics because she found it most unfulfilling, not relevant to her future, and not worth the effort. In line with such findings, feminist scholars have attributed the slow progress towards gender equity in mathematics to past researchers' tendencies to focus on answering the research question, "What is wrong with girls?" instead of the question, "What is wrong with Mathematics?" (Rogers, 1995). One of the suggestions for achieving equity in mathematics originating from such a perspective was revision of the mathematics curricula so that it became more appealing to the girls. However, some scholars have argued that despite such a call, little has been achieved because research in science and mathematics was tied strongly to the economics and political discourse of Western countries, and that restructuring mathematics would require a fundamental change in these dominant discourses (McComish, 1995; Zevenbergen, 1994).

In this study, I concur with the views of Fennema (1996: 21) that one way to approach the problem of a gendered mathematics is to look not at the subject, but at the way people think and learn within the subject and also at the teachers' role. Because teachers have the power to choose the teaching activities and assessment procedures in their classrooms, adhering to constructivist views of learning would require teachers to consider learning experiences that interest their students.

Constructivism and teaching and learning

One suggestion for promoting equity in mathematics education that has recently gained support was for teachers to use varied instructional strategies that were consistent with the students' different preferred learning styles (Boaler, 2000; 1997). From a constructivist perspective teachers were expected to use a variety of teaching styles according to the students' experiences because constructivism as a theory recognises that the knower, teacher and knowledge produced are inseparable (Scantlebury, 1998). Further, because reflexivity was central for those adhering to constructivism (Artzt &Armour-Thomas, 1999; Davis, 1997), teachers should continuously reflect on their teaching practices and attitudes, especially those that may negatively impact on their students. Support for this notion was provided by Wickett (1997) who, by reflecting on her own teaching practices, managed to uncover some of her gender biases and changed the dynamics of discussions in her classroom to include girls.

(b) Research related to social constructivist teaching

Evidence from research findings has so far shown that intervention programmes that have attempted to use methods that actively engaged students in learning mathematics had been successful in improving girls' confidence and achievement (Adedayo, 1999; Boaler, 2000; 1997; Carpenter, Franke, Jacobs, Fennema & Empson, 1998: Fuson, Carroll, & Drueck, 2000; Kahle & Meece, 1994; Scantlebury, 1998; Wood & Sellers, 1997). Boaler (2000; 1998; 1997) found that girls in a school that used an open problem-solving teaching approach developed increased confidence and enjoyment of mathematics, and attained statistically significant higher grades on the GCSE examination than girls in a school with a similar population using a textbook-based traditional approach. These latter girls were found to be less confident and felt that they were not given a chance to understand. The girls at the school that used an open problem-solving teaching approach related their satisfaction to the opportunities they received to explore, use their own ideas, conjecture and reflect. In contrast, many of the students, particularly the girls, from the school that used a textbook-based traditional approach reported that they were disaffected because they wanted to be able to understand mathematics and they felt unable to do so in a competitive, closed environment. Boaler further found that although the majority of the boys at the traditional school also preferred a more open, reflective approach, in the absence of this they seemed able to adapt to a system they did not like, but which gave them high grades. The finding of girls having preferences and requirements for a depth of understanding was also found in a subsequent study involving some United States secondary school students (Boaler, 2000). Other research studies have reported similar equitable gains for boys and girls in their confidence, problem-solving and conceptual understanding in mathematics as a result of open approaches to mathematics teaching (Carpenter et al, 1998; Fuson et al, 2000). In some studies, this gain was remarkable. For instance, Fuson et al (2000) reported that the Grade 3 students in their problem-centred instructional project showed performance equivalent to or stronger in some mathematical areas than the traditional-textbook seventh graders from a similar population. Fuson and her colleagues did not separate their findings by gender, but there is nothing to indicate that the reported strong gains in performance were different for boys and girls. In fact, a review by Leder et al (1996) of some intervention programmes published in major journals and collected volumes indicated that instructional approaches that actively involved students tended to benefit all students (boys and girls). They wrote,

> "In summary, the best intervention programmes use strategies that are not only effective for females but for all students. They respond to the needs of participants, involve 'hands-on' activities, tutoring, mentoring (or role models), the establishment of some kind of networking among students, between students and teachers, or between students and professionals. That is, a mathematical environment is created in which females are welcome and invited to contribute, a world in which they, and others, believe they can succeed. Active participation is integral to the definition and evaluation of programmes. An atmosphere conducive to collaboration, exchange and dialogue is developed." (Leder, et al, 1996: 974).

A number of different studies have further shown that meaning-based or constructivist approaches to mathematics teaching have resulted in increased achievement, even on standardised (traditional) tests that were not compatible with the teaching approaches used (Boaler, 1998; 1997; Maher, 1991; Sigurdson & Olson, 1992; Thompson & Senk, 2001). This was contrary to the general belief that test scores for students following an open based teaching approach may decline, given the restricted range of topics and behaviours covered on most standardised tests (Maher, 1991; Thompson & Senk, 2001). The reported gains in mathematics learning seemed to result from teaching approaches that offered students the opportunity to work in ways suited to their own preferred learning styles (Boaler, 1998; 1997).

3.8 Summary

In summary, studies of gender differences in mathematics achievement have been fairly consistent about the range of variables that differentiate boys and girls. However, they have been less successful in identifying specific factors that contribute to the improved opportunities for girls' learning mathematics. One of the limitations concerning most of the studies reviewed was that the majority of them were correlational, and thus limited in the evidence they could provide regarding the complex interplay of causal relationships. It has often been suggested that classroom observation studies combined with interviews with students and teachers might provide illumination of the complex interplay between socially constructed variables of gender and school environment, and students' attitudes towards mathematics (Norton & Rennie, 1998). Hence, it is hoped that classroom observation of cooperative lessons might provide insights regarding some experiences that contribute to students' learning of mathematics.

Because no one explanation had received unequivocal support, it appears that a comprehensive approach was needed to understand gender differences in mathematics achievement. Most of the studies focused on the influence of one variable, rather than multiple variables, and treated girls as a homogeneous group without considering their individual differences such as race and socio-economic status. This lack of a multivariable approach may have limited the progress on achieving equity in mathematical achievement (Boaler, 2000; Fennema, 1996; Trentacosta & Kennedy, 1997). Understanding how students learn, and the implication of that for teaching, seemed to have the potential for addressing the gender issues in a holistic manner. In particular, teaching strategies that built on socio-constructivism and feminist theories seemed to be promising. One such strategy that drew from both socio-constructivism and feminist theories was a cooperative learning approach. The next chapter provides a review of studies on cooperative learning.

Chapter four

Literature Review on Co-operative Learning

4.0 Introduction

I concluded in chapter two that co-operative learning seemed to be one element of a social constructivist approach that may have the potential for improving the learning of girls in mathematics. Co-operative learning was not a new idea in education. It dated back to as early as the first century (Johnson & Johnson, 1999a). Since then, a variety of different terms referring to forms of co-operative learning have appeared in the literature. Currently, co-operative learning is a very active research area in education (Johnson & Johnson, 1999a; Suri, 1997). In this chapter I review the literature on co-operative learning and, in particular, social interaction during co-operative activities because the social-interaction element is clearly related to the social constructivist and feminist views of learning which inform this research. From a constructivist perspective, students' interactions with one another, with the learning material, and with the teacher were considered significant activities for effective learning (Leikin & Zaslavsky, 1997).

As other researchers (Slavin, 1980; Suri, 1997) have found, the review of literature on co-operative learning was not easy; studies conducted in this field have a diversity of aims, subject matter, topics, grade levels and study designs. This was exacerbated by the many ways that researchers have defined co-operative learning, and the variety of terminology they have used for essentially the same instructional approach (e.g. co-operative learning, group-work, collaborative learning, team learning). This was further compounded by the fact that sometimes the same authors' ideas about co-operative learning have changed significantly over time. For example, Johnson and Johnson's ideas about positive interdependence in their 1993 publication were significantly different from those in their 1986 publication (Antil, Jenkins & Wayne, 1998; Johnson, Johnson & Holubec, 1993). Given that the different studies appeared to have used various models of co-operative learning that were different in their assumptions about the nature of teaching and learning, and about the role of teachers and students in co-operative learning, a definition of how I used the term co-operative learning in this study was important if the conclusions drawn from this research were to be accessible to others. The remainder of the chapter is divided as follows:

4.1 Definition of co-operative learning
4.2 Co-operative learning and social constructivism
4.3 Co-operative learning and feminism
4.4 Positive outcomes of co-operative learning
4.5 Productive co-operative small group interactions
4.6 Factors affecting interaction
4.7 Summary

4.1 Definition of co-operative learning

Most scholars have used the term 'co-operative learning' to refer to classroom techniques in which students work on learning activities in small groups (Artzt & Newman, 1990; Johnson & Johnson, 1999a; Slavin, 1980). There has also been a general consensus among scholars that co-operative learning involves more than just putting students together in small groups and giving them a task—certain features have to be present for a group-work arrangement to qualify as co-operative learning. Despite such agreement on the existence of certain features in co-operative group work, scholars have varied considerably in the criteria they have used to classify group-work as co-operative learning. For example, Davidson (1990) noted in his introductory chapter of the book he edited, that the authors of the various chapters of the book differed in their ideas regarding which attributes were critical for small-group co-operative learning. Davidson noted that the authors generally agreed on the requirements of (i) face-to-face interaction, (ii) individual accountability, (iii) mutual helpfulness within the group, and (iv) a mathematical task for group resolution. The authors differed on whether (v) heterogenous or random grouping, (vi) explicit teaching of social skills, and (vii) structured mutual interdependence, were necessary for a group to be considered co-operative. The most common defining characteristics of co-operative learning were contained in the Johnson and Johnson's list of five basic elements of co-operative learning. These five elements were:

1. **Positive interdependence**: This is when group members perceived that they were linked with other group members in such a way so that they could not succeed unless group-mates do. Johnson and Johnson explained that positive goal interdependence could be promoted by giving joint rewards (e.g. giving 5 bonus points to each member if all members of the group score 90 percent or above), divided resources (e.g. giving each group member a part of the total information required to complete an assignment), and complementary roles (e.g. checker, encourager, elaborator).
2. **Individual accountability**: This is when students recognised that they were accountable for their own learning. No one else could do the learning for them. The idea is that students learned together so that they could subsequently perform higher as individuals. According to Johnson and Johnson, common ways to structure individual accountability included (a) giving an individual test to each student, (b) randomly selecting one student's product to represent the entire group, or (c) having each student explain to a classmate what she or he has learned.
3. **Face-to-face promotive interaction**: This involved individuals promoting each other's success by discussing the material with each other, helping and assisting one another to understand, supporting and encouraging each other to work hard, and praising each other's efforts to achieve. To promote face-to-face interaction, the size of the groups needed to be small (2-4 members).
4. **Social skills**: This required group members to display some interpersonal skills such as leadership, decision-making, trust-building, communication, and conflict-management skills.
5. **Group processing**: This required group members to discuss how well they were achieving their goals and maintaining effective working relationships, that is, they should be able to identify actions that are helpful and unhelpful and make decisions about what behaviours to continue or change.

Some researchers (e.g. Antil, et al, 1998; Slavin, 1990) have argued that Johnson and Johnson's last three criteria were not essential if positive (reward) interdependence and individual accountability were in place. Slavin (1990) explained that within the positive reward interdependence structure, individuals could increase their chances of being rewarded by either working hard themselves, or by influencing or helping their group-mates to do their best, so it followed that group members would be motivated to help one another to be successful, and would facilitate one another's performance with whatever means they had. Contrary to this, Cohen (1994) argued that reward interdependence was not necessary. Instead, she recommended that "propositions be conditionalised on whether or not the assignment given to the group is a true group task and whether or not it is a problem with an ill-structured solution" (Cohen, 1994: 30).

Such differences regarding which elements were critical for the optimum functioning of a co-operative small-group have been attributed to the differences in the theoretical perspectives underpinning the various conceptions of co-operative learning (Cohen, 1994; Springer et al, 1999). For example, scholars who have based their co-operative learning in the motivational theories tended to emphasise group reward systems and individual accountability, whereas social theorists valued positive intergroup relations. The rationale for implementing group rewards was that if students valued the success of the group, then they were likely to encourage and help one another to achieve (Springer, Stanne, & Donovan, 1999). On the other hand, social theorists were more concerned with the desirable prosocial behaviours, such as being friendly towards students of minority groups; thus positive intergroup relations tended to be emphasised (Cohen, 1994). A discussion of theoretical perspectives and their relation to the type of interaction that is considered desirable is taken up further in section 4.5 of this thesis.

As pointed out in the introduction, different names have been used in the literature to refer to forms of group-work learning. Researchers have tried to clarify this confusion by using different terms to distinguish between various group-work arrangements, according to the quality of engagement fostered. A growing literature has distinguished between co-operative and collaborative learning. Co-operative learning has usually been defined as an arrangement which allowed teams of students to divide a task, master its separate parts and then combine the results into a final product, whereas collaborative learning has been defined as the interaction that occurred when team members shared their ideas in order to jointly solve a problem (Damon & Phelps, 1989; Springer et al, 1999; Underwood, 2000). Goos (2000) has argued that the distinguishing feature of collaborative learning is *mutuality*— a reciprocal process of exploring each other's reasoning and viewpoints in order to construct a shared understanding of the task.

In this thesis, the term co-operative learning is used broadly. It incorporates the orientations of both co-operative and collaborative learning. I have defined co-operative learning as 'small groups working together to achieve a common goal'. In achieving that common goal, the members of the group may choose to split up the work and share their results afterwards, or they may jointly solve the problem. This view is similar to the definition of collaboration offered by Scanlon (2000: 465) as "a co-ordinated attempt to solve and monitor a problem together, with perhaps some division of labour on aspects of the problem". I have chosen to use the term 'co-operative learning' in preference to 'collaborative learning' because it was the term that the teachers involved in the study seemed to be familiar with. However, at times similar terms such as 'group work' are also used.

4.2 Co-operative learning and its place in social constructivism

A co-operative learning approach has the potential to encourage a *constructivist learning* environment as it (i) provides opportunity for learners to reflect, (ii) promotes personal autonomy, and (iii) provides a diagnostic tool that allows teachers to uncover what is going on inside the heads of learners. These qualities are discussed in detail below.

Promotion of reflection

When students work in groups co-operatively, they have to verbalise how they see the problem and how they propose to solve it. This very act of verbalising their views promotes reflection which then leads to reorganisation of their ideas (von Glaserfeld, 1993; Wheatley, 1991).

Promotion of autonomy

Constructivists hold that [mathematical] knowledge results from individual constructions as modified by experience. Many educationists have asserted the importance of personal autonomy in the process of construction (Confrey, 1990; Wheatley, 1991). In co-operative learning, opportunities exist for students to talk about mathematics to each other, for meanings to be negotiated and consensus reached. In this way, the students do not look to the teacher/authority for sanctioning and this encourages intellectual autonomy (Wheatley, 1991).

Promotion of identification of learners' constructions

Constructivists believe that children's actions are rational to them and that as teachers we must try to make sense of their meanings (Cobb, Wood and Yackel, 1990: 132). From a constructivist perspective, teachers' knowledge of students' constructions (patterns of thinking, systematic errors, persistent misconceptions) is vital in devising appropriate teaching activities (Begg, 1995; Noddings, 1990). Many mathematics educators recognise the power of the one-to-one relationship between teacher and students in investigating the processes by which a student constructs mathematical knowledge (Cobb, Wood, & Yackel, 1990). But because teachers have to work with many students (50 students on average in Malawian classes), the use of small groups in co-operative learning within a class is recognised as a way that approximates the one-to-one relationship (Cobb, Wood, & Yackel, 1990; Maher & Alston, 1990). By the nature of co-operative learning, students are continuously communicating their strategies to one another. By listening to students talking to each other in groups, the teacher too is able to learn of individual students' constructions of mathematics.

4.3 Co-operative learning and its place in feminism

A number of teaching strategies have been suggested from a feminist perspective and are usually referred to as feminist pedagogy. Since feminist theories are numerous, a variety of feminist pedagogies exist. Most of the feminist pedagogies suggested for mathematics (Becker, 1995; Rogers, 1995; Solar, 1995) has been influenced by the work of Belenky et al (1986) which suggests that women and men have different ways of knowing and thus prefer different ways of working. For example, women tend to value connected knowledge which is characterised by subjectivity, intuition, and a desire to maintain relationships, while men tend to value separate knowledge which is characterised by objectivity, reason, logic, and an appeal to justice. Feminist pedagogy seemed to take the position that the traditional expository approach to teaching mathematics has disadvantaged girls in that it encouraged separate ways of working, disempowered them, and did not encourage them to take ownership in the creation of their mathematics (Becker, 1995; Rogers, 1995; Solar, 1995). They instead suggested a pedagogy that:

- emphasises the need to 'break the silence' by giving all women the right to speak
- makes women active participants in their learning
- empowers girls and gives them a sense of ownership of the subject.

The co-operative learning approach is a pedagogy that has the potential to create a learning environment that promotes the above characteristics. Within a co-operative learning class, both females and males are encouraged to participate actively, and work co-operatively without competing with one another. It is hoped that within small co-operative learning groups, girls will feel more able to express themselves than they would in front of a whole class.

4.4 Positive outcomes of co-operative learning

The positive outcomes of co-operative learning strategies have been documented in studies conducted at all grade levels and in all subject areas. Co-operative learning strategies have been credited, among other things, with the promotion of critical thinking (Qin, Johnson, & Johnson, 1995), desirable social and affective goals, and race relations (Lou, Abrami, Spence, Poulsen, Chambers, & d'Apollonia, 1996; Sharan, 1980; Slavin, 1995). In his review of 28 co-operative learning studies, Slavin (1980), concluded that overall, in comparison with traditional methods of instruction, co-operative learning methods produced significant positive effects on such things as student achievement, race relations, mutual concern among students, and self-esteem. In a more recent synthesis of "best evidence" taken from studies of secondary school mathematics only, (Suri, 1997) confirmed earlier findings that co-operative learning had an overall positive effect in the cognitive domain as well as the social and affective domains. Similar results were found in a meta-analysis of studies involving students at tertiary level (Springer, Stanne & Donovan, 1999).

Despite the significant overall positive effects of co-operative learning in many studies, several researchers (Davidson, 1985; Lou et al, 1996; Suri, 1997) have also highlighted the inconsistencies in effectiveness between the individual studies. For example, Suri (1997) found that differences in variables such as duration of the study, form of co-operative learning method used, grouping criteria, and number of students in each co-operative group, produced different levels of positive effects. Similarly, Davidson (1985) summarised his review of co-operative learning studies as follows:

> "Considering all the studies comparing students achievement in small-group instruction and traditional methods in mathematics, the majority showed no significant difference. When significant differences were found, they almost always favoured the small-group procedure.... The issue of student attitude toward the subject matter and the method of instruction is rather clouded. In some studies, students preferred small-group treatment, and in others, they preferred a large-group treatment." (Davidson, 1985: 224).

In addition, different average effect sizes (calculated by subtracting the control group's average score from the experimental group's average score and dividing the difference by the average of the two standard deviations) have been found by different meta-analyses. For example, Suri's (1997) review of 29 studies reported an average effect size of +0.63, Springer et al's 1999 review of 39 studies reported an average effect size of +0.51, Slavin's (1987) review of 7 studies reported an average effect size of +0.32, while Lou et al's (1996) review of 66 studies reported an average effect size of +0.17, favouring co-operative learning. Lou et al attributed the differences in the findings of effect sizes to the differences in the number of studies used in each review (7 in Slavin, 1987 and 66 in Lou et al, 1996). Other scholars (Bossert, 1988; Cohen, 1994) have, however, argued that most of the discrepancies reported in the literature were due to the fact that most studies employed a "black box approach" in which they compared a co-operative learning instructional methods to non co-operative learning methods on outcomes alone without considering the conditions in which various co-operative learning activities produced their positive effects. Not surprisingly, most researchers concluded with a caution against the generalisation that co-operative learning was effective in all learning situations (Suri, 1997). A consistent recommendation advanced from the variability in findings reported above has been a call for researchers to progress beyond the question of effectiveness of small group learning to observational studies that examined conditions under which the use of small group learning might be productive (Cohen, 1994; Webb, 1985). The nature of interaction taking place within small-co-operative groups has been the focus of most such studies that have responded to the call.

The remainder of this discussion focuses on studies that have compared processes of interaction with learning outcomes. The purpose is to highlight the features of interaction that appeared to be important for producing positive learning outcomes and to understand the factors that promoted such interactions.

4.5 Productive co-operative small group interactions

Most researchers who have studied co-operative learning small-group interactions have noted that not all peer interactions were productive for the social construction of knowledge (Barnes, 2000; Cohen, 1994; Goos, 2000; Scanlon, 2000; Webb, 1985). This type of research has compared the patterns of interaction displayed by groups considered successful with the patterns displayed by unsuccessful groups. Findings from such studies have shown that successful groups demonstrated different patterns of interaction from unsuccessful groups.

Despite the shared view among researchers that not all interactions were productive, the researchers varied considerably in their propositions regarding the type of interaction considered to be productive, and thus desirable. Cohen (1994) and Springer et al (1999) argued that this was possibly due to the fact that co-operative small-group learning did not follow from a single theoretical perspective. Springer et al (1999), for example, noted that conceptual frameworks for small group learning were rooted in such disparate fields as philosophy of education, cognitive psychology, social psychology, humanist and feminist pedagogy. This section will focus its discussion of productive peer interaction within the constructivist and feminist perspectives as these are central to the present study.

Constructivist perspective of productive peer interaction

Researchers who have taken a Piagetian constructivist perspective of knowledge and knowing contended that productive peer interactions were those that engaged students in the resolution of conflicts (Abreu, 2000; Howe & Tolmie, 1999). As such they tended to emphasise face-to-face interaction that involved mathematical disagreements, debates, questioning or challenging each other's ideas, and arguments to be important for conceptual development (Scanlon, 2000; Wilkinson & Martino, 1993; Wood, 1999). Van Boxtel et al (2000) explained that such interactions were considered valuable for learning because they tended to generate explanations, justifications, reflection and a search for new information, which stimulated reorganisation, awareness of knowledge gaps and inconsistent reasoning, which in turn resulted in conceptual developments.

Abreu (2000) reviewed some studies (particularly focusing on the work of Perret-Clermount and her colleagues) that had attempted to apply Piaget's ideas in investigating interaction and conceptual development. Her review revealed that such studies

> "consistently showed that peer interaction was an opportunity for progress, particularly when it involved confrontation with a different solution, correct or incorrect" (Abreu, 2000: 11).

Similarly, the findings reported by Howe and Tolmie (1999) indicated that peer interaction was more productive when students with different prior conceptions regarding the topic to be learnt were grouped together than when students with similar views were grouped. Howe and Tolmie further used correlation techniques to determine particular features of interaction that were related to conceptual gain. They concluded from their analysis that the single most important element of productive interaction was discussion of individual group members' conceptions of the material in hand, particularly when group members coordinated their ideas across problems to form a more generalised understanding. Howe and Tolmie used Piaget's theory to explain that conceptual growth resulted from students experiencing and considering conflicting ideas via discussion.

Wilkinson and Martino (1993) also took a Piagetian perspective to describe an optimum style of interaction that was thought to be related to conceptual growth. Their analysis of the peer interaction of four students involved in their study showed that the student whose mathematics had improved most was the one who had the highest participation score, made the most demonstrations (e.g. referring to some objects, or reading part of the problem or counting), and initiated the most disagreement moves.

Some scholars (e.g. Kuhn, 1992; Pryor, 1995) have, however, cautioned against a general assumption that creating conflict or argument situations promoted learning. For example, Pryor's (1995) study suggested that whilst some children were able to cope with disagreement leading to discussion and debate in a positive way, others (especially boys) saw disagreement as arguing and tried to avoid it. A study by Wood (1999), however, showed how such students' negative reactions to mathematical disagreements could be minimised by the teacher's ability to create a conducive environment in which students could feel safe to participate in disagreements. Wood's (1999) study demonstrated how a teacher might organise the interactions in the classroom in such a way that it not only legitimised the existence of mathematical disagreements but also established some 'social norms' defined as "the expectations and responsibilities to which members agree to adhere". The teacher in Wood's study achieved this by stating, with the help of examples:

- that she expected that disagreement would occur because each student was an individual who would have a unique way of thinking about mathematics, students would express disagreement in ways that would not hurt the feelings of others, and when others disagreed with them, they would not interpret that disagreement as personal criticism;
- her expectations that as listeners they were to do more than pay attention and listen politely; they were expected to take an active role and to take responsibility for assisting others in making sense of mathematics. They were expected to voice their disagreement and to provide reasons for disagreeing.

By explicitly stating the above, the teacher implicitly created a context not only for enquiry, but also for argument. Wood explained that such classroom social norms enabled pupils to engage in disagreement with one another and to direct their cognitive activity to make sense of their mathematical experiences without having to worry about their social setting.

In contrast to focusing on conflict as a strategy for students' conceptual growth, others (Brown & Renshaw, 1999; Goos, 2000; Leikin & Zaslavsky, 1997) have used Vygotsky's concept of 'zone of proximal development' to focus on 'scaffolding', in this case meaning the mutual support that students give each other during co-operative group tasks. From this perspective, most researchers have focused on peer interactions that related to help-receiving and help-giving behaviours within the group (Leikin & Zaslavsky, 1997; Webb, 1995). Such interaction has been considered to promote learning since it provided an opportunity for students to play the role of a teacher and offered explanations to their peers (Leikin & Zaslavsky, 1997). Webb (1985), in trying to understand the characteristics of peer interaction related to mathematics learning, reviewed several studies that examined the relationship between student interaction and achievement in small group learning. She found that the degree of elaboration of help given was a critical feature of peer interaction. Students who gave high-level elaboration (for example, by explaining to their team-mates and giving extended answers) showed higher achievement than those who did not. In her later writing, Webb (1995) explained that giving explanations promoted one's own understanding because of the clarifying, organizing, and reorganizing of material that were part of giving explanations. Glaser (1991) also suggested that the quality of students' elaboration and self-explanations as they worked through a problem played a critical role in their acquisition of knowledge. This contrasted with giving other kinds of help such as yes/no responses or simple information, which involved little or no reorganisation of material, and therefore had fewer benefits for the help-giver.

Despite the consistent finding that high-level elaboration was related to the learning of the help giver, several scholars (Gooding & Stacey, 1993; Leikin & Zaslavsky, 1997) have noted that the link between receiving help and learning was a more complex matter. Webb (1995) hypothesised that to be effective for learning, help must be timely, relevant, of sufficient elaboration, understood by the recipient, and applied by the recipient to the problem at hand. Webb stressed that failure to meet even one of these conditions could make help ineffective for the recipient. In order to test her hypothesis, she analysed data on the verbal student-student interaction and achievement of eleventh-grade students learning novel mathematical problems. The help received was categorised as (i) explanations (high-level elaboration) or information (low-level elaboration), (ii) a match or mismatch between the need and the help received, and (iii) application of the help received, or not. Analysis of the sequences of interaction in the groups showed that students who received adequate help and applied the help they received not always succeeded on an immediate and a later test which, according to Webb, suggested that the two conditions, although necessary, were not sufficient for learning. Webb explained that the students did not perform well on the tests because they may have failed to satisfy the other conditions (understanding the help given, and the timeliness of the help given) for effective help.

Goos (2000) also took a Vygotskian constructivist notion of the zone of proximal development in order to characterise mechanisms of peer interaction of senior secondary school mathematics students over a three year period that contributed to learning. After finding that successful problem solving and unsuccessful problem solving were not distinguished by the amount of verbal interaction that occurred, she conducted a more detailed analysis to identify processes distinguishing successful from unsuccessful interactive activities. The analysis revealed that successful co-operative problem solving sessions occurred if students challenged and discarded unhelpful ideas and actively endorsed useful strategies; unsuccessful outcomes were characterised by students' lack of critical engagement with each other's thinking. She explained that learning occurred when students challenged each other's ideas because the process of explaining "how" and "why" may have prompted students to explore an idea more thoroughly, or step back from a task and recognise a mistake or anomaly. On the other hand, in the absence of challenges, such processes of students' monitoring and regulation were not overt, and were therefore unlikely to lead to successful problem solving.

Feminist perspective of productive peer interaction

From a feminist perspective, the occurrence of equal-status interaction within the small group is considered to be a critical element in small group learning (Cohen, 1994). From this perspective, it is assumed that students, particularly women and members of underrepresented groups, have greater opportunity to be heard and also to learn by participating in non-threatening small group-work environments. Springer et al saw this school of thought as originating from the work of Belenky et al's (1986) Women's Ways of Knowing. More detail about this theoretical model is given in chapter two of this thesis. From this perspective, most researchers have focused on power relationships and issues of domination in the construction of knowledge. Particularly relevant here is Barnes' (1998) model of power and construction of knowledge, in which she claimed that the ways in which power is exercised among a group of students working together on a mathematical activity might influence the construction of knowledge within the group— both the personal understanding of mathematics constructed by each member of the group, and the knowledge which becomes 'taken as shared' within the group. Barnes (1998: 86) explained that this was because there was a high likelihood that in groups with an imbalance of power among members:

> "A good idea may be accepted because of the status of its originator, without the rest of the group understanding its significance or being able to use it independently. Equally, a false or misleading idea may be accepted, and cause a time-wasting digression, or even failure of the group to complete the task satisfactorily."

Barnes' model was supported by several studies showing how students who controlled the discourse of a group's discussion affected other students' learning (Barnes, 2000; Klein, 1998). For example, Barnes (2000), in a study of an Australian city independent coeducational school observed that some collaboration was less effective because of the behaviours of some students who controlled the discourse of the groups' dynamics. A group of five students ("the Mates") exercised considerably more influence on proceedings than the rest of the class. They were highly successful in a variety of sports, were in the same band, had restless and attention-seeking behaviour, tended to move around more, made more noise, and were mostly together. Barnes found in her study that some students, especially the shyer students avoided participating in class discussions for fear of being ridiculed by "the Mates". On some occasions the progress of the whole class was slowed down by the Mates' disruptive behaviour (Barnes, 2000). During small group tasks, the mates tended to position girls as helpers or assistants, or introduced an element of competition to collaborative tasks by vying with one another for their groups to be first finished. They also had a tendency to always want to take a leading role in their groups, or else they frustrated the one leading the group discussions by initiating off-task talks, by displaying unco-operative behaviours (e.g. resting their head on the desk or leaning back in their seat and looking around the room) or by disrupting the group's reporting process (e.g. by interjecting, making jokes, faces or laughing). Such behaviour by the Mates tended to intimidate other students in their learning process.

Similarly, Klein (1998) reported that the mathematical learning during problem solving lessons of the female students in her study was disadvantaged by the attitude and behaviours of the two male students who positioned themselves as superior within the discourse. When the women spoke, the males leaned back in their chairs, arms up and folded behind heads, knees up against the desk. Klein explained that such behaviours presented an authoritative presence which might have negatively affected the females' learning.

4.6 Factors affecting interaction

Several other variables have been investigated to establish if they affected the nature of student-student interaction which in turn might affect the learning outcome during co-operative learning activities. Such variables have included the characteristics of the social group, the nature of the task, and the training of students in co-operative skills. In general, inconclusive findings have been reported by researchers who have tried to explore these factors. These findings are considered in more detail below.

Characteristics of social groups

Researchers concerned with the characteristics of social groups have considered that the social characteristics of the groups were important in predicting the nature of interaction and consequently how much students learned during co-operative group activities. Most such studies have suggested that positive outcomes and different forms of group processes appeared to be associated with the ability (Mulryan, 1992) and gender (Underwood, et al, 1994) composition of the group.

Ability composition of the groups

Most models of co-operative learning have advocated the use of mixed-ability groupings because low-achieving students can benefit from receiving elaborated help from high-achieving students and the high-achieving students can benefit from providing elaborated explanations to their lower-achieving peers (Webb, 1985; Xin, 1996). Several studies have been conducted to explore the relative effectiveness of heterogeneous versus homogeneous-ability groups. Conflicting findings about which group composition was the most effective have been reported. For example, whereas some studies reported that homogeneous groups were more effective (Lou et al, 1996), other studies reported that heterogeneous groups were more effective (Ma, 1996). Others (Linchevski & Kutscher, 1998; Webb, 1985), have shown that it was not a matter of heterogeneous/homogeneous ability *per se* that was important in predicting the nature of interaction within a group, but the *relative ability* within a group (defined as the difference between an individual's ability and the mean of his/her group) that was important. These studies have shown that students of a particular ability level behaved differently in different kinds of groups. Even those researchers who agreed that it was the relative ability that was important, varied in their descriptions of the most beneficial group composition for promoting student learning. For instance, Webb (1985) and Lou et al (1996) found that medium-ability students were less likely to benefit from mixed-ability groups composed of highs, mediums, and lows than when members of the group were relatively homogeneous (mediums only, or mixed-ability of mediums and lows). The proposed interpretation of such findings was that the middle ability students tended to be ignored because the more able pupils were focused on tutoring the less able; this helped the able consolidate their learning, and gave extra help to those who needed it most (Solomon, 1987). In contrast, Linchevski & Kutscher (1998) found that medium-ability students benefited significantly from working in mixed-ability groups but not in same-ability groups.

Gender composition of the groups

Some researchers have suggested that productive social interactions were more likely to occur in single-gender groups than in mixed-gender groups (Underwood, et al, 2000). In general, most studies that have compared interactions in single-gender and mixed-gender groups have reported that girls were more likely to experience interactions that were detrimental to achievement in mixed-gender groups than in single-gender groups (Scanlon, 2000; Underwood, et al 2000; Webb, 1985). As with mixed ability groups, Webb (1985) reported that the achievement and interaction depended on the ratio of females to males in a group. Groups with an unequal ratio, regardless of whether females out-numbered males or were out-numbered by males, were found to have interactions that were detrimental to the females' achievement. In both types of groups, the males tended to ignore the females by not asking them for help and not giving them help. In contrast, the females in groups with an equal number of females and males did not experience this problem of being ignored by males (Webb, 1985). However, this evidence concerning groups with equal number of females and males not being detrimental to females was not found when the size of the group was altered. For example, Underwood et al consistently found in a series of their studies with pairs of students that mixed-gender (Boy-Girl) pairs performed poorly in comparison with either boy-boy pairs or girl-girl pairs (Underwood et al, 2000; Underwood, et al, 1994; Underwood, McCaffrey & Underwood, 1990). Underwood et al (2000) observed that this was due to the fact that the boy-girl pairs interacted with each other in a different way to the boy-boy and girl-girl pairs during the co-operative computer based language task. The mixed-gender pairs tended to co-operate on the level of turn-taking whereas the single-gender pairs tended to talk about the problem, and in particular about alternative ideas for solving the task. Their analysis further showed that the boy-girl pairs tended to display more tensions and antagonistic type interactions than the single-gender pairs. Underwood et al (2000) explained that such interactions had a negative impact on the learning of the girls because they might not have felt free to contribute to the discussions, and their feelings of self-worth might have been affected because of the negative comments they received from their partners.

Such variability in findings indicated that the nature of interaction in a group appeared to depend on a number of interacting factors, and not necessarily on whether the group was single-gender, mixed-gender with majority female, mixed-gender with minority female, or mixed-gender with an equal female to male ratio. It was more likely that a number of factors, such as the size of the group, the composition of the group, the duration of the group and the way the groups were formed (see below), interacted to affect the functioning of the group.

Grouping strategies

Another factor that apparently affected peer interaction related to how students were grouped. There were several ways of assigning students to groups. One way was to ask students to form groups. This method (usually referred to as the self-select method) tended to result in homogeneous groups as students usually selected friends or peers who were much like themselves in terms of sex, ability, and background. Another method was to randomly assign students to groups using different random sampling techniques. Alternatively, a teacher assigned students to groups based on the students' past achievement and teacher's knowledge of the students. While some researchers (Artzt & Newman, 1990) have suggested that teacher-select methods were better because they were more likely to result in heterogeneous groups and consequently generated productive peer interaction, others have recommended that the students' self-select method was more productive because this led to group cohesiveness which could, in turn, lead to increased performance by enhancing members' commitment to the group task (Mullen & Copper, 1994).

Another related factor that has been found to influence the functioning of a group was the group size. Small groups of say 2–3 were apparently not effective because interaction was limited. On the other hand, if a group had too many students, it became difficult for everybody to air their ideas. Groups of 3–4 students have been found to be more effective than 5–7 member groups (Lou, et al, 1996; Artzt & Newman, 1990).

Another criteria for group success was the durability of the group. Groups must stay together long enough for cohesiveness to develop. When students knew that their group would be together for some time, they realised that they must improve their interpersonal skills so that they could function effectively. On the other hand, reassigning students to new groups gave students in low-scoring groups a new chance, allowed students to work with other classmates, and kept the programme fresh.

Groups staying together for a unit of work, a semester, or a year have all been found to be effective.

Nature of the task

Some researchers have investigated whether some particular types of tasks may predispose members of co-operative learning groups to particular modes of interaction. In general, most studies have shown that ill-defined tasks were more likely to generate discussion than well-defined tasks. For example, in their meta-analysis of 46 studies published between 1929 and 1993, Qin, Johnson & Johnson (1995) commented that problems which had many possible solution paths were more likely to generate discussion. Their conclusions were based on their finding that co-operative learning promoted greater success in nonlinguistic tasks and ill-defined problems than linguistics tasks. Nonlinguistic tasks were mostly mathematics problems and visual-spatial problems such as geometric figures, puzzles, and mazes whereas linguistic problems usually involved tasks such as essay questions and discussion questions. Qin et al attributed their findings to the fact that problems which had many ways of being solved were more likely to generate discussion. Wilkinson & Martino (1993) made similar observations in their study of second-graders' mathematics co-operative learning groups. They found that a cube problem stimulated more interaction involving higher order mathematical reasoning than problems requiring straightforward arithmetic procedures. In the cube problem, children were given tiny blocks and a big block, and were asked to find how many of the tiny blocks made up the big block. One of the explanations given by Wilkinson & Martino of why the cube problem promoted more mathematical discussion was that the task naturally required the children to use the materials given to them in order to provide a convincing explanation of their solution strategy. This model building provided time for reflection and refinement of one's strategy for solution.

In contrast to the generally accepted view that there was usually little interaction and limited engagement when a task was not open-ended, Leikin and Zaslavsky (1997) provided evidence which showed that the use of some closed tasks in which the ways to solve the problems were prescribed facilitated task-related interaction. Their sample comprised Israel secondary school students working on quadratic functions and equations. The students were given a set of four study cards which contained a worked-out-sample problem, followed by a similar problem to the worked-out sample; when appropriate, an additional problem to be solved by more advanced students was also included on the card. Each student was instructed to explain to his or her partner how to solve the worked-out example (in which he or she had gained expertise on the previous card) and listen to the explanations given by the partner on how to deal with the worked-out example on a new card. Leikin and Zaslavsky (1997) reported that their analysis of classroom observation revealed that there was an increase in students' mathematical communications and interactions as a result of the worked-out examples, despite the fact that the task was highly structured.

Training of students in co-operative skills

There seems to be a general consensus amongst educators that the mere physical placement of students into groups for learning was not sufficient on its own for promoting discussion amongst students. Consequently, several researchers have suggested that the physical placement of students in groups should be accompanied by training students in co-operative skills (McAllister, 1995; Tang, 1996). There were, however, variations amongst studies concerning the relationship between training students in co-operative skills and achievement. Underwood et al (2000), for instance, found that training students to cooperate only benefited the Boy-Boy pairs and not the Boy-Girl pairs. On the other hand, the Girl-Girl pairs naturally worked co-operatively even when they didn't receive training. Other studies have suggested that training teachers may help in structuring groups that promote peer interaction. Several meta-analyses of studies (Lou et al, 1996; Ma et al, 1996) have shown that teachers' experience with, or amount of training received for, co-operative learning affected the outcomes of student learning using a co-operative learning approach. The explanation given was that teachers with little or no training may have adapted co-operative learning to their existing practices and teaching philosophy, while teachers with extensive training adapted their practices and teaching philosophy to the new method (Lou et al, 1996).

4.7 Summary

In summary, there seems to be consistent evidence in the literature that overall, in contrast with competitive or individual learning, co-operative small-group learning in mathematics has a positive effect on students' achievement in mathematics. Recently, co-operative learning has been consistently recommended in the literature as a strategy for improving the learning of girls (Solar, 1995; Jacobs & Becker, 1997). The major arguments for using co-operative learning as a strategy for improving the learning of girls in mathematics were based on recent research evidence that females preferred and did better in mathematics classes which used co-operative learning in small groups, than in classes that promoted individualised or competitive learning strategies. Feminist scholars have further argued that a co-operative approach seemed to offer greater possibilities for connected teaching (Becker, 1995; Jacobs & Becker, 1997), and may also have benefited girls by decreasing the opportunity for boys to dominate classroom interaction (Barnes, 2000).

Despite wide acceptance of co-operative learning as a means to promote the learning of all students, research has also shown that such benefits can only be attained when certain interaction processes occur. Researchers have investigated the role played by variables such as group size, composition of the group and the nature of the task on mediating productive peer interaction within co-operative learning groups. However, the conditions under which co-operative small-group instruction could be most beneficial for all students have not yet been clearly identified. In other words, answers to questions such as, "What factors affect the nature of interaction and therefore the learning that takes place?" are yet to be established. Answers to such questions might help educators decide how to structure group context to promote beneficial interaction and to discourage detrimental interaction.

It is important to note, that the bulk of the research on co-operative learning reported in this chapter was conducted in "developed" countries, with relatively few studies conducted in Africa, and none in Malawi. The few exceptions included a study done at tertiary level by Adedayo (1999) in Nigeria, who reported that the students who learnt using a co-operative learning approach achieved higher grades than those learning through a lecture method. Consequently, little is known about the feasibility of implementing a co-operative learning approach in Malawi. It is possible that the gains of the co-operative learning approach reported above may be of little relevance to schools in developing countries if the approach is too expensive, or a country lacks resources, or has a large student-teacher ratio. The present study was therefore undertaken to determine the feasibility and likely benefits of co-operative learning in mathematics at the secondary school level in Malawi, especially as it pertained to girls.

Chapter five

Research design

5.0 Introduction

This chapter addresses issues concerning the design of the research study. The discussion has been structured into six sections as follows: Section 5.1 identifies this research as a qualitative ethnographic case study and discusses why a qualitative case study was considered appropriate to investigate the research question about the effects of co-operative learning on girls and boys in secondary school mathematics. Section 5.2 presents a descriptive overview of the research. Section 5.3 considers the methodology of the data collection, while Section 5.4 presents an overview of the means of data analysis. Section 5.5 discusses how aspects of research quality such as credibility, plausibility and trustworthiness of the research were addressed in the study. Finally, Section 5.6 addresses ethical concerns.

5.1 Research approach

Consistent with the social constructivist perspectives described in chapter 2, the research methodology in this study was qualitative. In such research, the researcher was actively engaged with participants and acknowledged that understanding was constructed in the minds of individuals and that multiple realities existed. A qualitative approach was also chosen because the issues relating to gender and mathematics are complex and may not be fully understood through a quantitative approach. One strength of qualitative research has been that it enabled the researcher to, "avoid the problem of overwriting internally structured subjectivities with a priori systems of meaning (as occurs for example, with standard survey instruments)" (Henwood, 1996:27). For similar reasons, a co-operative learning approach was chosen because it was considered to create an environment that presupposes a constructivist view of knowledge, as discussed in chapter four.

This study sought to gain an insight into the day-to-day experiences of girls and boys working in a co-operative learning environment in mathematics classrooms. It was not designed to establish a cause-effect relationship. To this end, an ethnographic case study was considered appropriate (Banister, Burman, Parker, Taylor & Tindall, 1994;

Cohen & Manion, 1994). Banister et al (1994) defined ethnography as, "a basic form of social research involving making observations, gaining data from informants, constructing hypotheses and acting upon them." The research environment in this study comprised the mathematics classrooms where the observations took place. Although the study focused on the mathematics classrooms, it must be acknowledged that there were other variables outside the mathematics classrooms interacting with the students that could have provided further insights into the issue under investigation. This might be seen by an ethnographer as a limitation. Every research approach does have limitations; the important thing is to recognise and acknowledge these (Ball, 1990). In this case the researcher did not have the resources to investigate the beyond-classroom variables.

The study adopted a grounded theory approach in that all conclusions emerged from the research data (Glaser & Strauss, 1967).

5.2 Research description

The research comprised four stages namely: (i) a preparatory stage, (ii) preliminary data collection, (iii) workshop for teachers, and (iv) main data collection phase. Table 5.2 provides an overview of a time line for each phase, and each is discussed in turn below:

Table 5.1. Time line for Research Activities Conducted in each Phase

Phase	Activity	Time line
STAGE 1	Preparatory Stage	TERM 1
	1. Negotiating and gaining access to schools	March 1999
	2. Questionnaires posted to teachers	4th May, 1999
	3. Teachers' Guide posted to teachers	26th May, 1999
STAGE 2	Preliminary Data Collection	TERM 2
	1. Teachers trying activities in the Teacher's Guide	June 1999–Aug 1999
	2. Questionnaire responses from teachers	16th August, 1999
STAGE 3	Teachers' Workshop	23rd–24th Aug, 1999
STAGE 4	Main Data Collection	TERM 3
	1. Classroom observation	Sep 1999–Nov 1999
	2. Students' and teacher interviews, students' journals	
	3. Administering students' questionnaire	

Preparatory stage

The initial preparatory stage involved negotiating and gaining access to schools, preparing a questionnaire for the survey and writing a Teachers' Guide. A brief description of how these were done is given below:

Negotiating and gaining access to schools

Access to the institution or organisation where the research was to be conducted, and acceptance by those whose permission one needs before embarking on the task, is very important (Banister et al,1994; Bell,1993; Cohen & Manion, 1994). In this research, access was gained by writing letters to the Ministry of Education, Science and Technology, the Headmistress of the school, the participating teachers, and to the students, stating the purpose and nature of the research, and their expected involvement in the research. This was done to enhance cooperation from the participants as well as to fully inform them before they decided whether to participate.

Questionnaire construction

A questionnaire was designed that asked teachers to provide information about (a) their perception of co-operative learning, (b) their current use of co-operative learning and their experience with the strategy, and (c) their judgement about the efficacy of co-operative learning for girls and boys. The questionnaire was piloted with a small group of international teachers who were studying at the University of Waikato to ensure that the questions elicited valid responses. This group was considered to be similar to those in the Malawi sample because of their experience in teaching in developing countries. Respondents to the pilot questionnaire were asked to comment on how long it took them to complete the questionnaire, the clarity of instructions and questions, the clarity and attractiveness of the layout of the questionnaire and anything else regarding the questionnaire which they considered significant. Their comments were used to either remove or reword questions that did not yield usable data, and to add more questions (Bell, 1993). The revised questionnaire is appended (see Appendix A).

Writing of teachers' guide

In this study, it was considered desirable that teachers should be given ample time to experiment with co-operative learning on their own before the researcher joined them in their classrooms. In this way they could build their confidence and make sure that they understood the nature of co-operative learning before the data collection period (De Lange, 1992). Mindful of Artzt and Newman's caution that, "To incorporate co-operative learning strategies successfully in their classes, teachers should first understand what co-operative learning is, they should believe in its value, and they should be given guidance regarding its application" (Artzt & Newman, 1990: 448), a Teacher's Guide on how to incorporate co-operative learning into teaching was written by the researcher based on the literature on co-operative learning and on her experience of Malawian schools. The aim of this guide was to give teachers some ideas on how they could incorporate co-operative learning in mathematics lessons. The content included the meaning of co-operative learning and what co-operative learning is not, the potential positive outcomes of co-operative learning, some grouping strategies and basic elements that make co-operative learning work, and some sample activities to illustrate how mathematics lessons can be used with co-operative learning groups. Another advantage of early use of this Teachers' Guide was that students would have an opportunity to practice some co-operative learning skills. This was necessary because research (Stodolsky, 1984) has shown the importance of training students in co-operative learning skills for co-operative learning to be productive. The teachers' guide is appended (see Appendix B).

Although the researcher worked in depth in just one secondary school, it was nevertheless considered desirable to send the Teachers' Guide to all five secondary schools in the region known as Zomba Urban. This was to enable teachers (including teacher colleagues from neighbouring schools) to offer support to each other as they implemented co-operative learning. A number of studies (De Lange, 1992; Robertson, Graves, and Tuck, 1990) have shown that collegiality, sharing, group commitment, and support significantly affect the level of implementation. Teachers have remarked that it is "*really quite scary to leave your textbooks behind, to leave your dictatorship from the front behind, to risk having chaos in your classroom, to try something new.*" They also found collegial support to be a strong factor to encourage them to keep going. Teachers have felt that " *... listening to other teachers, other practicing teachers ... to hear how other teachers coped with certain circumstances, to hear that other teachers had the same sorts of difficulties and what they had tried and what successes and failures they have had*" (Bell & Gilbert, 1994: 486) was certainly more encouraging than reading about it in a book.

Preliminary Data Collection

Preliminary data were collected using a survey. A questionnare was sent to the mathematics teachers (n = 18) in Zomba Urban secondary schools prior to the field work commencing. The purpose of the survey was to seek information from the teachers about their perception of co-operative learning and their co-operative learning practices prior to the research. Information from the survey provided insights that could be incorporated into the writing of the material for the training workshop which was conducted one week before the commencement of the term. Below is a description of the survey setting in terms of sampling procedures and the distribution of the questionnaire.

Survey Sampling

Because the survey was to collect information to guide the researcher in the writing of materials for the training workshop, the issue of representantiveness was not necessary and sampling decisions did not arise. Sufficient numbers of the questionnaire to cover all mathematics teachers teaching in the five Zomba Urban government and government–aided secondary schools in 1999 were sent. Zomba urban had 3 government and 2 government–aided secondary schools, described in table 5.2 below:

Table 5.2 Description of Zomba Urban secondary schools

Sec. Schools	Gender	Type	Control
St Mary's	Girls	Boarding	Govt-aided
Zomba Catholic	Boys	Boarding	Govt-aided
Mulunguzi	Coeducation	Boarding	Government
Likangala	Coeducation	Day	Government
Masongola	Coeducation	Day and Boarding	Government

Distribution and return of questionnaires

The questionnaire was printed and photocopied by the researcher to ensure that the layout and appearance of the questionnaire was not distorted. The questionnaires were sent by post to Malawi. Postal questionnaires have been criticised for their low response rates and that they are expensive (Bell, 1993). However, Cohen and Manion (1994) have argued that criticisms about postal questionnaires were myths not borne out by the evidence. It was not feasible in this survey for the researcher to personally distribute the questionnaire due to time and financial constraints, and because of the distance between Malawi and New Zealand. Having an agent in Malawi distribute the questionnaire seemed to be the best compromise. The questionnaires were sent in one envelop to a colleague at Chancellor College, who personally took them to all schools for the teachers to complete and hand back to her. A response rate of 83% was achieved, which may be considered high (Cohen & Manion, 1994).

Workshop

During the first week of the main data collection period, the researcher ran a professional development workshop with the fifteen Zomba Urban mathematics teachers. It was hoped that by that time, most teachers would have tried some of the co-operative learning activities suggested in the Teachers' Guide posted to them earlier by the researcher. All participating teachers had been invited to try co-operative learning activities in the Guide and they were instructed to keep a reflective diary of their experiences with the co-operative learning activities that they tried. The intention of the workshop was to clarify any misconceptions about co-operative learning that teachers had. Another aim of this workshop was to create opportunities for teachers to get to know other teachers who were trying to incorporate co-operative learning into their teaching so that they could support each other.

Main Data Collection Phase

The main data collection took place over a period of three months. The study involved one female teacher and the three form three classes she taught in one co-educational school. The researcher and the participating teacher prepared some of the co-operative learning activities together from the teacher's scheme of work, guided by the comments raised during the teacher development workshop. The lessons were taught in all three classes by the same teacher. It was considered unethical to leave one class as a control group because there is research evidence about the positive outcomes of co-operative learning— see chapter four for details of this.

Sample

The sample for the study consisted of one female teacher and 140 form three students (year eleven of schooling— see Appendix C for the structure of the education system in Malawi) who made up three classes in one secondary school in Zomba Urban. Form three students were used as the sample for this study because the forms I, II and IV students were considered not suitable, for various reasons: Forms II & IV were examination classes and too examination conscious to be ideal for the study; Form I was not suitable because this was their first year of secondary school life and therefore many factors were influencing them such as (i) the stress of living away from parents for the first time and getting used to boarding life, (ii) getting used to being taught by different subject teachers rather than one teacher as in their primary school classes, (iii) making new friends, (iv) feeling the influence of home background acting on them, and (v) coming from a wide primary school background (about 60 different primary schools).

The sampled school (Mulunguzi Secondary School) was selected by purposive sampling procedure from the five secondary schools in Zomba Urban. The school met the following criteria: (i) it was in Zomba urban with easy access from Chancellor College which was where the researcher was based (with access to facilities such as email, fax, telephone, printing, photocopying, office space, and library), (ii) it was a coeducation school because the research was about gender related effects, and (iii) it was a boarding school which meant that home background influences were not a daily factor.

Another advantage of using Mulunguzi Secondary School was that it was the school that the Ministry of Education has officially designated as a demonstration school for the Faculty of Education, Chancellor College. Hence pupils were used to having different adults in their classrooms for research or teaching practice purposes, so the presence of a visitor was not expected to interfere with the students' working patterns. A further advantage was that Mulunguzi secondary school is a government-owned secondary school and represents a typical Malawian school in terms of education standards, school resources, classroom environment, funding and teacher supply.

Formulation of groups:

The teacher was given autonomy to assign students to groups. A description of the number of groups formed in each class, size of groups, and group composition is given in chapter ten (table 10.1). It was explained at the beginning that the groups would stay together for the study period so that cohesiveness might develop, although the teacher was flexible in allowing pupils to change groups during the research period when it was necessary.

Data collection methods

A variety of qualitative data collection methods such as observations, interviews, conversations, teachers' diaries, students' journals and researcher's field notes were used to gain an understanding of the pupils' and the teachers' experiences in classrooms and their perceptions of their situations. The researcher took the role of participant observer (see section 5.3). In order to observe interactions and levels of support and cooperation within groups, lesson observations were used for all mathematics lessons throughout the period of data collection and the researcher took field notes using the process of open coding (Strauss & Corbin, 1990). Students' journals were used mainly to determine their opinions about the levels of cooperation within each group, and their day–to–day feelings in the mathematics lessons. An informal conversation was held at the end of most lessons with a group of students to gather answers to questions such as "How did your group work go?" "What have you learnt today?" "What did you like/not like about the way we worked today?"

To find out about the teacher's perceptions of co-operative learning, informal interviews were held with the teacher at the end of most lessons, or at the commencement of the lesson as we were walking to the classroom. Formal interviews with the teacher were completed at the beginning, mid-way through and end of the main research period. Formal interviews with the teacher were audio-tape recorded and transcribed while details from the informal interviews were noted in field notes.

A questionnaire was administered to all students to determine their opinions about co-operative learning. During the study, students were informally interviewed to gain a more in-depth perspective on their views.

Throughout the main period of data collection, the performance of girls and boys in all form three classes was monitored by using both normal classroom assessment activities and some designed by the researcher. The results of the assessment activities were considered in relation to the gender of the students, and also their reported views about levels of cooperation within their groups and related issues. A critical discussion of the methods used for data collection is given in section 5.3 below.

5.3 Research methodology

As indicated in section 5.2, a number of data collection methods were used. Although all of them are well-known qualitative data collection techniques, it is important to justify why these were chosen, and not others. Furthermore, these methods can vary considerably in their character among different practitioners and, as Jaworski (1994) has pointed out, simply naming them gives little indication of what was actually done. Hence, the aim of this section is to provide a discussion of the methodological issues relating to the data collection methods described in section 5.2. This is done by discussing their characteristics, strengths, weaknesses and the rationale for choosing each of them.

Participant observation

Observation is the oldest and probably the most commonly used data collection technique in quantitative and qualitative research (Aldler & Aldler, 1998; Banister et al, 1994; Cohen & Manion, 1994). Observation is defined as, "a systematic description of events, behaviours and artifacts in the social setting under study" (Marshall & Rossman, 1989: 79).

The observer can assume a number of roles that range anywhere from a non-participant, who observes from outside or with a passive presence, to the active participant who engages in the very activities he/she sets out to observe. Gold (1958) has proposed a typology that classifies observers' roles into four groups: the complete participant, the participant-as-observer, the observer-as-participant and the complete observer. This classification was based on the level of the observer's involvement in the research setting. Aldler and Aldler (1998) have developed a similar classification but theirs is based on membership roles that a researcher can assume in a research setting. According to Aldler and Aldler, three membership roles predominate: the complete-member-researcher, the active-member-researcher, and the peripheral-member-researcher. Aldler and Aldler's complete membership role described researchers who studied scenes where they were already members or those who became converted to genuine membership during the course of their research. The active membership role describes researchers who became more involved in the setting's central activities, assuming responsibilities that advanced the group, but without fully committing themselves to members' values and goals. Finally, researchers in peripheral membership roles observed and interacted closely enough with members to establish an insider's identity without participating in those activities constituting the core of group membership.

During my observation, I moved round the groups, listening, initiating or tape recording students' conversations and responding to their questions. I helped the teacher whenever my views were sought. I helped the teacher with the organisation of the groups. I was a willing participant and in most cases I took the role of the assistant teacher. I interacted with both the teacher and the students while maintaining my identity as a researcher. This enabled me to gain a better understanding of the issues in which I was interested. Thus, I might be regarded as *observer-as-participant* (Gold, 1958) or the *peripheral-member-researcher* (Aldler & Aldler, 1998).

Similarly, the research setting may vary considerably. Cohen and Manion (1994) have identified a continuum of settings ranging from totally artificial environments to natural environments, and from structured to unstructured. They emphasised that the role the observer adopted was usually influenced by the type of setting. For instance, it was difficult for the observer in a natural setting, who wished to be covert, not to act as a participant, and the opposite was true for the artificial setting. In my research, the class teacher taught the normal content that she had planned for the third term to the form three pupils in their usual classroom environment, although she was expected to change some of her teaching strategies somewhat to include some co-operative learning. I observed events as they occurred. Thus, the setting of my research was, as far as possible, natural and unstructured (in a research sense).

Thus, in this study, I as researcher took the role of a participant observer in a natural and unstructured setting. As Aldler & Aldler (1998: 81) have noted, such an approach, "enjoys the advantage of drawing the observer into phenomenological complexity of the world, where connections, correlations, and causes can be witnessed as and how they unfold". This was particularly important for this study as my desire was to avoid exploring the problem from my own preconceived ideas. However, as many people (Bogdan & Biklen, 1992; Merriam, 1988) have observed, the challenge was to balance participation and observation so as to become capable of understanding the situation as an insider while at the same time trying to stay sufficiently detached to observe and analyse. To achieve this, I began the observation as a passive participant and gradually increased my participation in the activities after gaining familiarity with the classroom environment. This also helped me to maintain my identity as a researcher.

Another advantage of the participant-observation approach lay in the flexibility it offered the researcher to alter problems and questions during the research process instead of working with predetermined categories, as was usually the case with structured methods (Aldler & Aldler, 1998). Analyses developed from previous classroom observations and other research processes were used to inform the following days' events. This allowed for new insights to be gained.

However, participant observation as an approach for data collection has not been without limitations. Critics of participant observation point to the highly subjective and therefore unreliable nature of human perception. Cohen and Manion (1994) have summarised some of the criticisms as follows:

> '*the accounts that typically emerge from participants observation are often described as subjective, biased, impressionistic, idiosyncratic and lacking in the precise quantifiable measures that are the hallmark of survey research and experimentation*' (Cohen & Manion 1994: 110).

As a participant observer, I was aware of the potential pitfalls summarised above and attempts were made to minimise them by use of different forms of triangulation (discussed in section 5.5). This increased the validity of the research findings and helped ensure that my biases had limited influence on the results.

Another concern of the participant observer was that students and the teacher were aware of the researcher's interests and the very presence of the researcher in the classroom could influence the pupils and the teacher to behave according to their perception of the researcher's interests; such behaviour could be completely different from that normally displayed in the natural setting (Banister et al, 1994; Merriam, 1988). This might create some ethical dilemmas in that observations conducted without the awareness of those being observed raised ethical issues of privacy and informed consent. However, Frankenberg (1982) has argued that it was unlikely that an observer's presence could change custom and practice built up over years.

Despite the potential drawbacks, this study accepted Merriam's (1988: 102) view that:

> *"participant observation is a major means of collecting data in case study research. It gives a firsthand account of the situation under study and, when combined with interviewing and document analysis, allows for a holistic interpretation of the phenomenon being investigated."*

Interviews

Interviews were the second main data collection technique used in the study. Interviewing as a research data collection method can be traced to as early as 1886 by Charles Booth (Fontana & Frey, 1998). Since then, not only has it become one of the most common means of collecting qualitative data, but it is the most likely method to be used in conjunction with observation (Aldler & Aldler, 1998; Fontana & Frey, 1998; Merriam, 1988). Interviewing is particularly valuable to investigate the meaning of behaviour, feelings, or how people interpret the world around them (Bogdan & Biklen, 1992; Merriam, 1988). Qualitative interviews can take various forms, ranging from structured interviewing (in which an interviewer asks each respondent a series of pre-established questions with a limited set of response categories) to the unstructured, open-ended interview. In most cases, my interviews were informal, more like conversations, starting with open-ended questions such as 'What do you think about today's lesson?' and then probing more deeply, picking up on issues raised by the respondents. I occasionally interviewed students and teachers formally seeking their perceptions of co-operative learning and these were audio-tape recorded and transcribed. My interview approach was consistent with that described by Bogdan & Biklen (1992: 96):

> *"In participant-observation-like studies, the researcher usually knows the subjects beforehand, so the interview is often like a conversation between friends. Here the interview cannot easily be separated from the other research activities. When the subject has a spare moment, for example, the researcher might say, "Have you got a few minutes? I haven't had a chance to talk with you alone." Sometimes an interview has no introduction; the researcher just makes the situation an interview. Particularly toward the end of a study, however, when specific information is sought, the participant observer sets up specific times to meet with the subjects for the purpose of a more formal interview".*

The major limitations of interviews as a research tool has been that they were expensive in terms of money and time, and there was always a danger of bias (Bell, 1993; Cohen & Manion, 1994). Cohen and Manion (1994) suggested that the major sources of bias were interviewers' tendency to see the respondents in their own image, to seek answers that support their preconceived notions, and to misunderstand what the respondent is saying. Status, race, gender, age and the context of the interview were also linked to problems surrounding interviews as a research technique. It was generally believed that these problems were more pronounced for female researchers in a male dominated world (Fontana & Frey, 1998).

Recently, a growing number of scholars, especially amongst feminist researchers (Fontana & Frey, 1998; Oakley, 1981), have expressed concerns with the ethical problems present in interviewing and with the controlling role of the interviewer. Oakley (1981) has leveled three criticisms against interviews namely that (i) interviewers tend to have an exploitative attitude to interviewees as a source of data; (ii) there is a lack of reciprocity in which the interviewer elicits and receives, but does not give information; and (iii) that no attention is paid to the emotions and feelings of the interviewers and respondents and the social interaction during the interview process. In this study, the researcher tried to be sensitive to these concerns and efforts were made to establish an intimate and non-hierarchical relationship between researcher and teacher/students. Many writers (Bogdan & Biklen, 1992; Oakley, 1981) have emphasised the importance of the relationship for successful interviewing. Thus, the closer the relationship, the more the respondents would trust the researcher and this will eventually enable them to open up and confide in the researcher. In my case, I developed the relationship by making the interviews more like natural conversations. Some of the conversations were initiated by the students themselves or the teacher, and I simply probed the issues raised by the respondents to gain an in-depth understanding. At the same time, I was willing to offer help and answer questions whenever required. All these actions conveyed the message to the students and the teacher that I did not intend to exploit either them or the information they were giving (Oakley, 1981).

Researcher's field notes

Bogdan & Biklen (1992: 107) define field notes as "the written account of what the researcher hears, sees, experiences, and thinks in the course of collecting and reflecting on the data in a qualitative study". Field notes, in this study, consisted of the written record of data which emerged from observations and interviews; most issues concerning field notes have been highlighted when discussing the two previous techniques. With this in mind, this section focuses on the content and how the notes were recorded. My full interview notes were written immediately after each informal interview, aided by brief notes which I jotted down during the actual interview. I felt that taking full notes during the interview might disturb the warmth of the conversation. An advantage of recording notes after the interview was that it allowed me to monitor the process of data collection as well as to begin to analyse the information itself (Merriam, 1988).

There is a general consensus in the literature that the successful outcome of any qualitative study depends on the detail, accuracy, and richness of the fieldnotes. The content of the field notes in this study included the following:

- Date, time and place of the interview/observation. This included weather, the place of the class period in the timetable, lessons that preceded it as well as the lessons after, if any.

- A brief description of the participants in terms of their physical appearance, dress, manner of talking.

- A brief description of the physical setting. This included a sketch where relevant of the space (furniture arrangement, position of the teacher's desk, content of the chalkboards, walls and so on).

- A description of activities. This included a description of behaviours, teacher-students and student-student interactions, and conversations that went on between them and the researcher.

- A description of the researcher. This included the researcher's dressing, her day's encounters prior to the fieldwork. All these might have affected the data recorded and should be taken into account during data analysis.

- Notes of things such as hunches, assumptions that came to light, and points needing more questioning.

In addition to the data that emerged from interviews and observations, the researcher's day-to-day thinking and world view, feelings, problems and ideas also formed part of my field notes. Bogdan & Biklen (1992) describe this as the *reflective part of fieldnotes* and Merriam (1988) calls it a *fieldwork journal.* Both Bogdan & Biklen and Merriam comment that the purpose of this reflection is to improve the notes. In my case, the major benefit was that it allowed me to reflect on my own development as a researcher and see how it related to the whole research process. This is discussed further in chapter 11.

Students' journals

Data relating to the students' perceptions about the success and group dynamics of each lesson were also collected through the use of students' journals. These were compared with the researcher's field notes and interview transcripts. According to Countryman (1992) students' journal entries allow teachers/researchers to be more aware of what students know, and how they come to construct that knowledge. In Countryman's own words, "reading math journal entries tells me considerably more about what students grasp and do not understand, like and dislike, care about and reject as they study mathematics... " (Countryman, 1992: 28). Another advantage of using students' journals was that it helped them develop critical and reflective skills about their learning process. This allowed the students to take more control of the learning process.

Each student was provided with paper each time a journal session was held. They were requested to record statements about what they did and did not understand, and their feelings about the whole lesson. At times group journals were asked for and collected instead of individual journals. This was consistent with the co-operative nature of learning. Papers instead of note books were used. The advantages of using papers were that it saved time, it reduced the risk of students losing them, and it allowed me to analyse responses at leisure while students were able to write further entries. At times prompts were written on the journal papers in the form of questions to be completed, but at other times questions were written on the board. The following journal prompts were used:

- What did you learn today?
- What questions do you have about the work?
- How do you find working in groups?
- Would you have preferred working individually or as a group?
- What confused/challenged you?
- Did working in groups help you sort out your confusion?
- Who was the most helpful today in your group and who was the least helpful?
- What did you like and what did you not like about the way you learned today?

Students were told that they need not worry about the grammar, spelling or punctuation and that they were allowed to write in their vernacular. Despite this, I noticed that students maintained using English in their journal writing. I could, however, see from their writing that they were not able to express themselves in English. I later realised that their persistent use of English was due to the emphasis the school placed on English (see chapter eight). The papers were collected by the researcher at the end of each journal session.

5.4 Data analysis

Data analysis is the "...process of systematically searching and arranging the interview transcripts, fieldnotes, and other materials that you accumulate to increase your own understanding of them and to enable you to present what you have discovered to others" (Bogdan & Biklen, 1992: 153). In the case study in this Malawi investigation, data analysis was done concurrently with data collection and was an on-going process throughout the data collection period. The emergent themes from the data collected and analysed were used to guide the researcher in her next observations and/or interviews, and about who to interview, what to ask, or where to look next. Merriam (1988) warns that without ongoing analysis one runs the risk of ending up with data that are unfocused, repetitious, and overwhelming in the sheer volume of material that needs to be processed.

All information gathered during the data collection period was typed and organised in categories that emerged from the data (Strauss & Corbin, 1990). These categories were used to locate data during the intensive data analysis following the fieldwork.

5.5 Research quality criteria

Research quality criteria refers to the credibility, plausibility and trustworthiness of the research (Altheide & Johnson, 1998). Traditionally, this has been evaluated in terms of the canons of validity and reliability that have evolved for the assessment of quantitative research. Such canons have included rigorous verification on such issues as sampling, coding, indicators, frequency distributions, conceptual formulation, and hypothesis construction (Glaser and Strauss, 1967). As a result, qualitative research has often been criticised for failing to meet conventional scientific standards (Glaser & Strauss, 1967; Smith, 1996). However, this view of judging qualitative research against quantitative research standards has been challenged by many as inappropriate, and a call for more relevant criteria has been made (Smith, 1996).

This study was conducted from a qualitative research approach that fits within a constructivist framework, and therefore issues of reliability and validity are viewed in a different perspective. For instance, the concept of reliability which is essentially about *consistency* contradicts the very nature of qualitative research. This view is supported by Banister et al (1994) in their description of qualitative research:

"Qualitative research recognizes a complex and dynamic social world. It involves the researcher's active engagement with participants and acknowledges that understanding is constructed and that multiple realities exist ... Replication in qualitative research has more to do with reinterpreting the findings from a different standpoint or exploring the same issues in different contexts rather than expecting or desiring consistent accounts."

(Banister et al, 1994:142–143)

They present a similar argument against traditional validity by quoting Marshall (1986: 197) as follows:

"Validity instead [in qualitative research] becomes largely a quality of the knower, in relation to her/his data and enhanced by different vantage points and forms of knowing– it is, then, personal, relational and contextual."

Having acknowledged the problems associated with the applicability of reliability and validity to qualitative research, this section describes a number of techniques that were employed throughout the research to enhance the credibility of the research. The first is 'triangulation' which is defined as "the use of two or more methods of data collection in the study of some aspect of human behaviour" (Cohen & Manion, 1994).

Triangulation

There are several types of triangulation including methodological triangulation, theoretical triangulation, time triangulation, and data triangulation (Cohen & Manion, 1994; Banister et al, 1994). The first three were used in this study.

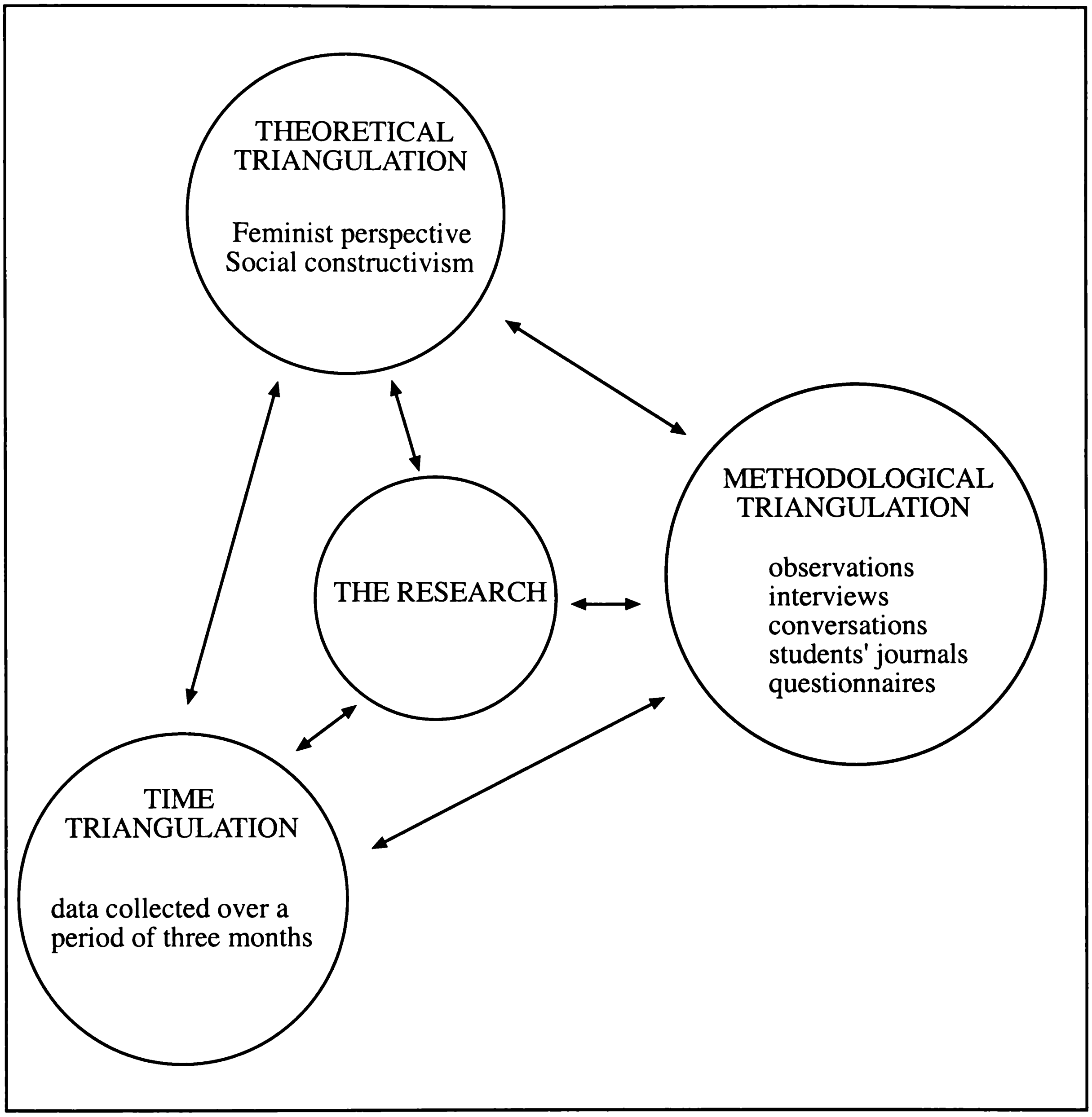
Methodological triangulation entails the use of different methods to collect data. Different data collection methods used in the study have already been explained in the preceding section.

Theoretical triangulation embraces multi-theory which breaks through the parameters and limitations that inevitably frame an explanation which relies on one theory. It recognises complexity and diversity and that multiple realities exist. The different theoretical perspectives used in this study were discussed in chapter two.

Time triangulation attempts to take into consideration the effects of social change and process by collecting data from the same group at different points in time (Cohen & Manion, 1994). In the present study, I collected data for the whole term (three months).

For the present study the three forms of triangulation are summarised and linked in figure 5.1 below:

Fig 5.1 Triangulation used in this research



Reflexivity

Efforts have been made by the researcher in reporting the interpretation of the data to present and justify detailed elements of the whole research design. All decisions about data collection and analysis, why these were made, the limitations of the methods used, and the researcher's beliefs have been explicitly stated. This represented what Banister et al (1994) called *reflexivity*. This enhanced credibility of the research; presenting data and data collection methods as visibly as possible enabled the reader to see how the researcher reached conclusions from the data. The reader "...will note for instance, what range of events the researcher saw, whom she interviewed, who talked to him[her], what diverse groups she compared, what kind of experiences she had, and how she might have appeared to various people whom she studied. That is, the reader will assess the types of data utilised from what is explicitly stated as well as from what he[she] can read between the lines" (Glaser & Strauss,1967: 230).

Credibility

In addition, the credibility of the research is enhanced by the description in chapter two of the researcher's assumptions and beliefs. This explicity enabled the reader to judge the conclusions in the context of the perspectives and assumptions by which it was shaped.

5.6 Ethical considerations

Ethical considerations refer to the researcher's awareness of the attendant moral issues implicit in the work of social researchers and of their need to meet their obligations with respect to those involved in, or affected by, their investigations (Cohen & Manion, 1994). It is another important issue that needs to be considered by the researcher as it can affect the credibility of the research. In this research a number of ethical issues such as informed consent, access, confidentiality and anonymity were addressed while conducting the study. Most of these have already been discussed in conjunction with the research design. They are summarised below:

1. Ethical approval was gained from the Human Research Ethics Committee of the Centre for Science, Mathematics and Technology Education Research, University of Waikato, before the study commenced (see Appendix E).

2. Letters, stating the purpose and nature of the research, and participants' expected involvement in the research were sent to the Ministry of Education, Science and Technology, Headmaster/mistress of the school, participating teachers, and pupils, before obtaining their consent. This was done because "...only when prospective participants are fully informed in advance are they in a position to give informed consent" (Banister et al, 1994: 153).

3. All information was treated with the strictest confidentiality and the anonymity and privacy of the participants was protected as far as possible.

4. A brief summary of the main findings (about 1–2 pages) was sent to the office of the Ministry of Education, Science and Technology and to the Headmaster/mistress of the school.

Chapter six

Secondary school teachers' beliefs about co-operative learning approach in mathematics

6.0 Introduction

Based on constructivist ideas from which this research is framed, I took the view that the teachers' constructions of the researcher's ideas of co-operative learning would be influenced by their prior conceptions of co-operative learning and the environments in which they were teaching. Thus, the questionnaire (Appendix A) was distributed to all mathematics teachers in the five Zomba secondary schools to survey their prior beliefs and practices relating to co-operative learning.

The results reported in this chapter are based on an analysis of the survey results and on the data generated during the 2-day teacher development. The questionnaire dealing with the teachers' perception of co-operative learning in mathematics was designed to find:

(a) background information

(b) teachers' typical instructional practices

(c) teachers' perception of co-operative learning

(d) their use of co-operative learning

(e) their views about the efficacy and constraints of co-operative learning for boys and girls

The questionnaires were sent in May 1999 and some details about the five schools have been given in Table 5.2. Sufficient numbers of the questionnaires to cover all mathematics teachers at each school were hand delivered and hand collected. A total of 15 responses (2 females and 13 males) were received. Three teachers from one school did not respond to the questionnaire but they did attend the workshop. So the 15 completed questionnaires represent a response rate of 83%. The teaching experience of the sample is given in table 6.1 below.

Table 6.1: Distribution of teaching experience of the sample.

Years of teaching	Number of teacher (n = 15)
Less than one	2
1 to 5	9
6 to 10	2
11 to 15	1
Not indicated	1

It can be seen from table 6.1 that the sample comprised relatively inexperienced teachers. The teaching experience ranged from just one term to 13 years with a mean of 4.4 years. This is typical of Malawi in general, possibly due to a high turn over of mathematics teachers. The respondents were coded for reporting purposes. For instance, F/T1 and M/T6 represents female and male teachers respectively.

The data from the survey are discussed in the following sections of the chapter:

- 6.1 Typical teaching approach used by teachers
- 6.2 Teachers' conceptions of co-operative learning
- 6.3 Prevalence of co-operative learning
- 6.4 Reasons for using co-operative learning
- 6.5 Grouping practices
- 6.6 Teachers' views about the applicability of co-operative learning in Malawian classes
- 6.7 Teachers' perceived indicators of a successful co-operative learning group
- 6.8 Teachers' perceptions of the benefits/constraints of co-operative learning on girls' learning of mathematics
- 6.9 Summary of findings

6.1 Typical teaching approach used by teachers

One question in the questionnaire asked teachers to 'describe how they would teach a typical lesson'. A content analysis of the teachers' responses to the question revealed three categories as shown in table 6.2 below.

Table 6.2 Teachers' typical teaching approach

Category	No. of responses (n = 15)
Introduction-example-exercise	11
Let students experience the concept through an activity followed by a discussion	2
'Imagine that students have blank minds'	1
No response	1

Table 6.2 reveals that the majority of the teachers (11 out of 15) claimed that they began their lessons with a quick introduction which in most cases related to the work covered in previous lessons, solved one or two examples on the chalkboard, gave students practice problems as a class exercise which was related to the examples, went round marking students' work and made corrections for the difficult problems on the chalkboard. The response from one teacher best represented what most teachers wrote:

> 'Firstly, examples are given on the chalkboard, during which explanations, questions are clarified and teaching and learning aids are used (if any), of course bearing in mind that the introduction should always lead to the new task. Secondly, pupils are given an exercise on the new task learnt, and I go round marking and helping those finding problems. Finally, correction on the most difficult problems are done.' (M/T15)

This appeared to be the typical teaching method for mathematics in Malawi. Little seems to have changed since the following extract appeared in the Instruction Handbook for Inspectors of the Malawi Ministry of Education:

> 'Mathematics teaching in secondary schools is taught by the class teaching method generally known as the traditional method. Using this method, the teacher begins his[her] lesson with a quick oral revision of the preceding or that part of earlier work which is to be developed during the lesson.' (Inspectorate and Examinations Division, 1981: 70)

Perhaps most teachers tended to use this method of teaching to cope with the large student numbers (the average teacher: pupil ratio in Malawi is 1:40 in secondary schools).With such large numbers, teachers needed to be in control of the class, and 'exposition' gave them maximum control. This teaching approach was similar to what Kuhs and Ball (1986) described as a

> 'content-focussed with an emphasis on performance' view of teaching mathematics. According to Kuhs and Ball, teaching mathematics from this view, "the role of the teacher is to demonstrate, explain, and define the material, presenting it in an expository style. Accordingly the role of the students was to listen, participate in didactic interactions (for example, responding to teacher questions) and complete exercises or problems using procedures that had been modeled by the teacher or text" (quoted in Thompson, 1992:136).

The Ministry's observation quoted above also has to be seen in context. It was made in 1981 before constructivism was being considered and it reflected the way that many expatriate teachers had taught.

This mathematics teaching approach seems to be premised on the belief that learning results from the transmission of knowledge— that mathematics can be transmitted intact from the teachers' mind to the students' mind (Thompson, 1992). This belief probably lay behind the response given by the teacher in the survey who wrote,

> ' By imagining that the students have blank minds'. (M/T10).

and the 11 teachers who reported using an introduction-example-exercise teaching format. However, a teaching approach based on the view that students had blank minds to be filled and reinforced through copious exercises did not encourage students' construction of their learning as suggested by constructivist and feminist ideas of mathematics learning. From a constructivist perspective, students constructed their own learning based on their experiences. It was difficult to imagine how students could construct their own knowledge in a class where students were always being 'filled in' with the teachers' ideas about solutions to mathematical problems or procedures. If the teacher defined his/her role as that of filling the blank minds of the students, then it likely followed that he/she saw the students' responsibility as that of passively assimilating the knowledge. Research in the past (e.g. Boaler, 1997; Buerk, 1985) has shown that this expository teaching approach was more likely to encourage students to view mathematics as an already finished product made of absolute sets of rules, formulae, and procedures ready to be transfered from the authority (teacher or textbook) to the students.

Similarly, from a feminist perspective, the transmission view of teaching was inappropriate considering the way that most girls and women seemed to learn. Scholars in this area (Becker, 1995; Buerk, 1985; Rogers, 1995) have argued that this teaching approach silences and disempowers students, especially female students. Such students come to believe that they might never create similar knowledge for themselves (Rogers, 1995).

One implication of the findings reported above concerning the teachers' views is that for teachers to adopt innovative teaching approaches for secondary mathematics in Malawi, there is need for professional development aimed at helping teachers to reflect and question their current practice of mathematics teaching and to learn about the ways children learn mathematics (Wood & Sellers, 1997). Additionally, teachers will require support systems such as classroom visits by professional development staff, and workshops where teachers could be brought together in order to share their experiences with others, so as to assist them in transition.

6.2 Teachers' conceptions of co-operative learning

Teachers were asked to respond to a questionnaire item: ' When you think of co-operative learning, what are some of the things that come to mind?' The teachers' responses were grouped into 7 overlapping categories as shown in table 6.3 below—some teachers' responses fitted more than one category.

Table 6.3 Descriptors used by teachers to indicate their conception of co-operative learning

Descriptors	No. of respondents (n = 15)
Group work [group discussion, pupils working together, teacher and pupils working together, students performing a group task]	11
Relative involvement of teacher and students [teacher less involved, only giving instructions, guidance, directions, supervision, on what to do. Learning is more child-centred, pupils actively involved in the learning process, students discover things on their own]	7
Organisational considerations [how to group students, present the chosen topic, how long it will take, how the group work will be assessed, availability of apparatus, ability of students, number of students per group, grouping should be heterogeneous]	4
Team teaching [teachers working as a team, working with colleagues, observing lessons, supervising teachers on teaching practice]	2
Team work/spirit [students solve problems as a team, solidarity among students, each party is aware of the direction/goal of the learning in question]	3
Efficacy [a type of learning that helps students better understand concepts, promotes academic achievement]	2
Project	1

Most teachers associated co-operative learning with students working in small groups (11 of 15). The most common responses from teachers were 'students working together in groups'; 'group discussions'; 'group work'. Of these eleven, two teachers highlighted that this group work included teachers working together with students. Usually teachers elaborated on some characteristics under which co-operative groups function in order to promote learning. The most prevalent idea was that each student was actively involved in the discussion (5 teachers) and that special effort should be made to encourage low achievers to participate in group discussions (two teachers). None of the teachers made any reference to the critical attributes of co-operative learning such as positive interdependence, individual accountability, face to face interaction, social skills and group processing suggested in literature (Johnson & Johnson, 1999a; Artzt & Newman, 1990). Only three mentioned the necessity of team spirit in co-operative learning groups.

One teacher wrote ' Same marks/grades are given to all group members— this is meant to engender a team spirit in which everyone pulls his/her own effort to participate fully' M/T15.

The next most common descriptor of co-operative learning was given by seven teachers. They spoke about the relative involvement of the teacher and the students in the learning process. All seven claimed that the teacher's involvement in co-operative learning was minimal. 'Pupils discover new ideas on their own, teachers become less involved in the learning process only directing pupils what to do' (M/T12). 'The learning is more child-centred than teacher-centred where the teacher only acts as a guide' (M/T15).

Some teachers described co-operative learning in terms of the things that a teacher needs to consider when planning a co-operative learning activity. Four teachers made reference to organisational considerations such as how to group students, how to assess, and the availability of resources.

One teacher wrote: "I think of it [co-operative learning] as a type of learning which helps students to understand better the concepts they learn. This is so because the students do discover things on their own rather than just being told' (M/T6). Another teacher expressed a similar belief about the co-operative learning approach enhancing learning. "Pupils working together to promote academic achievement. Teacher and pupil working together to promote learning" (M/T4).

Two teachers from the same school equated co-operative learning with team teaching. "Working with colleagues, observing lessons, discussing ways of teaching a particular topic using different ways of approach, supervising teachers on teaching practice" (F/T3); "Teachers of the same teaching subject working as a team in their various classes" (M/T4). I learned later that F/T3 was previously involved in a co-operative teaching project a couple of years ago and that M/T4 was a student on teaching practice and was working directly under F/T3. This may have explained why F/T3 considered supervising teachers on teaching practice as part and parcel of team teaching because she was directly involved with that at the time of the survey. Lastly, one teacher associated co-operative learning with students working together on projects.

One unexpected finding was that the majority of the teachers professed a belief about the importance of students' active participation in learning (student-centred), whereas their professed teaching approach described in section 6.1 was more teacher-centred than student-centred, representing an inconsistency between the teachers' professed beliefs and their professed instructional practices. This finding was similar to that of other researchers (Sosniak, Ethington and Varelas, 1991; Thompson, 1992; Thompson, 1984) who have documented some variability in the degree of consistency between teachers' professed beliefs about mathematics teaching/learning and their instructional practices. However, the finding of this study that this inconsistency was found amongst a sample of teachers who were at their early stage of their teaching career (below 5 years of teaching) was contrary to that reported by Artzt and Armour-Thomas (1999). In their analysis of teacher cognition in relation to instructional practices of 14 secondary school mathematics teachers (7 experienced and 7 beginning teachers) in the USA, Artzt and Armour-Thomas (1999) reported that the articulated beliefs about mathematics teaching/learning of the beginning teachers were highly consistent with their instructional practices and that these beliefs centred around content coverage for skill development and management concerns.

The majority of the Malawian teachers indicated that they had learnt about co-operative learning during their pre-service training (11 out of 15 teachers). Six teachers cited that they had learnt of it from more than one source as follows: pre-service training and reading from books (3 teachers); pre-service, reading from books and observing colleagues (2 teachers); reading from books, observing colleagues and attending conferences (1 teacher). Interestingly, none of the teachers specifically mentioned the teachers' guide I had sent to them.

One possible interpretation for the finding that the teachers professed a constructivist view of learning (students' active participation of learning) and yet were unable to practice it in their teaching might be that they may have learnt about the constructivist perspective of learning during their pre-service training but they lacked the necessary support to be able to incorporate such views into their teaching. Vacc and Bright (1999) found that the preservice teachers in their study experienced a change in beliefs and perceptions about mathematics instruction as a result of their participation in preservice mathematics methods course, but the extent to which they were able to incorporate those beliefs in their instruction depended on the support they received while in the classroom.

6.3 Prevalence of co-operative learning

Thirteen of the 15 respondents indicated that they had used co-operative learning in their mathematics teaching. Seeking to uncover the teachers' beliefs about opportunities that existed in their mathematics classrooms for co-operative learning, one questionnaire item asked teachers to list some activities in which they used co-operative learning. Teachers reported a wide range of activities for which they used co-operative learning, although only 4 out of the 13 (13%) teachers described more than one activity. The teachers recorded that they had used co-operative learning in proving theorems and formulae (4), problem solving (3), revision (3), class exercise (3), application of lesson gained to various situations, homework, task oriented topics, brainstorming and for modeling teaching aids with the teacher on teaching practice. From the list given by the respondents, it was clear that most of the teachers claimed to use co-operative learning for practicing the mathematics taught, which fits within the teachers' reported typical teaching approach (Table 6.2).

The teachers were also asked to indicate the frequency of their use of co-operative learning from a given frequency list (item 8 of questionnaire), and in item 9 they were asked to estimate the number of teaching periods in the last term that they used some co-operative learning. Their responses are summarised in table 6.4 below.

Table 6.4 Frequency in using co-operative learning

Frequency	No. of respondents	estimated no. of co-operative learning lessons last term respectively.
Every day	2	7 periods a week; 5/7 of teaching period
Once a week	4	0 (was not teaching); 11; 12; 13
Once a fortnight	1	4
After every topic	1	5
Depends on topic or need	5	1; 14; 15; 30; over 60

Analysis of the data presented in table 6.4 indicates reported use of co-operative learning, at least as the teachers understood it, ranging from using it everyday (2), once a week (4), once every fortnight (1) to after every topic (1). The remaining 5 teachers did not specify their frequency in item 8, but they stated that their use depended on the topic taught; for example:

> ' When I see that the topic I am going to teach can best be learnt and can be taught by co-operative learning.' (M/T9)

Overall, in their response to item 9 they claimed to use co-operative learning to varying extents with the frequency ranging from only one lesson to over 60 periods in the previous term.

6.4 Reasons for using co-operative learning

Teachers were asked to state their reasons for using co-operative learning (or why they have stopped using co-operative learning). Analysis of the teachers' responses revealed 3 categories as shown in table 6.5 below (with no teachers recording that they had stopped using it).

Table 6.5 Why teachers use co-operative learning

Category	No. of responses
Enhances students' learning	10
Promotes social skills	3
Makes teaching easy	2

The reason given by most teachers (10 out of 13, or 77%) was that co-operative learning enhanced students' learning of mathematics. Typical comments were:

> 'the students understand the concepts better'
>
> 'It improves pupils' performance in mathematics'

All of the 10 teachers elaborated on why they believed co-operative learning enhanced students' understanding. There were two most prevalent beliefs. Four of the ten teachers wrote that students have a better understanding of the concepts because the environment in co-operative learning was conducive for students to construct their own mathematics learning. For example, teachers wrote: 'It is because the pupils have a better understanding of the concept taught if they discover it on their own' (M/T6; 'it becomes hard for pupils to forget the things they have discovered themselves' (M/T9). Four of the remaining teachers believed that the co-operative approach enhanced learning because students learn better from each other than from the teacher since

> "students find it easier to explain ideas to a friend during group work" (E/T1),
>
> "pupils are able to air out their views in their groups" (M/T4).

The other two teachers believed that a co-operative approach motivated students to learn. For instance, one teacher wrote that it,

> "keeps pupils interested in subject matter, it gives confidence to pupils that they are capable of handling mathematical concepts and problems, even by themselves" (M/T2).

Two other reasons offered regarding the value of co-operative learning had to do with enhancing participation: "because every student becomes active in the lesson" (1 teacher) and anchoring mathematics ideas in students' minds, "it helps to consolidate a concept or a topic" (1 teacher).

Only three teachers mentioned the social benefits of co-operative learning. They all believed that co-operative learning helped students learn how to work with one another. One teacher elaborated on some specific social skills as follows: 'it promotes a sense of understanding, tolerance and discipline among the pupils' (M/T12).

Two teachers talked about how co-operative learning eased the task and the role of the teacher. One said that "it makes teaching easier for the teacher, that is, it reduces time of teaching" (M/T4); and the other mentioned that "it encourages slow learners to get more from their colleagues rather than go to a teacher who is having difficulty providing enough individual attention" (M/T5).

The teachers who reported minimal use of co-operative learning (once or four times per term) explained that they rarely used the strategy because they considered it to be time consuming and they felt that they would therefore not be able to complete the supposed 'too long and examination driven' syllabus.

6.5 Grouping practices

Teachers reported using a variety of approaches for forming co-operative learning groups although only 4 out of 13 teachers gave multiple strategies (i.e. they gave more than one strategy). All but one teacher reported that they formed groups of mixed ability and mixed gender using (a) their personal knowledge of students (8); (b) seating arrangement (4); (c) self-select (2); and (d) random assignment (1). The exception was a teacher who wrote that he formed groups of mixed gender but similar ability. None of the teachers mentioned considering students' personal characteristics such as task-orientation, leadership skills, or interests when forming heterogeneous groups, as suggested in some of the literature on co-operative learning (Artzt & Newman, 1990; Johnson & Johnson, 1999a).

Another aspect of grouping practices that was investigated concerned teachers' beliefs about how long groups needed to stay together (items 12 and 13 on questionnaire). Only

12 teachers responded to the items. Half of the teachers (6 out of 12) stated that they kept their groups for one term. The remaining 6 teachers reported retaining groups for other periods of time. For instance, they changed groups after every day, or at the end of every chapter, 3 weeks, month, half a term or, in one case, year. The teachers gave varied reasons for their decisions about how long they kept their groups, with the exception of the teacher who had indicated that he changed his groups every day. This teacher stated that he didn't have any particular reason for doing so. All but one of the teachers who stated that they kept groups together for a whole topic, or for one term or longer seemed to believe that members needed to stay together long enough for relationships to develop for co-operative groups to be productive. For example, they wrote:

> 'So that pupils feel a sense of belonging to a group, get used to each other to feel free to express themselves' (M/T1).
>
> 'changing frequently would disturb their interpersonal relationships and affect their cooperation' (M/T14).

However, one teacher seemed to have a more pragmatic reason for retaining groups over a period of time. This view was that if groups were kept together then they could continue using the same group exercise books whereas changing groups frequently would mean issuing new group exercise books frequently which the school could possibly not afford. The remaining three teachers who had indicated that they changed groups frequently, gave varied reasons for doing so. One of them expressed a belief that was quite opposite to the view of the majority of the teachers about the importance of peer relationship for co-operative groups to be productive. This teacher believed that students were less likely to be on task if they were used to one another in the social setting. She wrote about changing groups:

> 'To avoid playing or getting used to each other much more so that they agree to be lazy or not to write a given assignment' (F/T1).

The remaining two teachers believed that it was important for students to experience working in different groups for maximum benefit from co-operative learning groups. They wrote:

> 'Some pupils naturally don't feel comfortable working with certain individuals so I have to change the groups so that they should experience and get maximum social skills from others. Also by changing groups, you avoid one person dominating the group' (M/T12).

> 'Other groups don't perform well. As such, new ones have to be formed with some new and old members' (M/T6).

The teachers were asked to comment about how they assess co-operative learning group work. All the teachers reported that they usually assess the group product and that a small proportion of the mark contributes to the students' individual grades at the end of the term/year.

6.6 Teachers' views about the applicability of co-operative learning in Malawian classes

The teachers were asked to comment about the applicability of co-operative learning in mathematics classes in Malawi by responding to the following questionnaire item: 'What do you think about this teaching approach [co-operative learning]? Do you consider it applicable to your class?' All the teachers gave the answer 'yes' meaning that they considered the approach applicable to Malawian mathematics classrooms. Of the two teachers who elaborated on their answers, one wrote that the approach is even more suitable for Malawi considering the big teacher: pupil ratio. He wrote:

> 'It is a very good teaching approach; since my class is very big it reduces the work of marking exercises as I only mark group work' (M/T12).

The other expressed some reservations about its applicability in Malawian schools. His fears were that co-operative learning was time consuming and would probably be considered a waste of time for Malawian teachers who were desperate to finish the syllabus for the examinations. He wrote:

> 'It is a good approach in teaching and I consider it can be applied in my class. However, unless it proves not time wasting, it would be difficult for schools in Malawi which are exam-oriented.' (M/T15).

Although only two teachers elaborated on their 'yes' above, most (9 out of 15) seemed to share the 'time consuming' fear. In other words, they considered the traditional styles of teaching to be less time consuming. This was revealed in the content analysis of the teachers' responses to item 20 of the questionnaire 'What are some of the major constraints and difficulties of using co-operative learning?' The categories of teachers' responses are summarised in table 6.6 below:

Table 6.6 Perceived constraints of co-operative learning

Category	No. of respondents
Time consuming[requires lots of time to use it or for teacher to prepare]	9
Gifted students are disadvantaged [they are slowed down by slow learners, are overworked by slow learners]	5
Not all will participate [girls, weak and shy students may be dominated by other students]	4
Resources [requires lots of resources]	3
Pupils not doing the given task because they believe it is the teachers' duty to teach them	1

One interesting finding was that teachers seemed to be slightly more concerned about gifted students than weak students. Five teachers expressed a fear that co-operative learning may disadvantage the gifted students as compared to 4 teachers who feared for the girls, weak or shy students. Some teachers (3) seemed to believe that co-operative learning demands lots of resources which Malawian schools may not be able to afford.

6.7 Teachers' perceived indicators of a successful co-operative learning group

In order to understand the teachers' beliefs about the characteristics they interpreted as indicators of a successful co-operative learning group, the teachers were asked to respond to the following question: 'When a group is going really well, what would you see happening?' An analysis of the teachers' responses revealed four overlapping categories as shown in table 6.7 below:

Table 6.7 Descriptors used by teachers in indicating their beliefs about productive co-operative learning groups

Descriptors	No. of respondents (n = 15).
Motivated learners [enthusiastic, asking for more work, interesting, happy, wanting to do more work even if class is over, look forward to maths lessons]	9
Improved achievement [improved concept understanding, results, groups scoring high, individual performance improves]	6
Being actively engaged on the task [a lot of discussion, correct one another's mistakes, come to the teacher or invite teacher for clarification as a group, intensify research]	4
Equal participation [no domination, equal participation, every body involved in discussion, every member free to explain without being interrupted, interact with each other easily]	3

It can be seen from table 6.7 above that most teachers perceived productive groups from a motivational perspective (9 of 15). According to the teachers' responses, a group was going well if they saw that all members of the group were interested, enthusiastic, eager to learn, asked for more work from the teacher, and wanted to go on working even when the teacher asked them to stop. Only three mentioned the importance of equal participation for productive group work.

6.8 Teachers' perceptions of the benefits/constraints of co-operative learning on girls' learning of mathematics.

Teachers were asked to specifically consider co-operative learning in terms of the girls' learning of mathematics. They were asked to respond to the question: 'What are the major benefits/constraints/difficulties of using co-operative learning to girls?' An analysis of the teachers' responses revealed that three teachers did not give any response because they had never experienced teaching girls in their teaching career. Another four responses were disqualified because their responses did not specifically make any reference to the girls' learning. Hence, only eight respondents were considered for this item. All of these eight teachers shared a belief that the major benefits of co-operative learning were that girls would feel confident to express their ideas and might ask for clarification in a small group of familiar people rather than in front of the whole class. However, they gave varied explanations of some of the things they considered as constraints for the learning of girls. These are summarised in table 6.8 below:

Table 6.8 Constraints of co-operative learning to girls

Category	No. of respondents (n = 8)
Girls feel inferior socially to males	6
Boys dominate over girls	4
Boys humiliate girls	3
Others	3

Six of the eight teachers wrote that the major constraint they saw was that in the mixed gender groups the girls would feel inferior. For example, they recorded that the girls tended to 'wait for some men or boys to think and act for them'; 'many girls think maths is for men, as such they just sit idle'; 'they [girls] think that their ideas are inferior'.

Another major constraint feared by the teachers (4 out of 8), and similar to that above, was that boys tended to dominate girls. In addition to these four, three other teachers indicated that boys gained the dominance by humiliating the girls when the girls tried to speak. They wrote:

> 'Boys always laugh at girls when they try to contribute wisely to the group so this demoralise the girls' (F/T3).

> 'Girls have difficulties in spoken English which would fail to express where boys would laugh at them and this shun away these girls.' (M/T5)

> 'In a coeducation, the girls might feel shy to participate. If they participate they are thought to be like males, this demoralise them in turn' (M/T6)

The other constraints reported were: 'boys and girls groups were limited in time when they could conveniently meet for discussions outside school time'; 'girls don't take the discussions seriously [and] as a result they gain nothing out of it'; 'girls find it difficult in resolving conflicts which arise in their groups [and] as a result they just make noise'.

The concerns raised by teachers regarding the learning of girls in mixed gender groups are understandable, considering that culturally, girls were expected to be shy and submissive, whereas boys are socialised to be verbal and assertive (Davison & Kanyuka, 1992). These concerns may highlight some of the issues that need to be addressed when implementing co-operative learning.

6.9 Summary of findings

The questionnaire survey sought to understand the teachers' typical instructional practices, and their views and current use of co-operative learning. Analysis of the results has revealed that almost all of the teachers in the study taught mathematics using an expository teaching approach which suggested that they held a transmission view of mathematics teaching. This transmission view of teaching was not consistent with the researcher's constructivist and feminist ideas about mathematics learning from which this study on co-operative learning was designed. Thus, for the teachers to be able to adopt constructivist and feminist ideas embedded in co-operative learning, there is need to involve teachers in situations which can stimulate them to realise that their current beliefs about a transmission view of learning might be problematic (Cobb, Wood, & Yackel, 1990).

The teachers surveyed in this study reported that they used co-operative learning regularly. However, only one teacher mentioned putting students in co-operative learning groups when describing how they usually taught mathematics lessons. The exceptional teacher wrote that he at times put students in groups when they were doing class exercises. This implied that the reported prevalence of co-operative learning was either overestimated, or the teachers' conception of co-operative learning was different from the researcher's understanding of co-operative learning. Overestimating may in part be caused by the teachers' desire to provide answers that the researcher was thought to want, but there was no opportunity to check on this.

The majority of the teachers in this study reported that they had learnt about co-operative learning during their pre service training, but almost all of them reported that they had never experienced an opportunity to discuss co-operative learning after their pre service training. There were some indications from the teachers' responses that their interpretation of co-operative learning represented a somewhat narrow view of co-operative group work as it didn't include all the necessary conditions described in most literature for group work to be called co-operative learning. Notably absent in the teachers' descriptions was the emphasis on group processing (Johnson & Johnson, 1999a). None of the teachers mentioned having students reflect on their group processes. A lot of researchers (Artzt &Newman, 1990; Johnson & Johnson, 1999a) have emphasised the need to always give students time to reflect on their level of cooperation as a necessary condition for productive group work. Further, the teachers' understanding of a heterogeneous group seemed to be limited to mixed ability and mixed gender. There was no mention about considering other characteristics such as personal skills and interests when forming heterogeneous groups. This finding about the discrepancies between the teachers' ideas about co-operative learning and those found in most literature was also consistent with some American elementary school teachers in a study reported by Antil, Jenkins and Wayne (1998).

The Malawian teachers surveyed in this study reported that they used co-operative learning regularly. However, their use of co-operative learning was limited to revising and practicing mathematics. This seemed to be in line with their beliefs about the students' role in mathematics learning as that of 'doing exercises or problems using procedures that have been modeled by the teacher or text' (Thompson, 1992: 136).

On the basis of the findings reported in this chapter, I organised a two day teacher development workshop a week prior to the commencement of the third term in order to clarify the discrepancies between the teachers' conception of co-operative learning and the researcher's ideas of co-operative learning, and to negotiate a shared understanding of co-operative learning. The findings relating to the teachers' experiences during the workshop are reported in the next chapter.

Chapter seven

The teacher development workshop

7.0 Introduction

This chapter reports on the data generated during the two day teacher development workshop organised by the researcher a week prior to the main data collection period. Fourteen mathematics teachers drawn from Zomba urban secondary schools participated in the workshop. The researcher's approach to teacher development reflected a social constructivist perspective of learning. In this regard, the activities of the workshop were designed to

- encourage teachers to reflect on their teaching practices,
- expose teachers to alternative views of co-operative learning,
- negotiate a shared understanding of co-operative learning, and
- build a community of teachers who were trying to incorporate co-operative learning in their teaching.

The activities included: modeling some activities in the teachers' guide, watching a video on co-operative learning, participating in some simulation activities involving a co-operative learning approach, and practicing writing some co-operative learning activities. Table 7.1 summarises the activities carried out during the teacher development workshop. The chapter is organised as follows,

7.1 Implementation of the teachers' guide

7.2 Teachers' concerns

7.3 Teachers reconstructing their ideas about co-operative learning

7.4 Summary

Table 7.1 An outline of the Teacher Development Workshop

Day	Activity
Day 1 Monday 23/08/99	
Session 1	• Teachers break into groups to reflect on co-operative learning activities as suggested in the Teachers' Guide • modeling of activities in the teachers' guide • Group discussion
Session 2	• Show a Video on some co-operative lessons • Group discussions of the video
Session 3	• Group activity—Can Sarah buy the puppy? (see appendix D) • General discussions about the group activity with a focus on characteristics of co-operative learning
Day 2 Tuesday 24/08/ 1999	
Session 4	Group discussions about how to develop in students the co-operative skills discussed in previous sessions.
Session 5	Group work: Practicing writing some co-operative learning activities based on the mathematics syllabus

7.1 Implementation of the teachers' guide

With respect to the first goal, one aspect of the first day's workshop activity was to get teachers to reflect on their experiences with the activities suggested in the teachers' guide sent to them three months earlier (chapter five). However, in the course of interactions, it was revealed that only one of the fourteen teachers had tried the activities. Ten teachers reported that they did not try the activities because they were teaching examination classes. The teacher (the sample teacher in the present study) who had tried the activities was teaching form three— a non examination class. The remaining three teachers came from one school and reported that the head-teacher did not pass on the teachers' guide to them. Although it was not possible to establish whether the three teachers would have tried the activities if they had been given to them, there was a high possibility that they would not. This speculation is based on the fact that all of them reported that they were teaching examination classes (Form two or Form four) at the time. In the course of interaction, I also discovered that the reason almost all the teachers were teaching examination classes at the time was because it coincided with visiting Chancellor College student teachers on Teaching Practice. The non examination classes (Form one and Form three) had been surrendered to the student teachers, thus leaving examination classes to the teaching staff. Most school administrators were reluctant to allow the student teachers to teach examination classes because they feared that it might have a negative effect on the students' achievement. The discussion above suggests that the timing of the study was not convenient for most teachers. This issue of appropriate timing needs to be considered for future research.

Because almost all the teachers had not tried the activities and some were seeing the teachers' guide for the first time, the session on 'teachers' reflection' did not generate the intended discussion. Instead, teachers were given the opportunity to read examples of co-operative learning activities in the teachers' guide, and to model activity 4, "changing formula", in the teachers' Guide (appendix B) in groups so that they could experience what co-operative learning involves. During each session, the teachers were required to reflect on their experiences, relate those analyses with their classroom practices, and to discuss several other questions. Some of the group discussions were tape recorded and transcribed. The remaining part of this chapter reports on the teachers' experiences.

7.2 Teachers' concerns

The discussion revealed that the teachers' concerns about the applicability of co-operative learning, as revealed in the questionnaire, remained. The issues of time constraints due to heavy workloads, overloaded syllabus, and the pressures of external examinations featured prominently as perceived constraints to implementing co-operative learning in Malawian classes. For example, after viewing the video one teacher commented:

> "The method [referring to co-operative learning] is a very good one but it is time consuming especially if we are looking at our syllabus in Malawi whereby somehow somewhere I look at it as examination oriented. We want to cover it so that students are able to answer the questions. But where we are not examination oriented, then its OK. Because at the moment at the same time time, we will be accused of not finishing the syllabus and you will be looked at as you have been spending time on nothing".

One teacher remarked that the problem of lack of time was compounded by the fact that the school lacked sufficient resources.

> "materials are not enough. If you only have one article, you cannot present to all groups. Of course people talk of improvising but... if you think of teaching 21 periods a week and you sit down during the weekend, you only have 2 days to think about what you are going to eat, do you think you have time to think about how you can improvise your lesson (they all laugh and chip in)."

The teachers also felt that co-operative learning may be difficult to implement in non-boarding schools because teachers may require to ask students to discuss some activities outside school hours. Concerns such as those reported above point to some of the factors that may need to be considered for effective implementation of innovative approaches to mathematics teaching in Malawi.

7.3 Teachers reconstructing their ideas about co-operative learning

The findings of the questionnaire analyses reported in chapter six revealed that the teachers' descriptions of co-operative learning did not include some features such as group processing, and that their reported use of co-operative learning was limited to revising and practicing mathematics. In order to draw the teachers' attention to some alternative aspects of co-operative learning, the workshop activities served two purposes: First, they provided situations which enabled teachers to begin to question their current ideas (practice) of co-operative learning. Secondly, they served as stimuli to getting teachers to rethink about ways of incorporating such ideas in their teaching. During each session, teachers were asked to reflect on their experiences and to relate those analyses with their classroom practices. Thus, the role of the researcher (workshop facilitator) was not to directly convey her ideas about co-operative learning but instead to work with teachers to gain a shared understanding of co-operative learning.

In the course of discussions, it was revealed that many teachers realised that there were more opportunities in which they could use co-operative learning other than revising and practicing mathematics. For example, after viewing the video, teachers were asked to discuss what they felt about the teaching approach in terms of its applicability to their classroom context, its perceived benefits on students' learning, and several other questions. One teacher who had previously reported that he had only formed groups for the purposes of revising past examination questions remarked that,

> "it's a good strategy to use when starting a lesson. You can easily come in, joining in the discussion "

It appeared that the teachers' experience of watching the video and going through activities in the teachers' guide challenged their views that co-operative learning could only be used for revising and practicing mathematics. The video, "One Approach to Teaching and Learning Mathematics" showed a teacher using a co-operative learning approach to introduce a new topic about negative numbers to a form one class using a science topic on weather to provide the context for learning. During the lesson, the class was divided into groups which worked on different activities. It was also possible that the teachers' concern about lack of resources as a limiting factor was also challenged. The teacher in the video used everyday resources, and different groups of students in the video were working on different tasks. This indicated that in cases where there was only one piece of equipment, one group could be using it while other groups could be working at different tasks rotating until every group gets a turn.

The teachers' broadened view of co-operative learning was also reflected in the activities they wrote in groups on the second day of the workshop. The activities were varied including lesson introduction, revision and practicing mathematics; they also tended to include a strategy of some sort to ensure that all students in the group participated in the task. Most of the strategies were, however, imitated from the suggestions given in the teachers' guide.

Teachers reported that the experience of modeling some co-operative learning activities helped them to understand some of what the students go through as they solve mathematical problems. For example, after participating in the activity, "Can Sarah buy the puppy?" teachers reported that they were surprised to find that

> "even us teachers, we came up with different strategies of solving the problem; some strategies were more efficient than others and so the group benefited from efficient ones."

However, they commented that they were at times slowed down because the process of trying to reach a consensus was making them "move backwards and forwards" as reflected in the following comment,

> "After some contribution from a member, members had to be convinced before an idea could be written down; questions like "how?" had to be resolved before we could move on. It is possible that there are times when students cannot reach a general agreement."

The activity "Can Sarah buy the puppy?" was designed to generate discussion about whether assigning roles to students might contribute to the efficiency of group discussion. They commented that they found it very difficult to stick to their roles, indicating that their students would experience similar problems.

There was evidence from group discussions that the teachers realised that co-operative learning involved more than just putting students in groups. This was reflected in the comment below made by one teacher:

> "Of course in groups, you know that if you just group students and leave them to work, some students will not actually work. They know each other and they know that this person is intelligent in the group, so they will just depend on that person."

When this teacher was asked how he would ensure that everybody participated, he explained:

> "to make sure that everybody is learning, a teacher must be choosing a student at random to give the answer on the board. This will encourage the student who is intelligent to know that even if I

am intelligent and I know the answer, but if the teacher chooses this one [lower achiever], it will be bad for the group, so that student [the intelligent one] will make sure to share his [her] knowledge to every member of the group".

He continued to explain:

"of course the teacher must make sure that the random should not always go to the same students so as to give every student opportunity, a chance to speak in front. This will build their communication skill to develop in students, so when they go for an interview, they won't have problems."

Thus, the teachers began to see that co-operative learning was not only beneficial for academic gains, but that it also promoted some social skills.

7.4 Summary and discussion

The findings reported in this study showed that only one teacher involved in the study had implemented the activities suggested in the teachers' guide sent three months earlier. This was mainly because most of the teachers were teaching examination classes, and as a result were reluctant to try something new in these classes because they were unsure about how the implementation of such changes would affect the students' achievement during the examinations. The issue of teachers being concerned that their students' achievement in external examinations could be jeopardized as a result of innovative teaching approaches has been noted by other scholars (Maher, 1991; Thompson & Senk, 2001). However, I concur with Vulliamy, Lewin and Stephenes (1990) that the reason most teachers were reluctant to move away from traditional teaching approaches to adopt student-centred pedagogies was because they themselves had not experienced such teaching approaches during their school time and teacher training. This was confirmed by the teachers in this study. After the workshop, most indicated a commitment to implement co-operative learning in their teaching and asked if I could visit them in their schools at some point to discuss their experiences. Unfortunately, due to time constraints, I was unable to do so. The data reported in this chapter suggested that there was need to give teachers opportunities to participate in co-operative learning activities and to offer them support before they can be expected to implement co-operative learning in their teaching.

It was found that as a result of the teachers' participation in the workshop, their understanding of co-operative learning had broadened to include some aspects of co-operative learning that were missing in their prior practice. Their experience with the workshop activities helped them realise that co-operative learning could be used for many other activities than revising and practicing mathematics as previously conceived. In social-constructivist terms, the workshop activities might be seen to provide alternative conceptions of co-operative learning practices through which the teachers' meaning could develop. As teachers were participating in the workshop activities, the viability of their current knowledge was being challenged and in the process, modifications were being made. Further, giving teachers opportunity to model some of the activities in the guide, and to write their own activities, allowed them to share some ideas with each other and raise questions that reflected their concerns. This enabled the teachers to gain a better understanding of what co-operative learning involved, compared to learning about it through reading (Appleton, 1996).

The concerns raised by the teachers reported in the previous chapter such as time constraints due to demands of external examinations, heavy workloads and an overloaded syllabus as having a deterrant effect on their ability to implement co-operative learning in Malawi, were reiterated during the workshop. Pesek and Kirshner (2000), however, explained that the underlying belief for citing time constraints as a reason for relying on traditional instruction is the assumption that non traditional teaching approaches take more time than traditional methods to implement. They challenged this assumption in research evidence which showed that the students following a traditional approach spent twice the time that the students following a relational instruction approach took in learning the same content. Further, the students following the non traditional instructional approach achieved more highly than the students following the traditional teaching approach.

These findings point to the need for strategies to convince teachers that the implementation of progressive teaching approaches has a positive effect on achievement. Only then is it likely that co-operative learning can be implemented on a larger scale and longer term in Malawi.

In the next phase of my research I took a case study approach and observed one teacher for the whole of the third term with three of her classes as she incorporated co-operative learning into her mathematics teaching. The results of this case study are reported in the next three chapters.

Chapter eight

Description of the sample

8.0 Introduction

The underlying assumption through out this study was the socio-constructivist view that the meanings constructed from the present study were shaped by the social setting in which the teacher, students and the researcher were working. Thus, an understanding of the social setting of the research was important for understanding the findings reported in this thesis. Hence, the purpose of this chapter is to give a brief description of the second phase research setting, the staff and the students within it, and how these affect the research process. Data were gathered from various sources to describe relevant features of the school, teachers and students. In order to understand the culture of the school, I participated in several school activities. These included all morning assemblies, several morning tea breaks, two staff meetings, and some social activities. I chose to attend many school assemblies and many morning tea breaks as such occasions can provide important and relevant insights for the researcher. The chapter is organised as follows:

8.1The school

8.2 The teaching staff

8.3 The Students

8.4 Summary

8.1 The school

The secondary school involved in this study is coeducational, boarding, and a government school. It had approximately 720 students on its roll. It is located in the municipality of Zomba, commonly referred to as the university town. It is about 10 minutes walk from Chancellor College which is the main campus of the University of Malawi. Like other government secondary schools in Malawi, entry to the school is determined by means of a highly selective national examination, The Primary School Leaving Examination (PSLE). A Ministry of Education affirmative action policy requires that one-third of the secondary school places be reserved for girls, and that students selected to this particular secondary school should only be those that are originally from Zomba district or those sitting their PSLE in Zomba urban primary schools. As a result of the quota system, girls enter the school with lower PSLE scores than that of boys (Ministry of Education and Culture, 1985–1990). This may have had an impact on the girls' perceptions of their mathematical abilities, and hence their experiences during co-operative learning activities.

The school had its first intake in 1985. It was the only secondary school in the country which had a 'normal school' status to be used by Chancellor College, a constituent college of the University of Malawi. Until recently Chancellor College was the only college responsible for the training of secondary school teachers. Thus, throughout the year, students from Chancellor College came to the school for their micro-teaching or teaching practice. From a classroom researcher's point of view, this was an advantage in that students were already used to having observers in their classroom.

One of the first impressions gained when I began my research was the apparent high status English as a subject was accorded by the school. This view was derived from the following: As a result of the government's requirement to have a pass in English (awarded by certificate) at every level, the school placed English as the number one subject and this was professed to students both explicitly and implicitly in different ways. For instance, at every assembly, 3 students were given awards and each time the Deputy Headmaster would remark: "As you are all aware that English is our number one subject at this school" while presenting awards to the three students for being 'best English speakers for the week'. This award presentation sent strong messages to students. This, in turn, had implications when analysing the students' day-to-day experiences, attitudes, concerns and their perceived benefits of co-operative learning in mathematics (see section 10.2).

8.2 The teaching staff

All teachers in government and government-aided secondary schools in Malawi were recruited by the Public Service Commission. The posting to schools was done at the Ministry of Education headquarters based on the schools' needs; teachers could be transferred to different schools at any time. Teachers usually had no say on which school they wished to be posted to although staff members could negotiate to be posted to schools close to the working places of their spouses. Almost all teachers at the school involved in the main part of this research had negotiated to be posted to the school because of their spouses. There were 16 teaching staff of which 10 were female including the Head mistress and the deputy Head mistress. It was typical for an urban secondary school to have more female teachers than male teachers because women often followed their spouses working in urban areas.

I had personal knowledge of the majority of the teachers because some were my college peers at the university, some were my ex-students and some went to the same church as I did or belonged to the same Christian Organisation as I did. These connections gave me the benefits of an insider in the research process. I was also an outsider in the sense that I came in as a researcher using western methods (Vulliamy, Lewin & Stephens, 1990). I found that the demand to maintain both roles of an insider and outsider was challenging at times. On several occasions this created a tension. I felt uncomfortable when I had to cut short a 'lengthy' greeting with some of my staff member friends or a 'catch up talk' of some church programmes with some of my church-mates in the staff-room because I had to attend to my scheduled interviews or classroom observations. Although the problems of maintaining the dual role of insider/outsider came as no surprise, I was frustrated by the way it affected me emotionally. This frustration came about because when I chose the outsider's role, I was hurting the other party's feelings by 'abandoning' him/her. Prolonging the insider's role would have meant that my research plans were being slowed down. These experiences brought to my attention the challenges of being a Malawian and researching in Malawi. Much of the literature on qualitative research was about the problems faced by expatriates conducting research in Africa (Vulliamy, Lewin & Stephens , 1990). Most of the problems experienced related to language and culture. For example, Stephens, one of the authors in Vulliamy et al reported that some of the problems he experienced as a result of being an outsider researcher in Kano, Nigeria included: limited flexibility in the areas he could research, difficulties in gaining access to the participants' views and, in some cases, misinterpretation of information obtained due to minimal understanding of the culture. He explained that he had to restrict his research to the formal, western-style education system and exclude the respondents' experiences within the Mosque because he discovered that amongst bilinguals, there was a tendency for experiences codified in one language and appropriate to its culture, to be recalled in the same language. Consequently, if he were to include the data about the informants' experiences within the mosque he would have to use Arabic for the research to be meaningful. He also noted that due to the courteous nature of the culture, the respondents were unwilling to reveal too much too quickly to him, 'an outsider'.

In my visits to the staff room, I was always struck by how overcrowded the room was. Teachers were usually sitting at their desks littered with pupils' exercise books, textbooks and teaching aids both on top of their desks as well as on the floor. The staff room was always noisy. The teachers usually joked with each other, but their conversations were mainly about students not working, their workload and their low pay.

During the research period of this study, there were three teachers teaching Mathematics. They were all in their twenties. The teacher involved in this study (referred to as the sample teacher in this thesis), was enthusiastic, she had a Bachelor of Education degree in Mathematics with Physical Science as her minor subject. She had been teaching for 3 years. The sample teacher and the other male mathematics teacher usually sat in the recreation room with four other teachers because the main staff room was too small to accommodate all teachers; however, they went to the main staff room for tea. Consequently, I spent more time in the recreation room than in the main staff room.

Apart from teaching mathematics, the sample teacher was a boarding mistress and assistant dispensary officer. This meant that she had to attend to all boarding issues as well as sign permission slips for students wanting to go to hospital. This seemed to have an effect on her teaching as evidenced in the following extract between the sample teacher (ST) and the headmistress (H/M):

H/M: [surprised that the sample teacher taught without a lesson plan]. A lesson plan is very important .... it gives you structure and idea of what material you need to cover in a lesson. ...

ST: I don't have time to write lesson plans because I am so busy with boarding issues.
(Headmistress and the sample teacher, 19/10/99)

The other two mathematics teachers were VM (male) and MA (female). They are described in table 8.1 below:

Table 8.1 Description of Mathematics teachers at the school

	Code	Gender	Major teaching subject	Minor teaching subject	Years of teaching
Sample teacher	ST	Female	Mathematics	Physical Science	3
Other teacher 1	MA	Female	Mathematics	Home Economics	5
Other teacher 2	VM	Male	Biology	Mathematics	3

VM seemed an active teacher and eager to learn new ideas about teaching. He had previously worked on the 'cognitive acceleration in science learning project; and had participated in both the workshop and writing of teaching activities. He also incorporated some co-operative learning activities into his teaching during the research period and for the first three weeks of the study , we met once a week to discuss his experiences. Because he wasn't my focus, I did not observe or collect data from his classes. MA was away for Malawi School Certificate Examinations marking during a greater part of my research period and her classes were taken by VM.

The three teachers were ex-students of mine from Chancellor College. This posed some challenges on maintaining a horizontal and equitable power relationship with them. Malawian culture places great importance upon respect for authority. As a feminist and constructivist researcher, I intended as much as possible to allow the sample teacher autonomy in her decisions about how to organise co-operative learning activities. This intention proved difficult to sustain during the early phase of the study. The sample teacher was mostly looking to me for 'the right' way of organising the activities. Initially I wore interchangeable hats of 'teacher educator' and 'researcher'. After the early stages of data collection the intended roles for the research process were negotiated with the sample teacher (Cobb et al, 1990).

8.3 The students

The students had routines to follow with their day starting at 5.00 am and finishing at 8.30pm on all days except Saturday when it was 10.00pm. The days' activities are summarised in the table 8.2 below.

While it may appear that students had over 15 hours of study each week and could therefore devote nearly 2 hours per week to mathematics, in fact teachers of other subjects often used this time to give notes. Hence, students had only very little time to do mathematics outside the time-tabled mathematics classroom periods. The school also had a policy that allowed boys to stay in the classrooms after hours while girls had to go to their hostels immediately after evening study hours. This meant that boys had more opportunity to discuss their mathematics tasks after hours than girls.

Table 8.2: Summary of students' routine activities

Monday to Friday	
5.00 am – 6.30 am	Cleaning at the hostels
6.30 am – 7.00 am	Breakfast
7.00 am – 7.20 am	Cleaning classrooms and grounds
7.20 am – 7.30 am	Roll call
7.30 am – 9.30 am	Classes
9.30 am – 10.00 am	Morning tea break
10.00 am – 12.00 am	Classes
12.00 am – 1.30 pm	Lunch break
1.30pm – 3.30 pm	Classes
4.00pm – 5.00 pm	**Mon:** Study Time **Tue & Thu**: Compound work alternating with inter-hostel sports competition **Wed:** Clubs and societies **Fri**: Sports
5.45pm – 6.15pm	Supper
6.30 pm – 8.30 pm	Study time
Saturday	
5.00 am- 8.00 am	General cleaning
8.00am – 8.30 am	Breakfast
10.00am – 11.45am	Study time and roll call at 11.45
12.00 am	Lunch
2.00pm – 4.00 pm	Games
6.00 pm	Supper
7.00 pm – 10.00 pm	Entertainment
Sunday	
5.00 am – 7.00 am	Cleaning of hostels
7.00 am – 7.30 am	Breakfast
9.00 am – 12.00	Church activities
12.00	Lunch
2.00 pm – 4.00 pm	Prep
5.30 pm – 6.00 pm	Supper
6.30 pm – 8.30 pm	Prep

8.4 Summary

In this chapter, I have described some aspects of the social setting of the study and how this might have affected the findings reported in this study. The use of the school by Chancellor College as a demonstration school meant that the students' distraction by my presence in the classroom was minimised. My position of a Malawian doing research in Malawi and my personal knowledge of the staff gave me the benefit both of insider knowledge and being able to identify with the participants. However, the demand of having to sustain the 'insider' and 'outsider' roles posed some dilemmas which I had to resolve personally in various ways.

The school had separate policies for girls and boys concerning admission and the use of classrooms after hours.

Data collected during classroom observations is reported in the next two chapters.

Chapter nine

The Question/answer teaching approach: results and discussion

9.0 Introduction

In the previous chapters, I noted that my research into co-operative learning was theoretically based on social constructivism. This view posited that knowledge was not passively received but actively constructed by the learner, and emphasised the role of social interaction and prior experience in the process of knowledge construction. Thus, as the teacher was trying to make sense of the ideas of co-operative learning that I was suggesting, her implementation of co-operative learning resulted from the interaction of her existing beliefs and experiences that she brought to the 'action research', and my ideas of co-operative learning. In this light, I expected that both the teacher's and the students' prior beliefs about mathematics would have major implications in relation to analyses of their experiences of co-operative learning (reported in the next chapter). Thus, an aspect of this study was to understand the existing practices that the teacher used in the classroom, and how these affected the students' learning of mathematics. This chapter addresses the following research questions:

- What were the teacher's typical instructional practices?
- What were the students' experiences of this teaching approach?
- What effects did this teaching approach have on the students' conception of mathematics?

Data from classroom observations is used to describe some important features of the teaching approach used by the sample teacher. Implicit in this was the belief that the teacher's instructional practices in the classroom reflected her beliefs and the views she held about mathematics and mathematics teaching (Thompson, 1984; Cooney, 1999). In order to understand the students' experiences and feelings, I observed lessons, took field notes, interviewed some students (n = 150), gave students (n = 83) a questionnaire to fill in, and asked students to respond to some open questions in their journals. The results from all these are analysed and I discuss them in five sections as follows:

9.1 Typical teaching approach

9.2 Question/answer teaching approach

9.3 Students' experiences of mathematics in question/answer teaching approach

9.4 Students' perceptions of mathematics and mathematics learning

9.5 Effects of question/answer teaching approach on the girls' learning

9.6 Summary

9.1 Typical teaching approach

In order to characterise the sample teacher's teaching approach, I observed approximately 105 mathematics lessons over a period of 3 months, usually taking the role of a participant observer. I used a variety of data collection methods such as observations, interviews, conversations, writing field notes and students' journals. An analysis of the resulting data indicated that three broad sequential categories characterised her teaching. I have labeled them 'Introduction - Example(s) - class Exercise(s) (IEE)'. Typically, she introduced the topic by explaining the content of the lesson and defined some new terms. Next, she had the example(s) to be worked out. The students were then given exercises based on the example through which they practiced the topic. Within this broad framework her choice of teaching approach seemed to depend on the particular objectives she wanted to achieve in each category. Consequently, the sample teacher mostly used a combination of teaching approaches in a single lesson. For instance, she would introduce a lesson using a lecture method, work out an example using a question/answer method and let the students work on class exercises in co-operative learning groups. However, there was always a particular approach that took most of the class time and this was almost inevitably either the question/answer approach or co-operative learning. This allowed me to distinguish between two main approaches: *question/answer* and *co-operative learning,* depending on whichever approach dominated the lesson. Since my focus in this chapter is to investigate the sample teacher's beliefs about mathematics and mathematics teaching prior to the study, I have limited my discussion in this chapter to the *question/answer* teaching approach; I discuss her co-operative learning approach in chapter 10. As far as I can tell from the data, the question/answer teaching approach represented her typical teaching approach before she encountered the alternative ideas about co-operative learning and therefore probably reflects the prior beliefs that she brought into the research.

9.2 Question/answer teaching approach

As indicated above, the sample teacher mostly taught mathematics using what I would describe as a '*question/answer*' variation of a direct teaching approach. Using this approach, the sample teacher divided the content of the lesson into small logical bits. Instead of lecturing about these to students, as was usually the case with direct teaching, she linked the content using highly closed questions which had the next step as the only correct answer. These questions were asked of different students. The following excerpt from my field notes illustrates how the sample teacher taught using the question/answer approach within the IEE format:

> The lesson is about similar figures and the teacher has written this topic on the board. Teacher asks: 'What are polygons?' Students A, B and C give wrong answers. Teacher writes definition of polygons on the board. Teacher asks: 'What is the name of a 3-sided polygon?' Student D answers: 'triangle'. Teacher asks: 'What about a 4-sided polygon, 5-sided and so on until a 10-sided polygon'. Different students answer these questions and teacher writes the correct answers on the board. 'When are polygons similar?' she asks. 'if they have equal angles', 'if they have equal sides' 'if their sides are proportional' are some of the answers given by different students.

> Each time, teacher responds to students' answers that 'condition you have given is not enough' and moves on. Teacher then writes definition of similar polygons as follows: '2 polygons are similar if (i) they are equiangular and (ii) their corresponding sides are proportional.' She underlines the word proportional and asks: ' what does the word proportional mean?' Different students give answers. 'Can you give me an example of 2 figures which are equiangular but are not similar?' she asks. 'A square and a rectangle', some students shout. 'Correct', teacher answers, and pointing to the 2 conditions of similarity written on the board, she asks, 'So what does this tell us?' "Equiangular does not imply similar' is shouted by almost all students. Similarly teacher asks: 'Give me an example of two polygons that are proportional but not similar?' A rhombus and a square are given and teacher writes the conclusion that proportional sides do not imply similar. The teacher writes down answers in order of the questions asked and these form students' notes.
>
> (Form 3N, 12/10/99, 10.40–12.00)

The approach described above is not unique to Malawian classrooms. It was similar to what Peterson (1988:3) referred to as 'extensive teacher-directed explaining and questioning'. Peterson reported that it was also the most common in the United States in the 1980's. The sample teacher's motivation for such instructional practice was to actively involve the students to improve their learning of mathematics. On many occasions, she stated that she was very much against direct teaching and maintained a belief that students learnt better when they were involved during the teaching process. Her use of the question/answer approach was partly influenced by this belief; her desire was to involve students as much as possible in her teaching. Yet, the type of questions she asked and the way she reacted to students' responses in the classroom demonstrated behaviours that seem indicative of direct teaching in that: (i) most of her questions were convergent/closed, (ii) she provided immediate feedback to students' responses usually by reinforcing 'correct' answers, (iii) she accepted answers that matched the ideas and lesson sequence she had in mind, and (iv) she didn't allow enough time between questions for students to reflect on the questions. The discourse was highly focussed and fast paced, and there was little evidence of students' input. This seemed to be inconsistent with her professed belief that students learn better if they were involved.

This inconsistency seemed to stem from the tension between her desire to involve students in their learning and her belief in the unwillingness of the students to learn by themselves.

> 'if I try to give students a problem that is new to them, even if it is something they can do, they always say no, madam we can't do this because we haven't learnt it. They don't even want to try it. So they just wait for me to come and teach them.'

This had resulted in the teacher breaking down the content into small components and using closed questions to guide her students toward easy understanding of each component. Such practices reflected a behaviourist view of learning (Joyce & Weil, 1992). This approach seemed to fit with the beliefs she held about her role and responsibilities as a mathematics teacher. She perceived her role as that of preparing students for the Malawi School Certificate of Education (MSCE) examinations and thus, her major concern was to cover as much content of the syllabus as possible. This approach seemed to be the fastest way of covering the syllabus and presumably getting the work into the minds of students. In most cases, this seemed to result in isolated pieces of mathematical procedures and facts being learnt by students. This seemed to encourage students to view mathematics as a set of rules to be memorised (see section 9.4).

This concern about wanting to cover the content quickly was professed by the sample teacher on several occasions. She would 'warn me', as we walked into class, that she was going to use direct teaching instead of co-operative learning approach because she had to cover some content for the test she was to administer, or because a particular class had to catch up with content taught in other classes.

This conception of mathematics fitted well with what Thompson (1992) referred to as an absolutist or dualist view of mathematics. It was perhaps not surprising that the teacher had this absolutist belief about mathematics because she was teaching from a syllabus which could be argued to be absolutist in conception (Jaworski, 1994).

> The teacher who wants students to know, for example, about Pythagoras' theorem, possibly because the syllabus requires it, has her own construal of what Pythagoras' theorem is or says. It is very easy for her to dwell in an ontological state of mind, acting as if there is an object known

> as Pythagoras' theorem, that she knows it, and that she wants students to know too. ... If the student's *it* seems in any substantial way to differ from the teacher's *it*, then the teaching is regarded as less than successful. It could be argued that the mere fact that the syllabus requires Pythagoras' theorem to be known by the students suggests that the syllabus is absolutist in conception.'
>
> (Jaworski, 1994: 17–18)

Hence, asking the sample teacher to incorporate co-operative learning (constructivist in conception) in her teaching involved a shift in her beliefs from an absolutist view of mathematics to a constructivist philosophy. However, there was evidence that the teacher was experiencing some philosophical conflicts as she was trying to incorporate co-operative learning in her teaching. For instance, in the sample teacher's own words,

> "...they prefer group work when you are revising the topic, but when you are introducing the new topic they just want you to use lecture method, but for the bright kids they don't care, when you give them something new just give them a formula and you give them an example, ask them to discuss it; they will discuss and they will write. When they make a mistake they will come to you and ask you where they have made a mistake but those students who are dull or who know that they don't do well, they prefer that you first give them an example, then you give them an exercise, whether they do it in groups or they do it individually that's what I have discovered. So I don't know what I should do because it's like I have 2 groups of students in one class. If it were possible, may be if we had the bright students in one group and the below average in another class ... "
>
> (interview with the sample teacher, 15/09/99)

The sample teacher seemed to have a dilemma of wanting to give students autonomy in their learning but at the same time she believed that weak students needed to have direct instruction because they were unable to learn on their own. In her lexicon, they were "dull". Several teaching episodes seemed to support this interpretation. Her approach when teaching in 3W (top class) was markedly different from the way she taught the other two classes. Her teaching in 3E and 3N was usually reduced to procedures to be learnt by students while she allowed students in 3W to explore their own strategies. Below are excerpts of the notes taken while observing the sample teacher teach the same lesson to 3N and 3W:

> "teacher announces that today is trigonometry but we will do degrees and minutes. She writes on the board: $1^\circ = 60$ min; $1^\circ = 60'$; 1hour = 60 min. She writes example 1:
>
> | | | |
> |---|---|---|
> | | 2h | 50 min |
> | + | 3h | 30 min |
>
> Teacher demonstrates how to solve the example through question/answer method. She writes change $6'$ to degrees and asks students how to do it. Some students shout "multiply by 60", some students shout "divide by 60". Teacher illustrates the method by giving them a familiar example: "How would you change 40 minutes to hours?" All students shout "you divide by 60". Teacher explains that it is the same with changing $6'$ to degrees. Teacher writes rules on the board as follows: (1) to change minutes to degrees divide by 60, eg 6 min to degrees = 6divide by 60 = 0.1 degrees. (2) To change degrees to minutes, we multiply by 60, eg 60° to minutes is 60x60 = $3{,}600'$. 4 hrs to minutes becomes 4hrs x 60min = 240 mins. (3) to express 53.5° to degrees and minutes you first write 53.5° as $53^\circ + .5^\circ$ and change $.5^\circ$ to minutes since 53 is already in degrees. One student asks why you write 53.5 as 53 + .5, teacher explains that 30.9 is same as 30 + .9 etc. Students are given exercise to do.
>
> (3N, 13/10/99, 10.00–10.40)

and

> Teacher writes on the board "trigonometry degrees and minutes". Teacher remarks that these minutes are about angles not time. Teacher writes on the board as in 3N. Lesson proceeds as in 3N. Teacher doesn't write notes on rules on the board on how to change minutes to degrees and degrees to minutes as done in 3N. Teacher gives the following problem to students to discuss in groups. Teacher says "since I trust you I will give you this problem for you to try in groups, not in your usual groups but with the ones sitting next to you".
>
> | | | | | | |
> |---|---|---|---|---|---|
> | | 15° | $56'$ | | 26° | $48'$ |
> | + | 8° | $23'$ | – | 15° | $59'$ |
>
> (3W, 13/10/99, 11.20–12.00)

This belief in the inadequacies of some students may partly explain the teacher's differential instructional behaviours.

Teacher's shift towards a constructivist approach

The data from lesson observations revealed that the question/answer pedagogy was used intermittently by the sample teacher throughout the research period. Her use of the question/answer pedagogy was mainly due to her perceived belief that the question/answer approach required less time than the cooperative learning approach (see chapter 11). However, there was evidence that her use of the question/answer pedagogy had shifted from a behaviourist perspective towards a constructivist approach. Towards the end of the research period, the question/answer lessons were characterised by students working on the task either individually in class or as a homework task. The teacher would then ask one student to write and explain his/her solution on the board. Instead of verifying whether the solution was right or wrong, as was usually the case with most of her earlier lessons, the sample teacher would invite students to react to the solution regardless of whether the solution was correct or otherwise. Having the students work on the task before question/answer discussions gave the students the opportunity to think through the task before class discussion. This encouraged the students to be actively involved during the discussion. Inviting students to react to the solutions encouraged the students to engage in a dialogue amongst themselves as they tried to clarify and adjust their solutions to their fellow students.

9.3 Students' experiences with the question/answer teaching approach

Students usually sat in rows facing the chalkboard. When the teacher was teaching and writing from the front, the students were listening, watching, answering questions asked by the teacher, and copying down the procedures for solving the examples written on the board which students were intended to use in the exercises that followed. Thus, the majority of students' experiences in mathematics involved 'receiving' mathematical strategies and procedures from the teacher. Cooney (1985) argued that this learning experience embodied the notion of authority in that there was a presenter with a fixed message to send and therefore encouraged students to hold a platonic view about the existence of mathematical concepts outside their mind. The students in this research strongly believed that correct answers and strategies existed in the teacher's head and on several occasions expressed their frustrations regarding the teacher asking them questions instead of just telling them the answers.

> "the teacher I think would just tell what we are going to do instead of just keeping something and say we are going to see by the end of the lesson." (S89, Boy 3N 10/09/99)

> "There was a lot of complicated facts given by students and the teacher cannot say this is true or not." (S59, Girl 3N 10/09/99)

> "Today's lesson was not nice because the theorem is new to us so there is no reason to ask us instead of teaching us. (S79, Boy, 3N 10/09/99)

The teacher's tendency to reduce mathematics to procedures that could be learnt by heart meant that most of the students' experience of learning mathematics involved memorising disconnected pieces of mathematics unrelated to their everyday realities (the trigonometry extracts on pages 141 are earlier examples of this phenomenon). Students were often discouraged by the teacher from thinking about mathematical relationships among different topics. Comments such as "forget about the tangents we learnt last week in Arithmetic, this is now Geometry", or "these are minutes in angles and not as in time" were the order of the day. The resulting effect was that students seemed to compartmentalise knowledge for different topics and subjects. For instance, students learnt that plotting a graph in mathematics was a different exercise from plotting a graph in physical science, as evidenced by the following excerpt from my fieldnotes and a transcript of a group discussion involving four girls :

> 'the group was assigned to plot the graph of y=2x for values of x from –3 to 3. They draw axes from the origin, Later on one girl says "ah no we have made a mistake. This is not a physical science graph, it is a maths graph." '

The students' experiences of mathematics tended to encourage them to develop into what Becker (1995: 168–169) construed as separate knowers. My observation notes revealed that:

(i) Students did not experience the process of creating strategies for solving mathematics; rather these were handed down by the teacher.

(ii) Alternate methods of solution were not encouraged.

(iii) The students did not experience the process of posing a problem and solving it. Rather students were always answering questions posed by the teacher.

Becker also suggested that this type of knowing was preferred by boys; girls tended to be connected knowers (chapter two of this thesis).

Teacher's selection of students to respond to questions

I observed that the sample teacher tended to pick students whom she knew were unlikely to provide the correct answers to her questions. This tendency was contrary to most findings on classroom practices which report that teachers usually search for students who can provide correct answers to their questions (Tobin, 1993; Boaler, 1994). This difference was possibly due to the fact that the findings reported in these studies were about teachers who held traditional views of mathematics while the teacher involved in the present study seemed to hold a constructivist belief that students learnt better when they are involved—even though most of her teaching behaviours were not consistent with this belief (see section 9.2). Further, it was possible that because of her involvement in the present study, she was already in a transition stage, moving away from a traditional conception of mathematics teaching towards a constructivist perspective. Thus, her selection decisions possibly derived from her emerging belief that 'these weak students' needed to be involved in the class discussion if they were to learn mathematics. However, she did not seem to realise that from a constructivist perspective, she could never force students to construct knowledge (von Glasersfeld, 1993: 34). I conducted a small survey to monitor the sample teacher's pattern of students' selection to answer her questions. Observing a double period Geometry lesson on 9/09/99 and a single period Arithmetic lesson the following day in 3E, I recorded the sex of the student answering the question, regardless of whether the student volunteered to answer the question, and whether the answer given was correct. Table 9.1 below summarises the result:

Table 9.1: Pattern of students' selection to answer Questions

	Gave correct answer	Gave either wrong or no answer	Total
Volunteered	G: 6 B: 16	G: 7 B: 10	G: 13 B: 26
Did not volunteer(asked by the teachers)	G: 2 B: 2	G: 11 B: 9	G: 13 B: 11
Total	26	35	63

(Data from 9/09/99, 3E, Geometry and 10/09/99, 3E, Arithmetic)

The total sixty-three in table 9.1 means that the teacher sought responses from students 63 times. Of the 63 responses given by students, only twenty-six were correct; about a third of the students responding (24 out of 63) did not volunteer to answer a question but were still asked by the teacher. This tendency on the teacher's part to pick students who were either not ready to give a response or were unlikely to give a correct response may have promoted a sense of anxiety in students. One student wrote in the journal after a question/answer method that

> "today I was so relieved that the answer I gave in class was a correct one." (S116/B/3N, 10/09/99).

It seemed that many students spent a lot of time and energy being anxious about being picked to answer a question. I wrote in my field notes that 'many students are looking down avoiding teacher's eyes to avoid being picked to answer a question.'

Another practice also seemed to contribute to student anxiety and negativity. Students who failed to produce a correct response were made to stand for the rest of the lesson or until they gave a correct answer. This meant that most students experienced embarrassment and humiliation. Humiliating comments from fellow students included: 'move and stand to the other side, you are blocking us from seeing the board'. But because they were standing, it was difficult for them to write down whatever the teacher was writing on the board.

Pace of questions

In the majority of cases I observed, after the sample teacher had posed a question to the students, she quickly moved through students' responses until a right answer was given. Students had only a few seconds to think about and reflect on the questions asked and responses given. This was unlikely to promote their construction of mathematics. Here, I am assuming a social constructivist position that students learn by making sense of their experiences through social interaction (Yackel, Cobb, Wood, Wheatley and Merkel, 1990). For students to be able to construct their mathematics, they needed to experience an environment where they could listen to the question being asked and the response given to it, and reflect on what was being said and try to make sense of all of this in terms of their cognitive frameworks.

The majority of students in this study expressed their lack of understanding of the mathematics they encountered during the question/answer teaching approach. They felt that the pace of the lessons were too fast. Responding to an open journal prompt given to students soon after a question/answer lesson: 'What did you like/not like about the way we worked today?'; 36 out of 50 (72%) students commented on their lack of understanding in mathematics. Of these 36 students, 12 attributed their lack of understanding to the fast pace of teaching. Even the 14 students who commented that they had understood the lesson remarked in their journals that they didn't learn in class—they had practiced the problem in the textbook before coming to class. They did not blame their lack of understanding on their lack of ability, nor on the nature of mathematics as a difficult subject. They blamed it on the teaching style. They felt that:

(i) the pace of teaching was too fast (12)
(ii) they couldn't even hear what other students were saying (2)
(iii) they needed to be involved enough to stop them from sleeping in such hot weather (6)
(iv) the teacher did not handle their questions/responses properly (7)
(v) Others (9).

Typical comments from the students were:

> 'our madam teacher when she is teaching she does it fast.'
>
> 'what got into my mind is how students got the answers when the teacher questioned'

One girl felt that she was capable of learning mathematics but that she wasn't given enough time to make sense of her mathematical experiences. She wrote:

> "The way we worked today I didn't feel ok. I mean I am not satisfied [convinced] with the explanations for the proof we were doing. But by the way, I know myself that I am a slow learner. Sometimes I feel that even if the problem may look difficult, I know that with time I can manage, but in class, I don't get anything." (S100, Girl 3N 10/09/99)

The pace of question/response and feedback from the teacher was so fast that in most cases, the students were unable to hear both the response given by fellow students and the teacher's feedback to the responses.

> '...the problem is that when we were learning some people were making noise so I have missed some points and I wish the teacher to repeat the lesson so that I can get/understand it.'
>
> (S70, Girl 3N 10/09/99)

The above discussion reflected that the students in this study felt that they needed more time to understand what was going on than what was given to them.

Teacher's feedback to students' answers

Most of the teacher's feedback to students' responses related to whether the answers given by the students were correct or wrong. This was partly due to the teacher's tendency to use closed questions which had one correct answer. This meant that when she was responding to students' answers, she focussed more on whether their answers matched the response she was expecting. This was consistent with the teacher's belief that her role was to 'prepare students for the Malawi School Certificate of Education examinations'. Given her concern for preparing students for the examination, she emphasised particular strategies and algorithms that she perceived matched the examination standards. The notion that the teacher mainly focused on ideas that were relevant for examinations was reflected in the conversation below between the teacher and a student that occurred after the students were asked to draw the graph of $y = 3x^2 - 5x + 3$ for $x = -3$ to $x = 3$:

> S98: "Madam, suppose we were not given the range of x, how can we choose the values of x to form a table of values?"
>
> Teacher: "You will always be given the range of x. It is rare on an exam not to be given range of x." [conversation between sample teacher and S98, 3N, 28/10/99]

The above response to a students' question from the teacher reflected that her main concern was about students learning the materials that were tested in the examination. There were several other instances where the students' answers or questions were disregarded on the basis that they were perceived by the teacher not to be relevant to the examination requirement.

9.4 Students' perceptions of mathematics and mathematics learning

The students' experiences of mathematics in the question/answer lessons described above encouraged students to:

(i) see learning mathematics as being about passing Malawi School Certificate of Education exams,

(ii) believe that mathematical knowledge as either right or wrong,

(iii) rely on authority (in this case the teacher) for knowing.

The students' beliefs outlined above espoused an absolutist position. This contrasted with a constructivist perspective of mathematics and mathematics learning which I was trying to promote through the co-operative learning approach. These beliefs were to have major implications for the students' experiences of co-operative learning reported in this thesis.

View that learning mathematics was all about passing exams

As a result of approximately 105 lesson observations, I concluded that most students perceived mathematics learning as all about passing Malawi School Certificate of Education exams. On numerous instances, students produced behaviours which indicated that they equated learning mathematics with an ability to pass exams. In every lesson that I observed, there was always a question from the students about how they were expected to answer a question, based on the content of mathematics taught in that lesson, during MSCE exams. Questions such as: *'madam, if it is on MSCE exam, are we supposed to write all this including say if we find (x+2) is not a factor?'; 'Are we expected to remember formulas [on mensuration] in the MSCE exams or are we going to be given?'* were asked in almost every lesson. Students perceived that they had understood the lesson if they felt that they were able to answer MSCE questions on that content. For instance, students were given several group work activities over a period of two weeks (two lessons) to help them learn how to (i) construct a table of values from given functions, and use the values to plot graphs, (ii) choose scale, (iii) decide on whether the graph was a straight line or a curve. Based on the group discussions and the written work I saw while observing several groups, I was convinced that many students had understood the lessons. The students, on the other hand, believed they had not learnt any mathematics during those activities because they thought they still couldn't solve MSCE questions.

> 'I haven't understood anything on graphs. Of course we were solving those problems in class, and we were finding the solution, but the main problem is that I have gone through past papers, but I was unable to answer any question on graphs, so to be honest with you I have learnt nothing on this topic.'
>
> (S121, Girl, 3W)

Thus, the students considered that learning how to construct a table of values, plot points and choose scale was not learning mathematics because it was not good enough to help them tackle exam questions. They wanted the teacher to drill them through a typical MSCE question.

> "I enjoyed today's lesson because she gave us an example the same as the exercise and after that we were given an exercise just the same as the example. In so doing I knew what to do."
>
> (Name not specified, Girl, 3E 13/09/99)

This narrow perception of mathematics failed to recognise it as a creative and dynamic subject (Buerk, 1985). According to the Malawi National Examinations Board Guide book (Malawi National Examinations Board, 1992) the students were only expected to remember and apply mathematical facts and procedures in a restricted range of topics during examinations. This meant that students did not spend time trying to search for mathematical connections, or to explore other relationships. They thought that their role in mathematics classrooms was to memorise the facts and procedures handed to them by the teacher and to apply them in examination type questions. The view that students equated learning mathematics with memorising facts is reflected in a student's response to a questionnaire item below:

> " I find it difficult to learn all the theorems by heart and when I am given a problem I find it difficult to use my head and remember the facts."
>
> (S10, Girl, 3E questionnaire response)

This suggested that the students didn't really understand most of the mathematics they were learning in class. Rather, they had acquired what Boaler (1997) called procedural knowledge. Boaler suggested that procedural knowledge was inert, inflexible and tied to the solution or context in which it was learned (Boaler, 1997: 96). This may have partly explained why students experienced difficulties in solving problems that required more than the use of procedures they had learnt in class. I gave students a test on graphs. I included a question in the test that was not particularly difficult but was phrased slightly different from what students had experienced during class time. The question was:

> 'What is the value of $2x + y$ at the points A(-2,12); B(0,8); C(5,-2)?'

Only about 18 percent (17 out of 92) of the students who sat the test got the question correct. The most common answers given by students were:

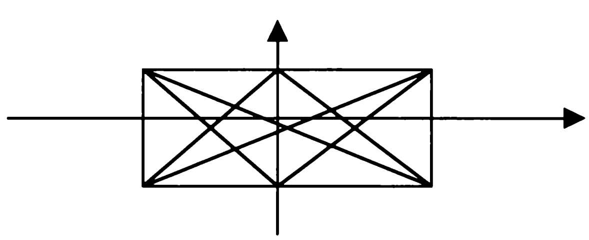
'x = -2 and y = 12' or just 'y = 12'.

This indicated that students were trying to remember the procedures they learnt in class to solve typical examples on graphs such as 'plot the graph of y = 2x + 3 for values of x = -3 to 3'. The procedure given to them by the teacher was that they had to substitute given values of x into the equation to calculate values of y to get coordinates of points. It seemed that the moment students saw the word 'value' and the given coordinates of points in the question, they thought that it was about plotting points and that they had to calculate values of y. Unfortunately, this was not the appropriate procedure for the task. This suggested to me that students based their mathematical thinking upon whatever procedure they could remember, rather than the mathematics within the task. Vinner (1997) called this pseudo-analytical thought processes. This inability to transfer what they learnt in class to examination situations seemed to be a concern for most students. On several occasions, students expressed their concern that 'when the teacher is teaching, I seem to understand but when it comes to exams I don't do well. I don't know why'.

Mathematics as either right or wrong

Several episodes, especially from early field notes, illustrate that students perceived there existed a right answer or a right procedure for solving a mathematical problem and that those 'right answers' existed in the teacher's head. This was probably influenced by their classroom experiences in that they never experienced situations where they could explore their own way of solving problems. They always had to solve problems the teacher's way. The following excerpt taken from field notes demonstrated this:

'After some discussions, the group has come up with the following diagram:



> Their next task is to name the figure. They think that they cannot name it and they are now not sure whether that's the diagram the teacher wants. They ask me if I know the name. I suggest to them: ' you can choose any name that makes sense to you. One girl suggests 'a zig zag shape'; another girl suggests, 'a rectangle with a star shape inside'. I say 'OK' to both answers. They seem not satisfied with this. 'So which one is the correct answer?' they ask, I tell them that both answers are correct because they make sense to them. During whole class discussion, all students are eager to know what is the correct name 'from the teacher' for the figure. When the teacher told them that they could give it any name that made sense to them, they say 'Ahhh!' showing their disappointment.
>
> (Lesson observation notes, Form 3N, 16/09/99)

The example above shows that students struggled to comprehend that two different names could both be correct. Further, they could not conceive that they were able to create some mathematical knowledge, in this case, the name of the figure. To them, the name existed somewhere outside their present knowledge and very likely the teacher had it. This belief that correct answers existed somewhere outside their mind did not fit with the constructivist perspective that knowledge was a product of human invention (upon which the present research into co-operative learning was premised). This misfit between the students' beliefs and the constructivist nature embedded in the present study was a significant factor in explaining the students' initial resistance to engage in their mathematical construction during co-operative learning activities reported in chapter ten.

Rely on the authority (of the teacher) for knowing

The students' belief in the existence of the correct answer embodied the notion of authority in that there was a presenter (the teacher) with a fixed message to send (Cooney, 1985). Cobb (1986) has suggested that if a pupil asked a teacher for confirmation about the rightness or wrongness of a piece of work as soon as it was completed, then this was evidence of the fact that the teacher was seen by the pupil as an authority. The students in this study displayed several characteristics that revealed they were relying on the teacher for knowing. The fact that students always took their answers to the teacher for marking demonstrated that they were unable on their own to decide whether what they had found was the solution to the problem. What is of concern is not that the teacher was seen as the authority— that's reasonable— but that the students saw themselves as powerless, and having no authority. In the example of naming the diagram given above, students were frustrated when the teacher was asking them questions instead of telling them the answers. This suggested that the students did not believe that there was an acceptable path to knowing other than from the teacher's lips.

Most feminist scholars have suggested that this experience tends to alienate girls (Becker, 1995; Buerk, 1985; Rogers, 1995). This issue is discussed in the next section.

9.5 Effects of question/answer teaching approach on the girls' learning

The above sections show how the students' experiences of mathematics within the question/answer teaching approach limited the students' learning of mathematics. The next sections suggests that although the teaching approach affected all students, there was also some evidence suggesting that this approach tended to inhibit girls more than the boys in the learning of mathematics.

Sense of powerlessness

Most girls in the present research indicated that the question/answer teaching approach made them feel like they could not contribute towards mathematical problem solving. They believed that boys could contribute towards getting mathematical solutions but not girls. This was reflected in the interview I had with a group of 7 girls about midway through the data collection period. I started the interview with an open-ended question:

> "I would want you to comment on the type of group discussions that we have had so far since the beginning of the term or even from last term."

All the girls mentioned at some stage during the interview that their experience of working in groups helped them to discover that they were capable of contributing to the process of solving mathematical problems. For example, one student stated:

> "If a boy gives a point in class, we used to say it's just because it is a boy, and we were just sitting waiting for the boys to give points. But in our groups since we are only girls, it forces us to think and when one girl gives a point we get encouraged and say ah! Even this girl can give a point! which means I can also think of one, and we see that we are able to come up with points." (interview, 3W, 14/09/99).

The above comment also showed that girls believed that boys were more capable of solving mathematical problems than them. This belief that boys knew how to solve mathematics better than the girls was also revealed in an earlier interview conducted with a group of 5 girls in a different class:

Researcher: you mentioned that some girls are shy when working with boys, what about yourself?

S30: I can't be shy because I know that I can learn more mathematics if I work with boys than girls because they[boys] know more maths than girls.

Researcher: Do you think the boys know more maths than girls?

S30: Not all of them; some girls know more maths than some boys but it is usually more boys than girls who know more maths.
(interview with a group of 5 girls, 3E, 8/09/99)

This finding that the girls believed they could not contribute towards the mathematical problem solving process during class discussion is similar to the experiences of women in Buerk's (1982) study. Buerk attributed the women's alienation from mathematics to the dualistic view of mathematics which the women in her study had developed as a result of the expository mathematics teaching approach. As Rogers (1995: 176) argued,

> "A pedagogy that emphasizes 'product' deprives students of the experiences of the 'process' by which ideas in mathematics come to be. It perpetuates a view of mathematics in which right answers are exclusive and sole property of experts....students...come to believe they can never create similar results for themselves."

Girls were silenced

Whole-class question/answer teaching approach seemed to silence the majority of the girls because they didn't feel 'psychologically safe' to expose their perceived ignorance. This is reflected in some of the students' comments below:

"if we were working in our groups I would have asked my friends but since it was in a large group I felt ashamed to ask the teacher especially, that I was afraid of being laughed by my friends."

(S59, Girl, 3N 10/09/99)

"sometimes when the teacher is here, she can teach and teach but somebody hasn't picked anything; may be if you ask the teacher, madam I didn't understand there and may be she used to say, ah you can ask your friend and sometimes she can shout at you and you fear to ask her again and may be if you know that I didn't understand there and may be you feel better to ask somebody and may be she can explain to you much better than you have heard from the teacher."

(S30, Girl, 3E 8/09/99 interview)

The girls' fear of asking or answering questions during a whole class discussion session also seemed to be influenced by some of the boys' behaviours. When the girls contributed to class discussion, the boys tended to display antagonistic behaviours which tended to silence some of the girls. For instance, on my first day of classroom observation in form 3W, I observed that there was a particular girl (S122) whom the boys jeered, moaned, or made some negative remarks about each time she made a contribution towards the class discussion. On one occasion, she was reporting on behalf of her group and almost all the boys and some girls jeered and laughed at her, correcting her 'broken English', so much so that she couldn't continue giving her report. On another occasion during the same lesson as she was making her contribution, the boys jeered at her again but this time the teacher intervened to allow her to finish explaining. At the end of the lesson, I asked the teacher why the boys were behaving that way towards that particular girl. The teacher replied:

"S122 is a new student from another secondary school. She is very vocal so the boys want to put her down." [conversation with teacher, 7/09/99].

The teacher's comment suggested that the boys had established a 'classroom culture' which expected the girls to be silent during whole class discussion.

Girls were feeling anxious

I reported in section 9.4 that the sample teacher tended to call upon students who were unlikely to produce correct answers. Given the teacher's awareness that my research had a focus on girls' learning, coupled with the fact that it was usually the girls who were unlikely to give correct answers, meant that she tended to choose more girls than boys to answer her questions. For example, in one class the teacher chose 13 girls (72% of the total girls in the class) compared to 11 boys (32% of the total boys in class). Thus, the majority of girls spent a lot of time feeling anxious about being chosen by the teacher to answer a question.

Classroom environment

The desks were close to each other making it very difficult for someone to go to the front. The majority of the whole class activities involved students going to write something on the board. Boys jumped over desks to go to the board but it was culturally incorrect for girls to jump over desks, especially with a visitor (researcher) present. In one instance, a girl tried to jump over a desk to reach the teacher's desk and almost the whole class jeered at her. She was asked to apologise to the teacher, and to the researcher. This probably discouraged girls from trying to go to write something on the board or take their work for marking.

I reported earlier in this chapter that one of the reasons students gave for their dislike of the question/answer teaching approach was that the method was not appropriate for the Malawian hot weather. It was very hot (an average of 28°C) during most of the lessons and even as an observer, I found it hard to keep awake when the teacher was lecturing. While this may have an effect on both boys and girls, there were several indications that the effect on girls was more than on the boys. For instance, on several occasions I observed that the boys would stand at the back of the class to avoid sleeping while the lesson was going on. Whenever a girl tried to do the same, many boys would shout at her saying, "you are blocking us", or some other unpleasant remark.

9.6 Summary and discussion

My purpose in this chapter has been to identify the teacher's and the students' beliefs about mathematics and mathematics teaching. I took the view suggested by a number of mathematics educationists (Vacc & Bright, 1999; Artz & Armour–Thomas, 1999; Thompson, 1992) that the teacher's instructional practices may communicate particular conceptions of the nature and meaning of mathematics, and about what it meant to learn mathematics. I also took the view that what students experience in the mathematics classrooms influenced their beliefs (Perry & Howard, 1999). I used data obtained from approximately 105 lesson observations to characterise the sample teacher's teaching.

An analysis of the resulting data revealed that the sample teacher mostly followed an Introduction - Example(s) - class Exercise(s), (IEE) lesson format. She taught mathematics using either a question/answer teaching approach or a co-operative learning approach. This chapter focused on the first of these two teaching approaches.

The findings reported in this chapter indicated that the teacher professed a constructivist view of learning but her teaching practice reflected a behaviourist view of learning. It seemed that the teachers' use of a behaviourist teaching approach stemmed from beliefs she held about her role as a mathematics teacher and the students' unwillingness to learn on their own. She perceived her role as that of preparing students for the external examinations, and making sure that students mastered the skills and procedures required for this. This finding is similar to that of other researchers elsewhere in the world. Sosniak et al. (1991) and Battista (1994) reported similar findings for US schools. They both suggested that the nature of the school curriculum and the environment in which teachers of secondary mathematics teach promoted these views of mathematics teaching.

The findings reported in this chapter indicated that most students in the present study did not like the question/answer teaching approach. They felt that

- the pace was too fast for them to be able to make sense of the mathematics they encountered, and that
- it was not appropriate for the classroom environment and the Malawian hot weather.

The majority of the students' experiences involved receiving mathematical procedures from the teacher. They were not encouraged to explore their own paths of solving problems. The teacher mostly pursued answers/questions that either matched ideas and a lesson sequence that she had in mind, or were relevant for examination requirements. These experiences resulted in students' developing misconceptions about the nature of mathematics and mathematics learning. Most of the students believed that learning mathematics was about passing examinations and that an answer was either right or wrong for every mathematics problem.

Clearly most of the teacher's and students' beliefs embodied a platonic and dualistic view of mathematics. They are similar to what Perry & Howard (1999) called the transmission view; that is mathematics is considered a static discipline which is taught and learned through the transmission of mathematical skills and knowledge from the teacher to the learner. This view of mathematics contradicted the constructivist ideas which I was trying to introduce in this study. As the teacher and students were trying to implement co-operative learning, they both experienced some philosophical conflicts. This is taken up in the next chapter.

Chapter ten

Co-operative learning approach: results and discussion

10.0 Introduction

This chapter reports on the experiences of the teacher, the students and the researcher during the co-operative learning activities in this research project. The findings are based on an analysis of lessons conducted at this time in which co-operative learning figured strongly. Data for the analysis consisted of field notes, transcripts of tape-recorded interviews with the students and the teacher, recorded informal conversations with the students and the teacher, students' written journals, and questionnaire responses of students gathered towards the end of the study. The data were used to gain an insight into the participants' experiences of the co-operative learning approaches used in the context of three Malawian form 3 mathematics classrooms with one teacher. The findings are discussed in five sections as follows:

10.1 Implementing co-operative learning
10.2 Dynamics of the co-operative learning groups
10.3 Students' mathematical experiences with the co-operative learning approach
10.4 Gender differences
10.5 Summary

10.1 Implementing co-operative learning

Throughout the research I took the view that I could not simply transmit a teaching model of co-operative learning and expect the teacher to accept it. In this section, I focus my discussion on the (i) initiation stage, (ii) assignment of students to groups and (iii) implementation process.

Initiation Phase

As reported in chapter seven, the experience of incorporating co-operative learning into mathematics teaching was a novel experience for the teacher and the students. To prepare students and the teacher for the innovation, the following steps were followed: first, a Teacher's Guide on how to incorporate co-operative learning into mathematics teaching was sent to the teacher three months prior to the data collection phase (see Appendix B for the content of the Teacher's Guide). This advance timing was to give the teacher and the students ample time to experiment with co-operative learning before I commenced classroom observations. In this way the teacher could build confidence and try to gain some understanding of the nature of co-operative learning prior to the data collection period. It also gave students opportunity to practice some co-operative learning skills. Much research has shown the importance of training students in co-operative learning skills for co-operative learning to be productive (Johnson et al, 1993; Sharan, 1980).

Second, after three months of experimenting with co-operative learning, a professional development workshop was organised and the sample teacher, together with 14 other teachers, participated in the workshop. The teachers' experiences, conceptions and concerns about incorporating co-operative leaning into their teaching, and how the researcher negotiated a shared understanding with the teachers, were reported in chapter seven.

Assignment of students to groups

The teacher was given autonomy to make her own decisions about how to assign students to groups. She decided to assign students into co-operative-base groups (Johnson & Johnson, 1999a) of the same gender but with mixed ability through a teacher-selected method. She explained that she had decided to form separate groups of boys and girls because she noticed during the initiation stage that girls were passive when placed in mixed gender groups. The base groups lasted for the whole term. There was a total of 31 groups as described below:

Table 10.1 Description of groups

	Form 3E (N = 52)	**Form 3N** (N = 59)	**Form 3W** (N = 39)
Girls	2 groups of 4 and 2 groups of 5	1 group of 4, and 3 groups of 5	2 groups of 3 and 1 group of 5
Boys	1 group of 3, 1 group of 4, 4 groups of 5 and 1 group of 7	2 groups of 5 and 5 groups of 6	3 groups of 4, 2 groups of 5 and 1 group of 6

Students were mostly working in these groups although the teacher would at times ask the students to work with peers of their own choice (self-selection groups) or those sitting next to them (seating arrangement groups).

Implementation process

Discussion in this section focuses on the teacher's growth, changes in the teacher's and the students' views of learning, and the problems experienced during the implementation process.

Growth during implementation process

There was some evidence that the teacher's conception of co-operative learning groups broadened as a result of the experimentation phase, as well as her participation in the teacher development workshop. Such changes were evidenced in her efforts to consciously encourage positive goal interdependence and individual accountability amongst group members. This was illustrated by an excerpt from my field notes.

> 'The students are given a task to be done in groups. The teacher makes an announcement that she is going to ask one member in the group to come and explain the group's solution on the board and she is going to award the group's grade based on the explanation. I am observing a group of 5

> boys. I observe that after the boys discover that the teacher is picking anybody, and not necessarily group leaders in the group to do the explanation on the board, the high achieving boys start teaching the low achieving group-mates, ensuring that they understand the group's solution. The low achieving students are also eager to understand the solution.'
>
> [Lesson observation notes, 3W, 13/09/99, 7.30–8.50]

In the excerpt above the marking scheme employed (and driven) by the teacher promoted individual accountability. When students understood that they might be selected to represent their group, they were encouraged to prepare themselves and their group-mates for this possibility. There were several other instances where the teacher used some strategies to encourage all students to be actively involved in the group discussion. For example, every time she gave students a group activity, she would remind students saying: "Remember our motto in this class is: never to dominate, but to listen and give everyone a chance to contribute."

However, it was possible that this shift did not necessarily represent true growth in the teacher but a mere performance of what she was inducted to do. She may have felt she was under an implied obligation to implement the ideas that she had encountered during the workshop because she was being observed by the researcher. This is a recognised issue that participant observation researchers encounter (Banister et al, 1994; Merriam, 1988), and especially in a culture that expected her to agree with the views of the researcher . Nevertheless, although the researcher's presence in the classroom may have influenced some of the teacher's actions, it was likely that the teacher did not apply the 'ready-made ideas' devised by the researcher unless they seemed plausible to her. Research in the past has shown that even if project teachers were inducted into the project models devised by researchers, it was not in itself a guarantee that the teachers would apply the researchers' model during the research unless they [teachers] realised that their current practices were problematic (Cobb, Wood & Yackel; 1990). Several scholars have noted that ideas learnt during professional development programs were more likely to be implemented in classrooms only if they were seen by teachers as being responsive to their needs. Thus, it was likely that the teacher was implementing some of the ideas she encountered at the workshop because she had seen that her previous practices of structuring co-operative learning groups were problematic. It is reported in chapter seven that one of the concerns raised and discussed by the teachers during the workshop was about ensuring that all students participated during group discussions.

The sample teacher appeared to be aware before the research began that her traditional whole class teaching was not effective. This was reflected in notes taken during the researcher's first meeting with the mathematics staff of the school:

> 'I was concerned with the poor performance of students in mathematics and I was looking for some ways of improving the students' performance but I didn't know how. When I received the teachers' guide you sent, I was very happy to try co-operative learning.' (Teacher, 19/08/99)

In reflecting on her classroom practices, she saw various concerns she needed to resolve. She was particularly concerned about the levels of interactions in groups. The weak students were always looking to the bright students to do all the work for them. In groups of mixed girls and boys, she was concerned that it was usually the boys dominating the discussions. These might have been the genuine reasons and motivation for the teacher to incorporate the ideas discussed at the workshop. She viewed the researcher as somebody she could work with to develop ways of encouraging all students to be actively involved in group discussions which was similar to what has been discussed by Cobb, Wood & Yackel (1990).

Changes in the teacher's and students' views of learning

The analysis of the data revealed that as the teacher was implementing the co-operative learning/teaching approach, both the teacher's and students' beliefs appeared to have shifted slightly from a transmission view of learning towards a constructivist view. During the first few weeks of the study, it was evident that the students were experiencing a great deal of frustration during co-operative learning group activities. They expressed these feelings openly, at times even angrily, as evidenced from some of the students' remarks (see remarks by S89 and S79 on page 142). The students' frustrations seemed to be influenced by a conflict in beliefs between the teacher's expectations of students during co-operative learning activities, and the students' beliefs about their own and the teacher's role, that they had developed from their past experiences of direct instruction. As noted earlier, the students believed that the teacher knew all the answers and they expected the teacher to just tell them what the right answers were. As a result of this belief, the students were resistant to engage in mathematical activities.

The teacher, on the other hand, expected the students to take responsibility for their learning. Consequently, she was disappointed by the students' initial reluctance to accept responsibility to figure things out for themselves. She said:

> 'the problem I have is that if I try to give students a problem that is new to them, even if it is something they can do, they always say no, madam we can't do this because we haven't learnt it. They don't even want to try it. So they just wait for me to come and teach them'
>
> (Teacher, 8/09/99)

Thus, the teacher's effort to encourage students to become autonomous learners proved a challenge during the early stages of the implementation. She was mostly alternating between 'telling everything' or 'no telling at all'. In the process, she learnt that neither strategy was productive. When she simply told the students how to do the task, it simply encouraged the students to rely on the teacher even more. On the other hand, when she refused to give any help so as to force the students to figure things out for themselves, the students simply gave up and waited for her to give the correct answers. As the school term progressed, I observed that the teacher gradually developed what Jaworski (1994) terms 'scaffolding', as a way of overcoming the situation. This was also acknowledged by the teacher, as reflected in her comment below:

> 'what I have discovered is that we need to initially go round and identify groups that don't know how to start the problem and help them to start the problem. As I said, when they see that they don't know where to start they just sit. So the best thing is to help them get started.'
>
> [conversation with teacher, 15/09/99]

As the teacher's role shifted to that of scaffolding, the students gradually began to take responsibility for their mathematical learning. This also illustrated the importance of the teacher's role for productive group discussion. This issue is discussed further in section 10.2.

Problems experienced while implementing co-operative learning

Data from the field notes revealed that the teacher encountered some problems while she was implementing co-operative learning. These problems related to: (i) a shortage of resources, (ii) a time constraint and (iii) the influence of external examinations. These are discussed in turn below:

(i) *Shortage of resources*

One of the difficulties encountered during the implementation of co-operative learning related to shortage of resources. Research has shown that co-operative learning was productive when students were physically placed in small groups of three to four members (Lou et al, 1996), facing one another (Johnson & Johnson, 1999a), and the teacher took an active role, circulating from group to group, giving assistance and encouragement, and asking thought-provoking questions as needed. The circumstances under which the teacher in the present study was working provided some challenges when trying to achieve a classroom environment conducive for productive learning (as discussed below).

One problem was that due to the physical arrangement of the desks it was not possible to move them around during group discussions. The furniture in classrooms (students' writing desks and sitting benches) was joined together by metal rods, and the desks were arranged in rows joining each other from the front desk to the wall at the back. This made it difficult for the teacher and the researcher to pass through for supervision/support/observation, and for the students to move to and from the teacher's desk.

Related to the above factor was that the class sizes were very big resulting in too many groups for one teacher to productively supervise all of them in a single session. For instance, there were 52 students in Form 3E which usually resulted in 11 groups of 5 members (see Table 10.1 for the number of groups in each class). This meant that in a 40 minute mathematics period, the teacher had less than 3 minutes to spend per group. In most cases, this was not enough time for the teacher to be able to listen to each group's discussions and offer necessary support. This created a dilemma about how much time to spend on each group during group discussions. When the teacher spent time listening to a group's discussion, and offering necessary support, she usually didn't have enough time to go round all the groups before the bell rang. On the other hand, when she tried to go round every group, pressure of time meant that she tended to tell them the answers or tried to offer help that was usually not productive. Each of these had a negative effect on the students' learning. This is further discussed in section 10.2 in the context of the role of the teacher in the dynamics of co-operative learning groups.

The school lacked other resources. For instance, one of the topics taught during the research period was **Graphs** but the school didn't have enough graph paper for the students to use during their group activities. The graph paper that was available was reserved for examinations. Instead, the students were using ordinary ruled papers for their graphing activities. As a result of this, the teacher tended to limit the activities to problems that involved whole numbers or simple fractions. The school didn't have a photocopier, and each time the teacher needed multiple copies for the groups, she hand wrote copies of group activities.

(ii) Time constraints

The complex and demanding role of the teacher within the school meant her implementation of co-operative learning was impeded. The teacher involved in this study not only had 21 teaching periods per week, but was also a boarding mistress and an assistant dispensary officer. This meant that she had to attend to all boarding issues as well as sign permission slips for students to go to the hospital. The teacher expressed on several occasions that because of her heavy workload, she was finding it difficult to implement co-operative learning to her full potential. For example, on one occasion, she explained to me as we were walking out of the form 3E class in which students were working on problems involving angles in alternate segments through a game:

> 'I wasn't happy with the organisation of today's group activity. A lot of groups could not start working on the activity because they didn't seem to understand the rules of the game, so I spent more than half the time just explaining the rules of the game to groups. I thought about it and I had planned to write down the instructions on paper for each group this morning, but I was called to the hostels because a student is sick and I had to arrange for transport to take her to the hospital and to telephone the student's parents. So I didn't have time to write the rules on papers for each group. So I decided to just explain the rules orally.'
>
> [Teacher, 14/09/99, 8.10–9.30]

Several other instances indicated that she at times gave students group activities without proper preparation, possibly due to her busy schedule. For example, some of the activities she gave required more time than was available, did not match with the students' capabilities, or did not contain adequate information for students to solve. This resulted in student frustration. For example, one student wrote:

> "In our today's activity, the question was introduced yesterday and the question did not specify that the given chord was a diameter. We tried to solve the problem by assuming that the given chord was not necessarily a diameter but we couldn't. Today in class during revision, we discovered that it was actually a diameter. This has caused difficulties in trying to solve it."
>
> [S102, Boy, 3N, 10/09/99]

Several other students had commented in their journal entries of 10/09/99 about their frustration in trying to solve the problem by assuming that the chord was not a diameter. The teacher apologised for having overlooked this point in her phrasing of the question. However, the teacher in this study viewed this concern as only short term, as illustrated in her comment below during our weekly meeting:

> 'Of course now it looks as though co-operative learning is time consuming. But it is because it is my first time to use it. I am sure that next year, I won't need to spend a lot of time preparing group

> activities. I am keeping the activities that are successful in a file and next year I will just use the same ones. I will only adjust them, and it won't take a lot of time.' [Teacher, 10/09/99]

(iii) The influence of external examinations

Another constraint in implementing co-operative learning was the emphasis the education system places on the external examination. The students in this study were due to sit the Malawi School Certificate of Education the following year. Entrance to the University of Malawi is based on the ranked aggregate grades of the best six grades including English, obtained in this examination. The selection is highly competitive with less than one percent being selected. Given the competitive nature of the examination, students were under pressure to be in the top 1% in order to get a place at the university. As a result of this some students were unwilling to actively participate in group discussions and share their knowledge with group-mates. This avoidance of participation was revealed in an interview with a group of students:

Interviewer: What are some of the problems that you experience when you work in groups?

MC: Sometimes some of the students do not want to give their ideas when we are solving problems. They pretend that they are tired and they say, 'I am tired today; I am not going to take part in discussion.'

(Interview with 5 girls, 8/09/99)

Other comments included:

> 'The problem is that when we go to ask our friends they always say "I don't know the answer" even when they know the answer.'

Related to the above problem is that the examination required students to answer problems in a particular way. For example, students were given the following question:

> 'An aerial is 83 $^1/_2$ m high. Calculate the angle of elevation of its point 120 m away on level ground.'

Some groups solved the problem by drawing a scaled diagram and then measured the required angle. The teacher was in a dilemma about how to handle this answer because she was aware that such an answer was inappropriate for the examination requirement. The 'examination way' was to solve the problem using a tangent formula. This tended to limit the students' opportunity to come to explore problems on their own. The students didn't want to invest energy in exploring solution paths which would not contribute to their passing the examinations. They just wanted the teacher to tell them what the 'appropriate' strategies were, an issue discussed earlier in chapter nine.

The problems discussed above supported the findings reported in chapters six and seven, that the implementation of the co-operative learning approach caused some concerns amongst the teachers. All teachers who participated in the workshop, said that they were reluctant to adopt this teaching approach because they felt that co-operative learning was not suitable for the supposedly examination oriented-syllabus, was time consuming and it required a lot of resources which they couldn't afford.

10.2 Dynamics of the co-operative learning groups

Several studies have shown that merely placing students together in small groups does not necessarily ensure that all students will be equally involved in the group discussions (see chapter four). In this study, a group was described as having a high participation level if the following behaviours were displayed:

- All group members were absorbed and fully engaged on the group task.
- Every member interacted with fellow group members by contributing an idea, explanation, question, or response to other members' questions or suggestions.
- Contributions from all members were valued.

If these conditions were not met, then the group was considered to have a moderate or low participation rate. Findings from this study revealed that the level of students' participation during co-operative learning group tasks depended on (i) group composition, (ii) the nature of the task and (iii) the role of the teacher. They are discussed in turn below:

Group composition

Data from lesson observations revealed that the composition of the group had some effect on the level of students' interaction during co-operative group tasks. There was usually less interaction amongst students in groups where the achievement gap amongst group members was wide as compared to groups with similar achievement. An exception was where members of a similar achievement group had low overall achievement. In the latter case, the students simply gave up and did not engage in discussions at all. Given a group task, other students seemed to always form initial judgements about each other's relative performance within the group, and the most capable students in the group assumed the leadership role, regardless of their personality or social status. Whether the groups were formed by the teacher or the students themselves did not seem to matter. Observations revealed on several occasions that the presence of very high achieving students in groups tended to dis-empower other students, the consequence being that the other students blindly waited upon the high achieving students to do all the work, even in the case of simple tasks that they could have done themselves. This is illustrated by the following excerpt from my field notes:

I observed a group of 5 students (4 boys and one girl) working on the following problem:

TS is a tangent to the circle PQRS. If PR = PS and angle PQR = 117, Calculate angle RST

S127 is the brightest student in the group as well as the top student in all three of the classes. S127 assumes the role of the teacher. He draws and labels the diagram and continues to 'teach' his group mates as follows: 'We know PQRS is cyclic quad so TSP + 117 = 180 so TSP = 180 – 117. S127 subtracts and gets 73 (which is wrong) so PRS = 73 multiply by 2 get 146, subtract 180 to RPS and they get RPS = 34. RPS = RST = 34, angles in alternate segment.'

After they finished solving the problem, I asked the students to calculate 180 – 117 individually and they all got 63 and immediately realised that S127 made a mistake.

Researcher: "Why didn't you correct S127?"

Students: "We were just listening to S127 without thinking because we just trusted S127 since he is good at maths."

[Lesson observation, Form 3W, 21/10/99, 8.50–9,30]

The observation that students were dis-empowered by high achieving students was confirmed by the teacher, as indicated in her remark below:

'S138 was a bright student but ever since he started working in S127's group, I have noticed that his confidence and performance in mathematics has gone down.'

[informal conversation with teacher]

The high achieving students seemed to be aware that their peers were expecting them to solve the problem for the group. This is reflected in a comment made by one of the high achieving students:

> "the main problem is that most students do not participate. You find that a lot of students are waiting for the person they think he or she has the potential of getting the answer correct. They just wait for he or she to get the solution" [S121, Girl, 3W, interview, 14/09/99].

In contrast to this group dynamic, when high achieving students were paired, they tended to work co-operatively and engaged in high level mathematical discussion. This was illustrated in the excerpt from my field notes recorded while observing a pair of boys:

'A pair of boys (S84 and S104) were working on the following problem:

(I) Draw the graph of $y = 3x^2 - 5x + 3$ from $x = -3$ to 3.

(II) Use your graph to solve $3x^2 - 5x = 3$.

S84 and S104 were both top students in Form 3N. They solve the problem while discussing. S84 is drawing and filling in the table of values while it is S104 doing the substitutions and calculations. S84 plots the points on the graph from the table of values, each time seeking for S104s' approval. After they have finished plotting the points, S84 gives the pencil to S104 to draw the curve. They now move on to solve $3x^2 - 5x = 3$. S104 says: "We can't just read the x values at $y = 0$ as the teacher did in the example because we have plotted $3x^2 - 5x + 3$ and we have to solve $3x^2 - 5x = 3$. Do we need to plot another graph?" S84 says: " But the teacher says we should use the same graph." After a lot of discussion, they agree that adding 3 to both sides of the given equation will make the left hand equal to the plotted graph and won't change the solution, but instead of reading values of x at y = 0 as the teacher did, they will read values at y = 6.' They check their answers by solving the equation using the quadratic formula.

[Lesson observation notes, 3N, 28/10/99, 7.30–8.50]

The excerpt above illustrated that there was high level interaction between the pair. They swapped roles and jointly solved the problem.

Nature of the task.

My field notes revealed that the nature of the task seemed to play an important role in determining how well students worked together. If the task was too simple, students tended to work individually even though they were sitting together. Alternatively, if the task was too difficult, it was usually only the high achieving students who were struggling with the problem on their own while the other students were just waiting. Groups usually acted on the first idea suggested by the high achieving student without considering whether other ideas might be better. This process broke down when the high achieving student could no longer continue. It was at this stage that co-operative group discussions started to be displayed. When this stage was reached, every idea that was suggested, regardless of whether the suggestion came from a less achieving student or a high achieving student, was pursued until it was clear that it wouldn't lead to a desired solution. It was usually in the process of pursuing such ideas that a valid idea would emerge. An excerpt from my field notes recorded while observing a lesson, is given below to illustrate this.

'A group of 3 boys (B1, B2 and B3) were working on the following problem:

(i) Construct circle centre O.

(ii) Choose a point Q anywhere outside the circle.

(iii) Join OQ.

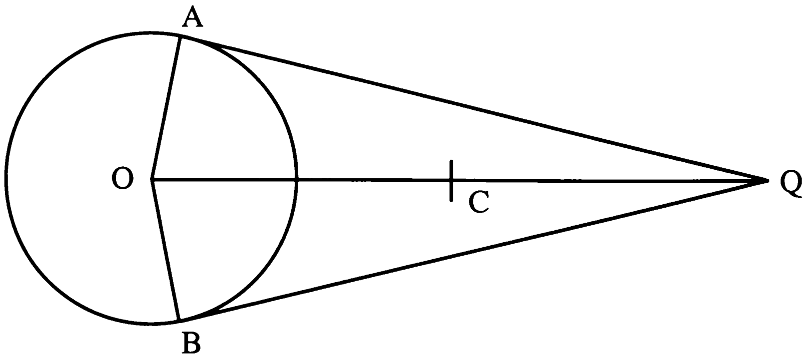
(iv) Bisect OQ at C.

(v) With C as centre and OC as radius, draw arc at A and B.

(vi) Join AQ and BQ.

(vii) Prove that AQ and BQ are tangents.

The students came up with the following diagram:



B1: (the highest achieving student in the group) takes the leadership role and explains to the group-mates saying: "We need to show that angle OAQ = angle OBQ = 90°, because a tangent is perpendicular to a radius". He then joins OA and OB and begins to prove that triangle OAQ is congruent to triangle OBQ. He writes: "OA = OB, radii, OQ is common, AQ = BQ, tangents from external point".

B2: corrects B1 saying: "We can't use AQ = BQ, because that is what we are supposed to prove." At this point B1 is stuck and doesn't know how to continue.

B2: suggests (after a long silence), "What about if we use AOBQ is a cyclic quadrilateral?"

B1: picks this up and writes: " angle OAQ + angle OBQ = 180°; angle AOB + angle AQB = 180°". While they all seem to be deeply thinking about how to continue from here so that they could show that angle OAQ = angle OBQ,

B3: (the least achieving in the group), who has been quiet all this time, points to the diagram and says: "OC = CQ, radius".

B1: (immediately, in an excited tone) says: "yes, so OCQ is a diameter and therefore angle OAQ is a right angle because it is an angle in a semi-circle."

[lesson observation notes, 3W, 5/10/99, 2.10–3.30]

While it is clear from the excerpt above that the idea suggested by B3 was not helpful in achieving the group's current thought processes of trying to show that angle OAQ = angle OBQ, B3's idea nevertheless helped B1 to see that OCQ was a diameter, and this led to the desired solution. This seemed to be a positive experience for both high achieving and low achieving students. The low achieving students were mostly excited when their ideas contributed to the solution and this boosted their confidence. The high achieving students, too, learnt to value the alternative thinking styles of their classmates (Neyland, 1994), as exemplified by one student during an interview. She said:

'We like working in groups because we share ideas. At times, I can have a point but at times someone else in my group, even a 'dull' student, can come up with a point that I didn't even think of. So even though I am a 'bright' student, I also benefit a lot from working in groups.'
[tape recorded conversation with a group of 7 girls, 14/09/99]

Teacher's role

This section expands on the previously discussed observation that the role adopted by the teacher had an effect on the groups' functioning. Data from my field notes revealed that the timing of the teacher's intervention for assistance and the nature of assistance given to the groups, influenced the way the groups functioned. I noticed that the teacher was faced with a number of dilemmas in deciding when and how to intervene when a group was experiencing difficulties with the given task. A delayed teacher intervention either caused frustration in students, or gave students opportunity to resolve their own difficulties. For example, there was some evidence from my field notes that when the teacher delayed offering assistance, the students displayed frustration in a variety of ways such as: lying their head on the desk, excusing themselves to go out, or reading non mathematical work. Other evidence of the students' frustration came from a transcript of a tape recorded interview with a group of 7 girls:

Researcher: "What are some of the problems you experience while working in groups?"

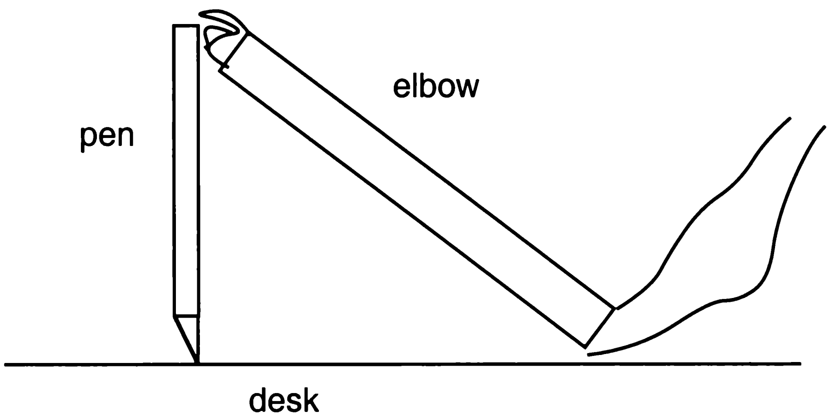
S122: "The problem with group work is that at times, all members in the group have no idea and when we ask the teacher, she simply says: "Discuss with your team-mates". And yet we all don't know where to start, so we just stay looking at each other".
[S122, Girl, 3W, 14/09/99]

Further evidence came from the students' journal entries. For example, one student wrote:

'Today I didn't enjoy our work because in our group, we all didn't know how to solve the problem and when we asked our teacher for help, she simply said: "discuss it in your groups", so we just sat in our group doing nothing.'

On the other hand, there was also evidence that when the teacher delayed her intervention, the students were able to resolve their difficulties and moved on, as evidenced from an excerpt from my field notes below:

> 'A group of 3 boys and one girl were in the process of calculating the surface area of a cone with given radius and height. They all, except one member, believed that the length (slant height) and height of the cone are the same. When they couldn't reach an agreement, they said, "let's ask madam." When they asked the teacher, she simply said: "Continue discussing", and she left to assist another group. They looked disappointed but the only member in the group who believed that length and height were different, picked a pencil, put it up on the desk and held the top of the pencil, with his elbow touching the desk as shown in the diagram below, and asked, "Can these be of same length?" pointing to the pen and the elbow.



They all agreed that the length (elbow) and the height (pen) were different.'

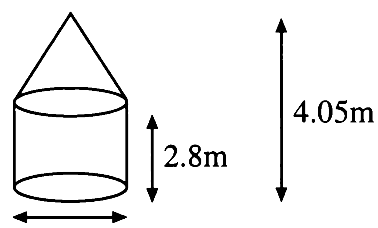
[Lesson observation notes, 20/10/99, 3W, 11.20–12.00]

10.3 Students' mathematical experiences with co-operative learning approach

There were many learning opportunities for both high and low achieving students. An analysis of data revealed that the co-operative learning/teaching approach offered students the following learning opportunities: (i) opportunity to identify pitfalls in their solutions, (ii) opportunity for revision, and (iii) opportunity to learn from peers. These are discussed in turn below.

Opportunity to identify pitfalls in their solutions

Working with group members with little understanding of the problem pushed the able students to clarify their ideas more carefully and often it helped them to see the pitfalls of their solutions that they might not otherwise have seen. This was illustrated in the following excerpt from my field notes:

> 'A group of 3 boys (S11, S37 and S44) and one girl (S32), were working on the following problem: 'A house is built in the shape of a cylindrical base with a conical roof as shown in figure below. Calculate the surface area of the roof. Surface area of a cone is $\pi rl + \pi r^2$ '
>
> 
>
>
> 6m
>
> After a lot of group discussion, the students agreed that they should calculate the surface area of the roof using the given formula for finding surface of the cone.
> S11 (the highest achieving member in the group) explains: "We are going to use the formula πrl because we just want to find the area of the roof. We know $\pi = 22/7$; our $r = 3$ and our $l = 1.25$."
> S44 asks S11, "Where did you get $r = 3$ and $l = 1.25$?" S11 explains to S44, "We can find r by dividing the diameter by 2, and our diameter is 6, so $r = 3$. We are given that the height from the bottom to the top of the house is 4.05m, and the height of the house without the roof is 2.8m, so the height of the roof must be $4.05-2.8 = 1.25$." As S11 is explaining how they calculated l, he pauses and immediately he recognises that, 'this is not l, it is height!', and they calculate l as
> $l^2 = 3^2 + 1.25^2$ using Pythagoras theorem. [Lesson observation notes, 3E, 21/10/99, 1.30–2.10]

There were several similar incidences where students were able to spot pitfalls in their solutions as they were trying to clarify their ideas to group-mates. This was perceived by students as one of the benefits of co-operative learning. Another example of this came during an interview:

Researcher: What do you think are the benefits of working co-operatively?

S79: When we are working in groups, it is very easy for your friend to spot a mistake but when you are working individually you cannot until you take it to the teacher for marking.

[S79, Boy, 3N, 20/10/99]

Opportunity for revision

Co-operative learning seemed to offer opportunities for students to identify some gaps in their mathematical understanding and to revise them before moving on. This might not have been possible in the course of a direct teaching approach. This seemed to be the greatest benefit of the co-operative learning/teaching approach, a view shared by the teacher as evidenced in her remark below:

> 'I have noticed while marking students' work that many students show an understanding of the concepts I have taught using co-operative learning. Most of the mistakes students are making are due to lack of understanding of previous topics [topics taught using a non co-operative learning/teaching approach] such as adding and subtracting negative numbers. Again during group discussions, students tend to spend more time discussing previously taught concepts because they didn't understand them . I think if we had started [the] co-operative learning/teaching approach right in Form 1, most of these misconceptions would have been minimised and that group discussions wouldn't be taking a lot of time as it does now.'
> [informal conversation with Teacher, 1/11/99].

The teacher's observation of students' difficulties in solving problems, due to their lack of understanding of some basic skills, was particularly evident during the early phase of the research. This supported my own observations as researcher. During the beginning stage, students spent a lot of their discussion time on revision of the basic skills before they could successfully solve the given task. For instance, a group of students was asked to plot the graph of $y = 3x^2 + 5x - 28$ for values of $x = -3$ to $+3$. The teacher's aim with the activity was that the students' discussions would centre on plotting and drawing smooth curves, exploring concepts such as vertical intercept, and the shape of the curve. However, what dominated the discussion was different from that which the teacher had planned, as illustrated in the excerpt below from the transcript of the group discussion:

After some discussion, they reach a stage when they want to find the coordinates for the point at x = 0. When x = 0 they get $3(0)^2 + 5(0) - 28 = 0 + 0 - 28 = 0 - 28$ and they all agree. 3 students agree that 0- 28 = -28.

S17 : 0 - 28 = 0. It can't be -28 because zero has no value and if you try to subtract 28 from nothing, you can't because you have nothing to subtract from, so the answer is still zero.

S1 : Suppose you have no money and you buy something worth K28, what will happen?
S17 : I can't buy anything because I don't have money, so I still have zero money.
S2 : Ok suppose you borrowed K28 from a friend and somehow you got K10 pocket money from your parents and you give it to the one you borrowed the money from, how much loan do you still have?
S17 : K18.
S2 : What about if you had been given K2
S17 : K26
S3 : What about if you haven't been given any money?
S17 : I still have a loan of K28. Oh! I see yes the answer is -28!.

More than three-quarters of the time centred around discussing how to add, subtract or multiply negative numbers. I observed that this was the case during the majority of group activities. Further, more than half the students, especially girls, expressed at one point or another that they were able to expose their ignorance of some basic concepts during group discussions because they felt psychologically safe to ask for clarification and to take risks to test their thoughts in small co-operative learning groups. This was in marked contrast to asking in front of the whole class or asking clarification from the teacher. This was clearly illustrated by one girl who explained,

'...there are some questions which I don't feel like asking the teacher because I just feel like she may discuss you with other people but I feel safe to ask my friends to help me'.
[interview with S30, Girl, 7/09/99]

and a boy who commented,

'I prefer working in groups because I have a free mind to ask as many questions as I need to my group-mates than to ask the teacher' [journal entry, S89, Boy, 9/09/99]

Opportunity to learn from peers

Almost all of the students expressed at one time or another that they preferred working in co-operative learning groups because of the opportunity it offered them to learn from peers. This was clearly illustrated from the students' responses to the journal entry prompt : 'Would you have preferred working individually or as a group?' —given to Form 3N students immediately after a co-operative lesson. All students expressed that they preferred to work in groups. Content analysis of the reasons for their preference revealed the categories shown in Table 10.2

Table 10.2 Students' reasons for preferring co-operative learning

Category	No. of responses
Sharing of different ideas	37
Learn better from friends than from the teacher	15
Find it easier to ask or express views in front of friends than to the teacher	7

Table 10.2 reveals that almost all students perceived the benefit for working in co-operative learning groups as the opportunity to learn from peers mainly because they shared different ideas or because they learnt better from peers than from the teacher. Typical comments from students' responses included:

'I prefer working in groups because different individuals have different ideas which we share in groups'

'we share ideas from different heads'

'there were some people who knew what I didn't know and some who didn't know what I knew and we shared'

'I can learn something new from friends'

'I learn better from another student rather than from a teacher'

10.4 Gender differences

The data analysis revealed that the working style of the boys was qualitatively different from that of the girls, in terms of their (i) co-operative group strategies, (ii) student-

student power relations and (iii) preferences for group composition. These differences are discussed in turn below.

Co-operative group strategies

Excerpts from field notes taken while observing a group of girls in 3N and a group of boys in 3W working on the same activity are given below to illustrate the differences in group strategies employed by boys and girls. The notes are presented in columns for easy comparison.

> The activity was about 'revision of circle theorems'. The students were asked to list down as many theorems as they could in their co-operative learning groups. The teacher explained and wrote on the board the following: (i) write down your names against each theorem you contribute. (ii) I will deduct a mark each, for every member whose name does not appear or dominates, from the groups' total marks.

Lesson with 3N, 7/09/99, 10.40–12.00

I decide to join the group with 4 girls. They are sitting in a row. I don't know the students' names yet and I don't want to ask them what their names are to avoid distracting their discussion. So I have called them G1, G2, G3 and G4 from left to right. G1 picks the notebook and says the theorem she wants to write aloud, in a question form and as if uncertain. She makes gestures as if seeking for group's approval/correction. The other girls approve it so she writes the theorem on the group's paper and she passes it to G2. G2 does the same and passes the paper to G3 and so on. The paper goes round for the second time. G4 is unable to give a 2nd theorem (7 theorems have been listed so far).

Lesson with 3W, 7/09/99 14.10–15.30

I decide to observe a group of boys this time. There are 5 boys in this group. I call them B1, B2, B3, B4 and B5.

B3 (I learnt later from the teacher that he was the brightest in the group) says, "let us have everyone write 2 theorems each; then we will proceed from there'. B1 writes down the theorems on the paper. He does not first seek approval from the group members in the way the girls I observed in 3N did. He passes the paper to the next boy. They do this quietly and individually. The other boys in the group are not even looking at what is being written. They are simply waiting for their turn to come.

The excerpt from data collected above reflects the typical working styles of girls' and boys' co-operative groups that I observed. Most often, I noted that the strategies of solving the mathematical activity for many of the boys seemed to be that of working through the given activities as quickly as possible. They seemed to achieve this by avoiding discussion as much as possible. For instance, the statement 'let us have everyone write 2 theorems each; then we will proceed from there' could be interpreted as a strategy to minimise discussion. This type of behaviour was particularly common amongst groups which had the 'top-achieving boys' in it. In most cases, this meant that interruptions by less achieving group members for explanations or clarifications were only entertained after the answer was produced. This is illustrated in the excerpt below:

> 'a group of 6 boys were about to plot the points they had worked out for the graph y = x + 3. When it came to plotting (-3,0) only one boy S64 knew where to plot the point. After some discussions, three other boys understood the concept while the other two boys were still lost. S64 says: 'because we are running out of time, the few of us who know how to do it let's go on and we will explain to you afterwards'. [lesson with 3N, 9/09/99, 7.30 – 8.10]

This tendency of going on to completion for the more competent students and then explaining to others afterwards contrasted with how most girls worked. The girls' strategy for working seemed to be that of all moving together. They seemed to be less concerned about working quickly and finishing the task, than with involving everyone in the group in doing the given task. Consequently, instead of avoiding discussions as the boys did, the girls tended to initiate discussion as much as possible. They usually did that by 'verbalising their ideas in a question form and as if uncertain'. This type of 'tentative behaviour' displayed by girls seemed to serve three purposes:

- to make a contribution without the exercise of power over others,
- to make sure that everyone else in the group understood what was being put forward before moving on,
- to test the contributor's ideas by using the group's views and evaluative comments.

As the presenter verbalised the idea aloud and noticed through gestures that some members of the group seemed lost, they would discuss the idea until they reached a consensus before they would move on to the next idea. This was not perceived as beneficial by some boys, possibly because they felt that they were being slowed down:

> 'girls tend to insist for explanation of the problem step by step; therefore this makes the group to spend a lot of time on a problem.' (S91, boy, 3N, questionnaire response)

Girls' tendency to discuss problems seemed to have a positive effect on their learning of mathematics. Several girls expressed a positive attitude towards mathematics as a result of their participation in co-operative groups. Some of the comments included:

> "I have found working in groups a very good practice because I was one of them who were hating maths but working in groups has encouraged me to start liking the subject because I understand better working with friends." [S76, Girl, 3N, 9/09/99, journal entry]

The teacher had remarked on several occasions that she had noticed that the girls had gained confidence as a result of working in groups. She commented that, "The girls are now able to put up their hand and give their ideas even when they are not necessarily correct". This gain in confidence possibly resulted from making a contribution in small groups without being laughed at. However, in the classroom context in which they were working, the strategies adopted by girls were less rewarding than those used by boys. On many occasions, the girls lost some marks because they were unable to complete their tasks in the given time.

Student-student power relations

During my lesson observations, I noticed on many occasions that for both boys' and girls' groups, the more able students in the groups regardless of sex usually assumed leadership roles. The difference was in the way they exercised their leadership powers. The girls were often tentative and negotiative when leading the group, usually presenting their ideas in a question form as though they were unsure. At times, they deliberately gave an incomplete idea to allow the other members to fill in so that the idea looked like it came from all of them. Boys, on the other hand, tended to lead their groups in a controlling manner. Excerpts from my field notes recorded while observing a group of girls in 3E and a group of boys in 3N working on the same activity are given below to illustrate these differences.

Lesson with 3E, 12/10/99, 8.10–9.30

'The students were asked to calculate the values of missing angles and sides in the given pairs of similar triangles. There are four girls in the group. S7 is the brightest girl in the group. They tried to use Pythagoras theorem but, after some discussions, they discovered they couldn't because the triangles were not right angled. S7 writes a set of three parallel horizontal lines and another set of three vertical parallel lines and asks in an uncertain manner: Is the symbol for similar triangles this [pointing to horizontal lines] or this [pointing to vertical lines]. Immediately, the other girls completed the symbol by arranging the letters of the given triangles in the right order and it became obvious to all of them that they needed to use the ratio of the sides, and one by one started chipping in their ideas.'

Lesson with 3N, 12/10/99 10.40–12.00

The teacher gives a similar exercise as in 3E. I decide to observe a group of 4 boys. S108 is the brightest boy in the group and he automatically assumes a leadership role. S108 asks, "in whose notebook are we going to write?" B2 answers "mine". "So you will be our secretary", says S108 in a commanding tone. S108 calculates the missing angles using angle sum in a triangle and dictates the solution step by step for B2 to write down. B3 chips in once in a while. B4 is very quiet. I wonder if he is following what is going on. They all don't know how to calculate the sides. With some help from me, they calculate the sides. They move on to question 2. S108 grabs the notebook from B2 and quickly copies down the diagrams for Q2 and hands back the note book to B2. "Can I label this triangle ABC instead of XYZ since XYZ is already used in Q1?", asks B2 [directing the question to S108]. S108 says, "yes", and continues to dictate the solution for Q2.

In the excerpts above, S7 related with her group mates in a tentative manner, whereas S108 related with his group mates in a controlling manner. For instance, S108's group mates were simply obeying instructions from him such as "you will be the secretary", "you write this", and so on. The competent student's role in the majority of boys' groups resembled that of the teacher's role in a teacher-centred classroom. In the excerpt above, for instance, S108 was teaching his group-mates who had to endorse (or reject) whether B2 could use different letters for the triangle in Q2. Such roles of teaching, endorsing or rejecting an idea from students are characteristics of teachers in a teacher–centred classroom. As indicated in section 10.2, the resulting effect was that some of the boys, especially those working in groups with top students, lost their confidence in mathematics competence.

In contrast to the leadership style displayed by the high achieving boys described above, the high achieving girls tended to take the role of facilitator rather than posing as someone who knew better than the rest. In the excerpt from the lesson on 12/10/99, S7's use of an incomplete symbol for similar triangles gave other students an opportunity to contribute to the solution. This seemed to promote a sense of shared ownership of whatever they were producing, rather than individual success or failure. The excerpt below from my field notes illustrated this team spirit in girls of the 'we-succeed-or-fail together' approach/strategy.

> ' a group of 4 girls had just finished plotting the given points on the graph paper. They plotted one of the points wrongly. They had plotted (0,3) instead of (3,0). The teacher pointed to the wrong point and asked them: "What are the coordinates of this point?" They all said, "Ah we have made a mistake." They correct it. The teacher moves on to another group. The girl who had plotted the wrong point says, "so I am the one who made the mistake". The other three girls all said at once in an assuring way, "No it is all of us, not just you!".

The statement 'it is all of us' demonstrates that team spirit was involved. Although it was not possible to probe into the causes for the gender differences in the leadership styles demonstrated by boys and girls, it is possible that there were underlying cultural values that influenced these gender differences. For instance, the participatory leadership style displayed by girls reflected the behavioural norms of women in the broader community within the gender-structuring process in Malawi. Culturally, Malawian men are unlikely to implement ideas that are openly suggested by women, even when the men believe in the ideas. Women tend to push in their ideas through suggestions.

Preferences for group composition

Another observed gender difference related to the preferences for group composition held by boys and girls. I observed on several occasions that when students were allowed to choose who to work with, the majority of the girls would cluster around boys, especially bright boys, while boys usually formed groups with students sitting next to them. Further evidence of the different priorities held by boys and girls regarding who to work with was revealed by the students' responses to the questionnaire item (Appendix F): 'Would you prefer to work in a girls only/boys only group, or in a group of mixed boys and girls? Give some reasons.' A total of 53 boys and 30 girls responded to the question. The 83 completed questionnaires represent the number of students who attended the mathematics lessons on the day the questionnaire was administered. There were 140 students on the roll, so the 83 completed questionnaires represent the responses of 59.3% of the total sample of the students. Their responses are summarised in table 10.3 below.

Table 10.3: Students' preferences for group composition

	Mixed sex	Single sex	Total
Boys	21 (=39.6%)	32 (=60.4%)	53 (63.8%)
Girls	24 (=80%)	6 (=20%)	30 (36.2%)

Table 10.3 shows that 80 per cent of the girls preferred to work in mixed sex groups compared with about 40 per cent of boys. The girls' preference for mixed sex groups seemed to be influenced by their beliefs that boys were more capable of doing mathematics than them. The 24 girls all stated that they preferred to work in groups with boys because the likelihood of solving the given problem was higher if they had boys in the group than if the group was composed of girls only. Typical comments from the girls were:

> 'when girls fail to solve the problem, boys can do it'
>
> 'a lot of girls don't like maths but boys do better in maths'
>
> 'boys are more intelligent than girls and when we have boys in the group we solve problems very easily'
>
> 'girls easily say its difficult, let's leave it, while boys say let's try it.'

These comments may be added to views expressed earlier in chapter nine. This belief that boys knew more mathematics than girls was evident throughout the research period (see interview transcript with S30 on page 103). Such a belief probably convinced the girls that it was beneficial for them to work with boys because it gave them opportunity to earn high group marks.

The other girls preferred to work in single-sex groups:

- so that they could continue to discuss mathematical problems in their hostels after school hours (4)
- "because we girls understand each other than boys. Sometimes instead of working they speak some nonsense" (1)

- "so that we should compete between girls and boys"
- "because if you work with boys, they think that they are more intelligent than girls"
- "because if we are girls only, we can ask each other whatever we did not understand without feeling ashamed, but if we are mixed with boys we feel ashamed to ask."

It appears that the main reason for the girls' preference for single-sex groups was convenience.

Similarly, the most prevalent reason given by boys (11 out of 32) for their preference to work in a boys only group was that it allowed them to meet and discuss mathematics at any time and any place which was not possible due to boarding rules if they had girls in the group. Other reasons given by boys included: less work was achieved because girls were playful during group discussions (9 out of 32), boys or girls were shy in the presence of the opposite sex (9 out of 32), girls made the boys do all the work, believing that boys knew more than them (2), and one boy wrote,

> "In a boys-only group, you can work hard to compete with the fellow boys while if it includes girls it gives you a false impression that you are doing well just because you see that you do better than the girls".

The reasons given by boys that preferred to work in mixed-sex groups included:

- maximum benefit of sharing ideas (13 out of 21)
- gives them opportunity to learn to socialise with members of opposite sex (5 out of 21)
- boys are playful in single-sex groups (3 out of 21)
- gives opportunity for girls to learn from boys since girls are less intelligent than boys (3 out of 21)
- presence of girls in a group forces them to contribute an idea so as to impress on the girls (2 out of 21).

In general, the reasons given by most boys for preferring to work in mixed-gender groups was that it enhanced their opportunity to learn varied ideas. One student wrote:

"If a group contains boys and girls it's easy to come up with more ideas because they view things differently."

10.5 Summary

This chapter sought to understand the experiences of the teacher and the students during the co-operative learning activities. Findings that emerged from the analysis of data can be summarised as follows:

Implementation

- The study found that allowing the teacher to experiment with co-operative learning and participate in a teacher development workshop prior to the data collection period helped her to broaden her understanding of co-operative learning. The growth that occurred for the teacher may, in part, be attributed to the opportunity she had to reflect on her practices. The teacher was asked to keep a reflective journal. Her experience during this initiation phase influenced her decisions on how to group the students..

- The implementation process was not without problems. Both the teacher and the students had to overcome some initial tensions between their traditional expectations of their roles and the new roles that the nature of co-operative learning demanded. In the process, the teacher's and the students' views of learning moved from a transmission view of learning towards a constructivist view. These research findings supported those of previous research that suggested that teachers' implementation of co-operative learning in their classrooms tended to result in a shift of their instructional style from traditional direct teaching to a more student-focused approach (Hertz-Lazararowitz, 1995; Trotman, 1999). Hertz-Lazararowitz argued that as teachers acted upon the mirrors of classroom organisation and task structure, the mirrors of teacher behaviour were simultaneously changed to bring them into harmony with the classroom context.

Dynamics of co-operative learning

Levels of student interaction depended on three factors, namely (i) group composition, (ii) role of the teacher, and (iii) nature of the task.

- The study found that the achievement gap amongst students in the group highly affected the level of interaction during group discussions. The bigger the gap, the less interaction was displayed. Gender, social and economic status had little or no influence on students' interaction level. High achieving students were more active and influential during group activities than those students perceived to be low achieving students. This finding is similar to that reported by Cohen (1994). In her review of literature, Cohen (1994: 23) concluded that academic status was the most powerful influence of interaction amongst group members compared with other factors such as gender, race, and ethnicity.
- The study found that there was low interaction when the task was either too simple, or too difficult for the group.
- The timing of the teacher's intervention for assistance and the nature of assistance given to groups was found, in this study, to have an effect on the interaction levels of the students. Too much or too early help from the teacher tended to reduce interaction amongst students.

Students' learning

- This study found that all students preferred the co-operative learning approach because of the opportunity it offered them to learn from peers. As students were interacting with peers during group activities, they were able to identify some gaps in their mathematical understanding and revised them before moving on. The high achievers benefited from working with low achievers because of the explanations they were giving. Giving explanations to the low achieving peers often pushed the high achievers to clarify their ideas more carefully, and this helped them to see the pitfalls of their solutions. Similarly, the low achieving students benefited from working with high achieving students because they were able to have the mathematical concepts explained to them, using the students' language, better than the teacher could do so.

Gender differences

This study revealed some differences in preferred modes of working between boys and girls during co-operative learning.

- The boys preferred to quickly work through the given tasks with a minimum of discussion. Speed, rather than discussion, was the focus for many boys. This tendency was most acute amongst the highest achieving boys. The girls, on the other hand, were more concerned with discussion amongst the group than the speed at which the task was done.

- The boys were more controlling when leading a group discussion while the girls were negotiative, trying to include everyone, when leading the group.

- The boys generally preferred to work in a single sex group while a larger percentage of girls indicated that they preferred to work in a mixed sex. The girls' preference seemed to be related to their belief that boys are better at mathematics than girls.

The findings reported in this chapter may be peculiar to the context of the Malawian secondary school in which the data were collected and therefore need to be understood within certain limitations. The implications for the findings and their limitations, are discussed in the next chapter.

Chapter eleven

Findings, limitations, implications and conclusion

11.0 Introduction

The primary focus of this study was to investigate the possibility of a co-operative leaning approach as a strategy to improve the mathematics learning of girls at secondary school level in Malawi. Consequently, an in-depth qualitative, ethnographic case study was undertaken to explore the experiences of three Form 3 classes, comprising 48 girls and 102 boys, during mathematics lessons in one secondary school in Malawi. The results were analysed from the perspectives of *constructivist* and *feminists* theories. The analysis of lesson observation notes revealed that two different teaching approaches—*whole class question/answer* and *co-operative learning*, were used by the teacher during the research period. While a study of the question/answer teaching approach was not part of the original question, it became clear during the course of field work that the teacher's and students' prior experiences of this teaching approach had implications for understanding their experiences with co-operative learning. This was in line with constructivist learning theory where prior experiences of the learner are central to the learner's construction of knowledge. The study also allowed me to compare the experiences of boys and girls in the two different teaching approaches. This chapter summarises the research findings of the investigation and examines implications of the study. The remainder of the chapter contains:

11.1 Summary of research findings
11.2 Limitations of the study
11.3 Implications of findings
11.4 Implications for future research
11.5 Concluding remarks

11.1 Summary of research findings

The main findings of this study are discussed in terms of: (i) mathematics teaching in Malawi, (ii) the teacher's implementation of co-operative learning, and (iii) changes in the teacher's and students' classroom practices, (iv) effects of co-operative learning on students' learning, and (v) gender differences.

Mathematics teaching in Malawi

The findings from the present study revealed that the teaching approach commonly used for mathematics teaching in Malawi was a *whole-class question/answer* variation of direct instruction. A description of this teaching approach was given in Chapter nine. The findings from the students' experiences of a question/answer teaching approach in this study revealed that this instructional approach did not help many students in their learning of mathematics. Chapter nine also demonstrated that the question/answer teaching approach disadvantaged girls more than boys in the learning of mathematics. Use of this approach may have contributed to the relatively low mathematics achievement of students overall, as well as the gap between boys' and girls' achievement in mathematics, reported in chapter one. The girls' experiences of mathematics during the question/answer teaching approach, reported in chapter nine, supported the recent argument that the traditional style of teaching mathematics disempowered and alienated girls (Boaler, 1997, 2000; Buerk, 1982; Rogers, 1995). This was in marked contrast to finding in the present study that the same girls were not anxious, they actively participated in mathematics discussion, and they displayed some confidence in mathematics when small co-operative learning groups were used (chapter ten).

Teacher's implementation of co-operative learning

The findings reported in chapters six, seven, eight, nine and ten supported those of many researchers who have observed that the current education systems in many countries present pressures, constraints and demands on a teacher's time and energy. These factors discouraged teachers from using enquiry methods of mathematics teaching (Trotman, 1999; Vinner, 2000). All the teachers who participated in the present study shared a belief that a co-operative approach enhanced students' learning. However, data discussed in chapters six, eight and nine revealed that there were some concerns which might seriously constrain teachers in Malawi implementing co-operative learning. Such concerns related to the teachers' beliefs that:

(i) The present syllabus was examination oriented and overloaded.

(ii) Co-operative learning was time consuming. In other words, they considered the traditional styles of teaching to be less time consuming and to be the efficient method for teaching for the exams.

(iii) Co-operative learning required a lot of resources which many Malawian schools could not afford.

Such concerns need to be carefully considered by curriculum planners if a co-operative learning approach is to be implemented in Malawian secondary schools.

Changes in the teacher's and students' classroom practices

The findings reported in chapter nine revealed that the teacher and students involved in the present study experienced changes in their respective roles, and in their beliefs and expectations about mathematics learning. These support findings from earlier studies that have shown that when teachers introduced active learning into the classroom, it altered and redesigned the classroom's milieu (Cobb et al, 1990; Hertz-Lazarowitz, 1995). The teacher's shift of her instructional style from direct teaching to co-operative learning required a change in role definition from an expositor of content to a facilitator of students' active construction of knowledge through co-operative activities. In turn, this shift in the teacher's role necessitated students to redefine their beliefs about their own and the teacher's roles that they had constructed during earlier direct instruction lessons. Such changes did not occur instantly. Both the students and their teacher experienced dilemmas/tensions which they had to confront, as their new roles required them to act in ways which were in conflict with their established and expected classroom procedures. For example, the teacher experienced dilemmas in:

(i) deciding when and how to intervene to provide assistance,

(ii) reconciling a commitment to encourage students' to explore their own solution paths, with the requirement that only certain strategies were appropriate for examination purposes, and

(iii) striking a balance between frustrating the students because she didn't spend enough time per group to offer them the assistance needed, and spending too much time with some groups and thus running out of time for other groups.

(iv) For their part the students experienced a dilemma between acting co-operatively during group discussions, and the expectation that they should compete with each other for selection purposes.

There was also conflict between the teacher's expectation of students to be autonomous, independent learners during co-operative learning, and students' established expectations of the teacher as a dispenser of knowledge.

The dilemmas experienced in this study might be attributed to the conflict between the constructivist nature of a co-operative learning approach, and the teacher's and students' transmission views of mathematics learning established from their familiar past experiences with traditional teaching practices. In the process of reconciling these dilemmas, the teacher's and students' practices of co-operative learning became more and more productive. This was consistent with a constructivist theory of learning where the processes of resolving perturbation produced knowledge growth (von Glasersfeld, 1990).

Effects of co-operative learning on students' learning

The findings of this study showed that the girls involved in this study gained confidence, actively participated in mathematics discussions, showed an increasing understanding of mathematical concepts, and stated on several different occasions that they found mathematics less difficult as a result of their involvement in the co-operative learning approach. These findings contrasted with past research conclusions that girls in Malawi were less confident (Davison & Kanyuka, 1992), and perceived mathematics as a difficult subject (Hiddleston, 1993). The data also indicated that when a question/answer teaching approach was used, many girls experienced a sense of failure, anxiety and embarrassment (chapter nine).

The findings of this study, interpreted within the frameworks of social constructivism and feminist theories, further challenged interpretations of previous international research on gender and mathematics which attributed the under-participation and lower achievement of girls in mathematics to girls' negative attitude (lack of confidence and interest, anxiety) in mathematics (see chapter three). The present findings supported recent recommendations which suggested that efforts to improve the mathematical learning of girls should incorporate teaching methods that created learning environments 'sympathetic towards' both girls' and boys' preferred learning styles (Barnes, 2000; Boaler, 2000; Solar, 1995).

All the boys and girls involved in the present study stated that they preferred co-operative learning compared to the traditional question/answer teaching approach because of the learning benefits it offered them. The benefits of the co-operative learning/teaching approach identified in the present study are discussed in detail in section 10.3 of chapter ten. A major finding was that peer interaction significantly contributed to the individual students' construction of mathematical knowledge and understanding. This finding supported the social constructivist perspective that mathematics learning is an interactive as well as a constructive process (Cobb, 1994a; b). The data revealed that peer interaction during co-operative learning activities stimulated elaboration, justification and reflection of individual student's ideas, and this process often resulted in re-organisation, and an awareness of both knowledge gaps and inconsistent reasoning (chapter ten).

Research in the past has shown that not all forms of peer interaction were beneficial for learning (Goos, 2000; Webb, 1995). One of the aims for this research was to understand the dynamics of co-operative learning that influenced learning. The findings of this study showed that productive group interaction depended on three factors: (i) group composition, (ii) the nature of the task, and (iii) the role of the teacher. These factors have been discussed in detail in chapter nine.

Gender differences

The results of this study showed that there were some differences in working styles between girls and boys during co-operative learning. The boys' style of working focused on finishing the task quickly, while the girls were more concerned with including all group members in the process of getting a solution. These differences supported previous claims that males and females have different ways of coming to know and subsequently different ways of working. Women tend to value connected knowledge while men tend to value separate knowledge (Becker, 1995; Belenky et al, 1986). Connected knowers construct their knowledge through access to others' experiences while separate knowers learn separately from others (Jacobs & Becker, 1997). Thus, the finding that girls involved in this study tended to initiate discussions more than the boys during co-operative tasks supported Becker's notion that women (in many cases) were more connected knowers than males. It seemed that discussions allowed the girls to listen to alternative solution methods and, through the sharing of ideas, they constructed the mathematics together.

11.2 Limitations of the study

There were certain limitations that I anticipated at the outset, but I endeavoured to minimise their effects (chapter 5). In addition to the limitations and difficulties discussed in chapters five, seven, and eight, there were some others which arose during the study period. These are discussed below:

Technology

There were over ten groups in a class working on an activity at the same time (chapter ten), and this made it difficult to capture the nature of interaction and discussion that was going on in groups other than the one I was observing. However, the same activities were repeated in three different classes at different times, and this gave me the opportunity to observe a minimum of three different groups working on the same activity. A tape recorder was used when necessary to capture the conversation that was going on in other groups. The researcher encountered a limitation with audio-taping in that the students tended to use a lot of physical and non-verbal expressions not captured by the tape recorder. Had the technology been available, the use of video recording would have been useful for this type of study, especially for capturing the full nature of students' interactions reported in this thesis.

Disruptions during the study

My data collection period coincided with the period when the Ministry of Education was in the process of introducing new policies concerning the administration of national examinations. The new policy stated that the examination period should not coincide with school term dates. As a result, the opening of the third term was delayed by a week to accommodate the requirements of the new policy. This meant that I had to adjust my research plans in response to the changes. The biggest disruption happened mid-way through my data collection phase when a Ministry of Education official contacted the Headmistress of the school to advise of the Ministry's decision to push the closing date of the school term forward. At that stage, the new date had not yet been finalised. This created some time pressure on the teacher to finish her planned work and administer the end-of-year tests before the 'unknown' closing date. This had an effect on the data that was collected since the teacher abandoned the co-operative learning approach and resorted to direct teaching to cope with the time pressure.

Other disruptions that impacted on my research related to management of time. In Malawi, like many African countries, we have what we call 'African time'. This represented a relaxed attitude to time. A morning assembly planned to finish at 7.20 am usually went on to 8.00 am, which resulted in Form 3W repeatedly losing one teaching period a week. At times I would arrive at the school to be informed that the class was cancelled because the teacher was held up in a meeting, or attending to a sick neighbour, or a Ministry official was visiting the school. Such events were common and I had to continuously adjust my plans in response to the changes. Other disruptions during my data collection phase included: a two and a half day strike by students, occasional disruptions of classes due to water shortages which required students to fetch water from nearby alternative sources.

These disruptions may have had an effect on the findings reported in this thesis. For instance, the teacher's differential instructional behaviour between Form 3W and the other two forms, reported in chapter eight could be partially explained by such disruptions. On the other hand, the disruptions also exposed key issues concerning the unstable everyday school realities that need to be understood and addressed when planning for innovations in Malawian schools, and in conducting research in the Malawian schooling system.

Researcher/participant relationship in a Malawian setting

Most scholars, especially feminist researchers, suggested that a commitment to a relatively intimate and non-hierarchical power relationship between the researcher and the researched was central for the validity of the findings (Fontana & Frey, 1998; Oakley, 1981). During my research, I found it difficult to sustain such a relationship due to cultural expectations. Malawian culture places great emphasis upon respect for those who are older and those in authority. I was older than all the participants and my position as a university lecturer placed me in higher authority. I realised that this had consequences for the kinds of data I could collect and the processes for collecting it. For instance, it was viewed as 'inappropriate' for the students to openly express their negative feelings about co-operative learning because it was perceived as 'my idea'— that is, an idea from someone older and of higher social status than them. In other words, it was respectful for the students to agree with what they perceived to be 'my' views; it would be disrespectful to 'oppose' them. Within such cultural expectations, it required a lot of effort to convince the respondents that it was acceptable to express their feelings even when their feelings seemed to oppose those of people older than themselves. Nevertheless, it was possible that some of the positive responses given by students revealed little of what students' really felt about co-operative learning. Some of their negative feelings may not have been revealed. This may have affected the findings reported in this thesis.

Similarly, the findings reported in chapters six and seven revealed that the teachers, for various reasons, did not try the suggested lessons in the teachers' guide (see chapter seven), and yet their response to the teacher questionnaire on cooperative learning indicated that they used cooperative learning regularly (see chapter six). This may indicate that the questionnaire needed to ask rather more focussed questions such as, "Did you use cooperative groups in the last fortnightr?" "If so, then what was the topic and what did you do?" to elicit more valid responses from teachers.

Researching in a second language

Related to the above problem was the issue of conducting research in a second language. I tried as much as possible to allow students to express themselves in their first language, but because the school placed a lot of emphasis on speaking English (see chapter eight), the students mostly responded in English. One of the aims of my research was to gain an insight into the students' day-to-day experiences, attitudes, concerns and their perceived benefits of co-operative learning. Most references on qualitative research (Denzin & Lincoln, 1998) advised that asking open questions was more likely to elicit respondents' feelings than questions that might be answered either by 'yes' or 'no'. On several occasions, I consciously departed from this advice because it usually resulted either in silence or rhetoric responses due to the students' poor command of English. Instead of asking open-ended questions, I found it more effective to ask students to make a list of the things they liked and did not like about working in groups and then to follow these up with 'why questions'.

Despite these limitations, several implications may be drawn from the findings of this study, and they are outlined in the next section.

11.3 Implications of findings

Mathematics Curriculum reform is needed

The present study had revealed that, overall, co-operative learning has the potential to improve girls' learning of mathematics. When students' experiences during whole class question/answer teaching were compared with students' experiences during co-operative learning involving the same students and the same teacher, it was evident that there was a substantial increase in the girls' opportunity to learn mathematics. They were able to contribute their ideas or ask questions for clarification in small co-operative groups whereas they didn't feel able to do so in front of the whole class. It followed from this finding that if access, equity and quality for both girls and boys in education were to be achieved in Malawi, then the government should implement curriculum reforms aimed at discouraging the current whole class question/answer teaching approach because, as this thesis suggested, it disadvantaged girls in their learning of mathematics. Instead other methods such as a co-operative learning approach should be encouraged to overcome the disadvantages associated with the whole class question/answer teaching approach.

Time, and co-operative learning skills, need to be provided

The finding that most girls preferred to have more time for discussion suggested that the present teaching method that emphasised speed of production of the final correct answer disadvantaged girls. By focusing on the final correct answer, girls were denied the opportunity to explore different viewpoints. Teachers should ensure that small group tasks were allocated with reasonable time to allow maximum discussion among students. It was not inconceivable that time invested in developing understanding at this stage of schooling could lead to more rapid development of mathematics ideas later.

The findings of this study suggested that Malawian boys did not naturally work co-operatively, even when they were physically placed in groups. They appeared to need to be taught co-operative skills for co-operative learning in order to be productive. Teachers needed to carefully monitor boys to make sure that everyone in the group was given opportunity to contribute their ideas. The high achieving boys needed to be convinced of the importance of listening to others' view points when solving problems.

Mathematics teacher education needs to support changes in practice

The finding of this study revealed that the teacher experienced changes in her beliefs about her role and expectations about mathematics learning as a result of her experience with co-operative learning. In other words, the change in the teacher's beliefs came after her change in classroom practice. This implied that pre-service and in-service teacher training strategies for changing the teachers' beliefs must focus on exposing such beliefs and encouraging the teachers to use a variety of student-centred teaching practices.

Need for professional development

The findings that the teachers in this study had not tried out the lessons suggested in the teachers' guide (chapter seven) and that the sample teacher who had tried some of the lessons still gave some question/answer type lessons during the main data collection period (chapter nine), strongly suggest that without policy changes to assessment procedures, and without changes in beliefs of teachers about the time and resources required for cooperative learning, the teachers in Malawi seem unlikely to use the written materials on cooperative learning without supporting professional development. A future study should investigate whether teachers made changes to their teaching following their participation in an inservice workshop programme in addition to receiving printed guide materials..

Current national assessment practices need to be reviewed

The current requirement of particular strategies for solving mathematics problems demanded by the examination board was found to limit the teacher's use of co-operative learning and promoted students' dependency on the teacher for 'correct' solution paths. A review of the current assessment practices to allow the development of multiple strategies for solving problems is needed. Only in this way is initiative, deeper thinking and innovation likely to be encouraged.

11.4 Implications for future research

Overall, the results of this study indicated that the co-operative learning approach (using single-sex groups) enabled the girls to develop a positive attitude towards mathematics learning. It was not possible, however, on the basis of the present study, to comment on the impact of co-operative learning on the achievement of girls in the public examinations. This aspect was not part of this study and indeed it was questionable whether such an impact could be determined within a short term (Rodgers, 1995). To examine the long term effect of co-operative learning on the achievement of girls in the Malawian context, a longitudinal study is needed. Findings of co-operative learning approach resulting in students' achievement gains in examinations may encourage the teachers to use co-operative learning.

Most of the groups studied in this research comprised single-sex, mixed ability groups selected by the teacher. Consequently, little was known about the effects of other grouping strategies on the students' learning of mathematics. Research comparing the effects of co-operative learning using different grouping strategies is needed to determine the grouping strategy that gives the maximum benefit in a Malawian context.

There were some indications from the present study that there is considerable potential for co-operative learning to foster democratic values amongst students, but research is needed to investigate this further.

11.5 Concluding remarks

The findings of this study contributed to the literature on gender and mathematics, and indicated that co-operative learning has considerable potential for enhancing girls' learning of mathematics, at least in a developing country such as Malawi. Further, the results provided in this thesis extended the findings of previous studies by elaborating on salient issues concerning the factors influencing classroom interaction during co-operative learning activities. The present study focussed on specific group processes and interactions within co-operative learning. Most other studies of co-operative learning in mathematics have focused on the academic and attitudinal benefits of co-operative learning. In comparison to most international research on co-operative learning (Johnson & Johnson, 1999b), the students involved in this study were in a senior year of secondary school (see Appendix C for structure of Education system in Malawi).

LIST OF APPENDICES

APPENDIX A

QUESTIONNAIRE: SECONDARY TEACHERS' PERCEPTION OF CO-OPERATIVE LEARNING

Dear colleagues,

I am in the process of conducting research in the area of gender and co-operative learning in mathematics. You are kindly requested to participate in this study by completing the attached questionnaire. Please note that your views and opinions will be valuable contributions to this study and that all responses are confidential. Your participation is greatly appreciated.

Yours sincerely,

Catherine Panji Chamdimba (Mrs)

TEACHERS' PERCEPTION OF CO-OPERATIVE LEARNING

Please answer the following questions by providing as much information as you can in the spaces provided. Return your completed questionnaire to:

Panji Catherine Chamdimba
Centre for Mathematics Science and Technology Education Research
University of Waikato
P.B. 3015
Hamilton, New Zealand
email: cppc1@waikato.ac.nz

1. **Personal information**

Name (optional): ________________________

School: ______________________ Class: ____________

Teaching subjects: (1)______________ (2)________________

Years of teaching experience: _____

2. Describe how you would teach a typical lesson.

____

____

____

____

____

____

____

____

____

____

3. When you think of co-operative learning, what are some of the things that come to mind? ____

____

____

____

____

4. How did you learn about co-operative learning? Indicate your response with a tick on any of the suggestions listed below (you can have more than one ticks).

(a) pre–service training

(b) reading from books

(c) attending conferences/workshops

(d) observing colleagues

(e) others (specify) ____

____

5. Have you ever used co-operative learning in your teaching?_______________

If no, go to Q18 .

6. In what subjects do you use co-operative learning?

____

____

7. For what activities do you use co-operative learning?

____

____

____

8. How often do you use co-operative learning? Indicate your response with a tick on any of the suggestions listed below.

(a) everyday
(b) once a week
(c) once a month
(d) once a term
(e) others (specify) ____

9. Specifically in the last term of teaching, what would you estimate is the number of teaching periods that you used some co-operative learning? ____________________

10. What keeps you using co-operative learning, or why have you stoped using cooperative learning?____

____

____

____

11. How do you assign students to groups in group work?

____

____

____

12. How long do groups stay together before you change them?__________________

____

____

13. Are there any particular reasons for your answer to Q12 above? If so, state the reasons.____

____

____

14. Does co-operative learning in your class usually include group products?

____

15. How do you assess co-operative learning activities?

____

____

____

16. Do co-operative learning activities contribute to the students' grades? How?

____

____

____

17. Can you describe an example of a co-operative learning activity you have used recently? Your description should include the following:
(a) how you formed groups
(b) what kind of tasks you assigned to groups
(c) how you assessed the students' work
(d) your role as a teacher

(a) How you formed groups.

____

____

____

(b) What kind of task did you assign to students?

____

____

(c) How did you assess the students' work?

____

____

____

(d) What was your role as a teacher?

____

____

____

18. What do you think about this teaching approach? Do you consider it applicable to your class?____

19. When a group is going really well, what would you see happening?

____

____

____

20. What are some of the major constraints and difficulties of using co-operative learning?____

____

____

____

21. What are the major benefits/constraints/difficulties of co-operative learning to girls?

(i) Benefits:

____

____

____

(ii) Constraints

____

____

____

(ii) Difficulties

____

____

APPENDIX B

IMPLEMENTING CO-OPERATIVE LEARNING

IN

MATHEMATICS CLASSROOMS

A Teacher's Guide

SOME IDEAS FOR COOPERATIVE LEARNING IN MATHEMATICS

By

Catherine Panji Chamdimba

Centre for Science Mathematics & Technology Education Research
University of Waikato, Hamilton, New Zealand

Foreword

Dear Colleagues,

This booklet is designed to help you, Mathematics classroom teachers, with some strategies to help you get started in using co-operative learning or improving your current use of co-operative learning strategy. It will assist you to understand what co-operative learning is, and why every teacher should trial co-operative learning. It outlines some basic elements that make co-operative learning work and gives you some suggestions on how you can train your students to use those skills that are essential for co-operative learning to work. Some sample activities are given to illustrate how some mathematics lessons can be used with co-operative learning groups. I suggest that you read and discuss this booklet with a group of your colleagues so that you can help each other implement co-operative learning in your classrooms.

Thank you for your cooperation,

Yours sincerely,

Catherine Panji Chamdimba

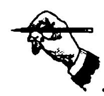
SECTION 1

"Two are better than one, because they have a good reward for toil. For if they fall, one will lift up his fellow; but woe to him who is alone when he falls and has not another to lift him up. And though a man might prevail against one who is alone, two will withstand him. A threefold cord is not quickly broken." Ecclesiastics 4: 9–12

" If classrooms and schools are to become places where people achieve worthy goals, they must become places where students, teachers, administrators, and other staff co–operate in pursuit of those goals. Such co-operation must be consciously implemented until it becomes a natural way of acting and interacting. Johnson, Johnson and Holubec, 1994 *Co-operative Learning in the Classroom*, pg 1.

Introduction

This booklet is designed to help mathematics classroom teachers with some strategies to help get started in using co-operative learning or improve your current use of co-operative learning strategy. The booklet consists of six sections, each of which is divided into subsections. It starts with a general introduction which gives an overview of the booklet. Section 2 starts by looking at the meaning of co-operative learning and goes on to give some reasons why every teacher is encouraged to try co-operative learning. Some grouping strategies and basic elements that make co-operative learning work are outlined in sections 3 & 4 . The last two sections contain some sample activities to illustrate how mathematics lessons can be used with co-operative learning groups.

Each section has a **points to ponder** section with this symbol . Here, you are asked to reflect on something you have read or tried and jot down the ideas. These will be discussed during the two day workshop planned to take place during the week prior to the opening of third term. I suggest that you read and discuss this booklet with a group of your colleagues so that you can help each other implement co-operative learning in your classrooms.

SECTION 2

What is co-operative learning?

Co-operative learning is an approach that involves small groups of learners working together as teams to solve problems, complete tasks, or accomplish common goals. Group members must realise that they are part of a team and that the success or failure of the group will be shared by all members of the group.

To accomplish the group's goal, students need to talk with one another about the topic and help one another. The teacher is not seen as the authority who dispenses knowledge to the students. The students are not seen as merely absorbing information. Instead, students are important resources for one another in the learning process. The teacher–student and student–student interactions in a co-operative classroom can be represented diagramatically as in figure 1 below:

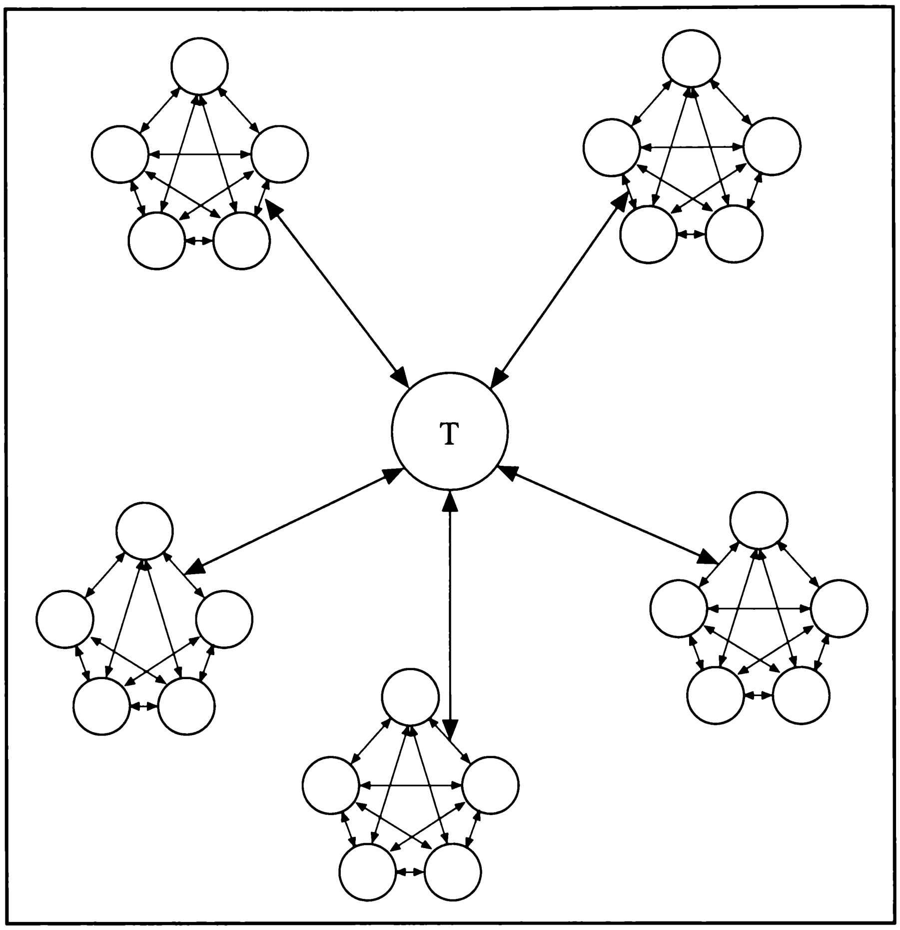


Figure 1 Co-operative learning classroom

Another way of answering the question, what is co-operative learning is to imagine ourselves walking into a co-operative learning classroom and let us look at some of the things we would observe if we take a look around.

• Students are engaged in explaining to others.

• Teachers are not always the centre of attention.

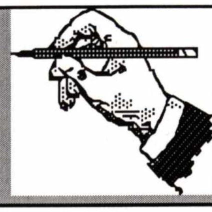
• Students are not passive receivers of a teacher's explanation, they are actively engaged in their learning.

• Students are working in groups as teams, to solve problems, complete tasks, or accomplish common goals.

Points to ponder

• What else might you see in a successful co-operative learning activity?

• What would your role be in all of this?



It is not co-operative learning if:

• students sit together in groups (or in rows) and work on problems individually.

• if students sit together in groups and let one person do all the work.

Why use co-operative learning?

A motivation to use co-operative learning comes from knowing what other teachers have experienced after using the method. A lot of teachers who have tried the strategy report that co-operative learning has positive effects on students. The following are some quotations by teachers who tried co-operative learning:

"I enjoy and understand math more each year. My class seems to get better and we've had fewer and fewer discipline problems since the changes. My class has had wonderful test scores to back up my new approach."

"Students look forward to math. Their attitudes are definitely more positive and I think they are beginning to develop stronger math concepts."

"The students are excited and look forward to class. Parents' remarks are: 'keep doing what you're doing– my child is excited about maths.' Kids are willing to try and work hard."

" My students love math class. They know that I respect their thinking and the process of problem solving. They like working in groups and are more ready to take chances than before. They love working with materials and are eager to try new experiences."

Some other benefits include:

• *Accommodates individual differences*
Co-operative learning has a potential for accommodating individual differences in the classroom.

• *Social benefits*
One of the responsibilities that teachers have is to develop your students' social skills. Co-operative learning provides opportunities for students to learn and practice interpersonal skills. Co-operative learning has been found to promote positive interpersonal relationships. By promoting interaction within the group, students in a co-operative learning classroom, learn to be supportive and accepting of students who are different from them.

• *High achievement*
Co-operative learning promotes higher achievement in mathematics class. A lot of research have shown that co-operative learning strategies promote critical thinking, higher level thinking, and improved problem solving. Students have to think through and organise their ideas before they can explain to others. Children have their own language. They are able to express their thoughts and ideas to each other in a way that teachers can't.

• *Active learning*
Co-operative learning is beneficial because it results in broader student participation in lessons, more active learning, or greater task engagement in classroom lessons as a result of being permitted to work together.

• *Students gain confidence in mathematics*
By working co-operatively within mathematics classes, students gain confidence in their individual mathematics abilities.

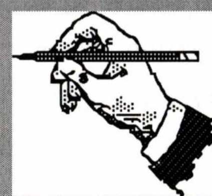
• *Equal participation:*

In the traditional approach, only a few students actively participate during the class oral question–answer time, and it is often the boys. In co-operative learning all students participate during group discussion.

Points to ponder

• Have you ever used co-operative learning in your classroom?

• If yes, How was it done? What do you feel were the advantages and disadvantages?



• If no, what do you think about this teaching approach? Do you consider it applicable to your form?

• How could the use of this teaching approach enhance the learning of boys and girls in mathematics?

SECTION 3

How will students be grouped?

There are several methods of assigning students to groups; all of which result in groups that are either homogeneous (similar) or heterogeneous (diverse) in nature. Some of these methods include:

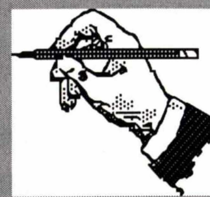
(i) Students can be randomly assigned to groups. Students can count off, or names can be placed on slips of paper and drawn from a bag.

(ii) Using the natural seating pattern of the room, teacher can ask the students to turn to their nearest neighbours.

(iii) Teacher can ask students to choose their own group members.

(iv) Teacher can assign the students into groups based on his/her knowledge of the students so that high–ability students are placed with medium–and low–ability students, task–oriented students with non–task–oriented students, females with males.

Points to ponder



• What do you think about these methods? Which ones are applicable to your form? Why?

• Have you ever used any of them? If yes, which ones? If no, what method do you use?

• What would you consider to be an advantage and a weakness of each of the method above?

• What do you think should be the size of the group? Give reasons for your answer.

SECTION 4

What makes co-operative learning work?

You need to understand that simply placing students in groups and telling them to work together does not in and of itself result in co-operative efforts or positive effects on students. To structure lessons so students do in fact work co-operatively with each other, you must ensure that the groups have the basic elements that make co-operation work.

For co-operation to work well, you must explicitly structure five essential elements in each lesson. These are:

- *positive interdependence*
- *individual accountability*
- *face to face*
- *social skills*
- *group processing*

Positive interdependence

- Positive interdependence is the most important component. Positive interdependence is successfully structured when all members of a group feel connected to each other in the accomplishment of a common goal so that one cannot succeed unless everyone succeeds.

• Such positive interdependence creates commitment to other people's success as well as one's own. "We sink or swim together!" spirit.

Individual accountability

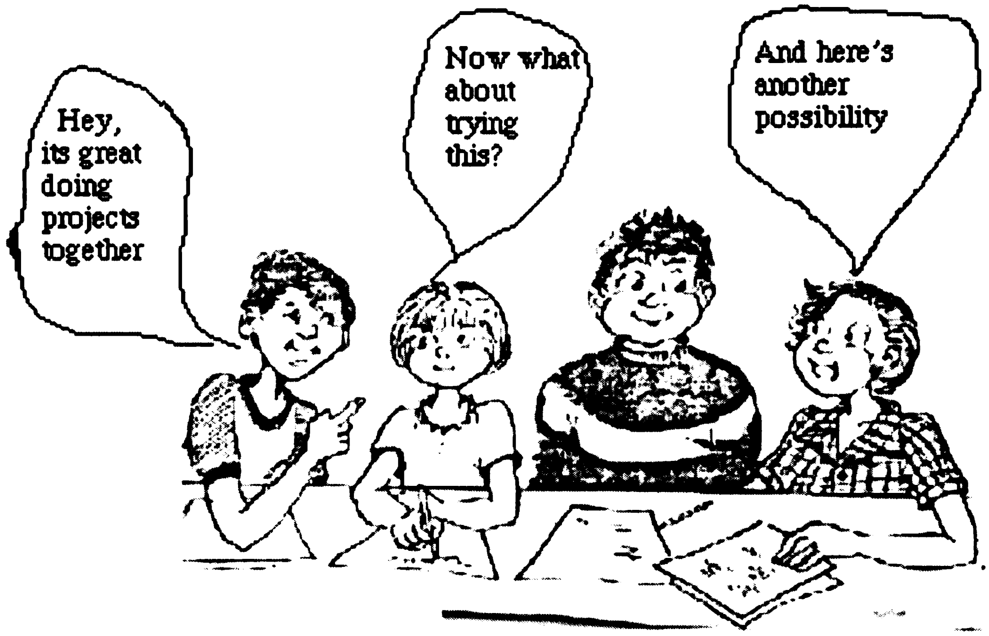
• The purpose of co-operative learning groups is to make each member a stronger individual, that is, students learn together so that they can subsequently perform better as individuals.

• For co-operative learning to succeed, there must be individual accountability. Individual accountability exists when students realise that learning is an activity which they must engage in for themselves and that no one else can do the learning for them.

• Every member of the group is held responsible for their own learning and for their contributions to the group.

• Students are aware that they cannot "hitch–hike' on the work of others.

Face–to–face Interaction



• For co-operative learning to succeed, students must talk to one another. There must be a regular exchange of ideas.

• Students communicate, explain and justify ideas and when necessary, engage in intellectual conflict over ideas.

• Students promote each other's success by sharing resources and helping, supporting, encouraging, and praising each other's efforts to learn.

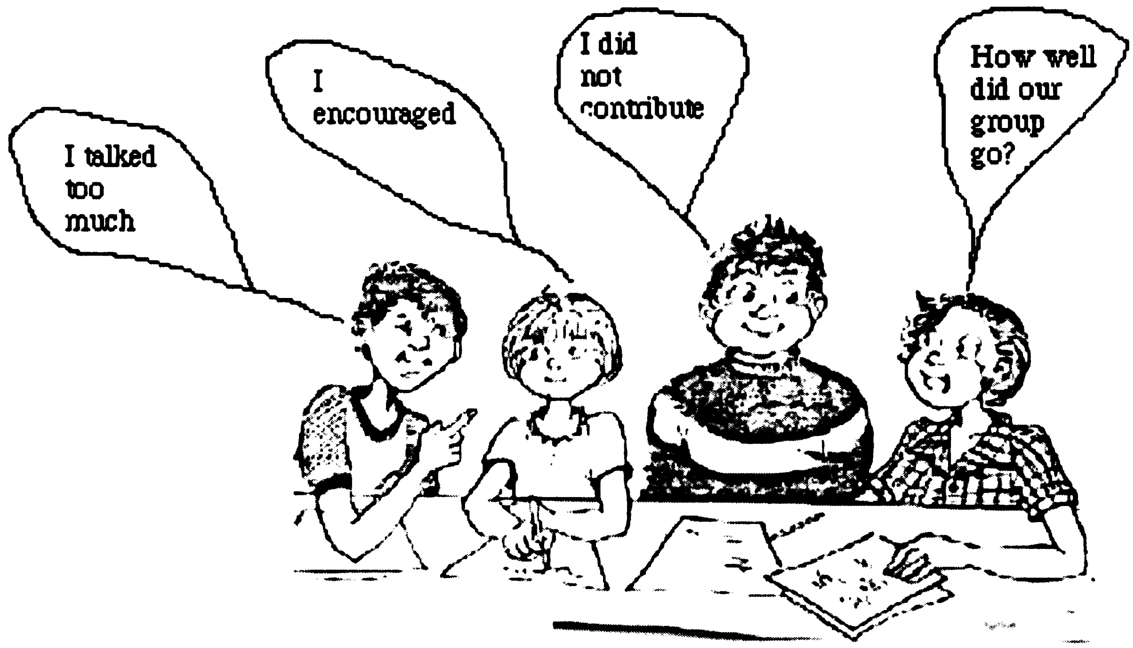
Social skills

• Certain social skills (for example, taking turns, encouraging, listening, giving help, clarifying, checking understanding, probing) are essential for people to work together in a group effectively.

• When differences and disagreements arise, group members need the skills to manage such conflicts. Communication plays an important role in enhancing such skills.

• Members of the group should be able to express themselves so that others can understand their ideas and those receiving should be able to check that they are understanding what is being communicated. Such communication enhances trust amongst group members.

Group processing.

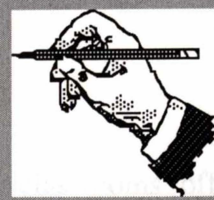


• Group processing exists when group members discuss how well they are achieving their goals and maintaining effective working relationships.

• Groups need to describe what member actions are helpful and unhelpful and make decisions about what behaviours to continue or change.

Points to ponder

• What do you think about the elements suggested above? Are they applicable to your form?



• Can you think of other skills that might help make co-operative learning more productive?

• List the skills you consider essential for productive co-operative learning for your form?

SECTION 5

How can one incorporate co-operative learning in a mathematics classroom?

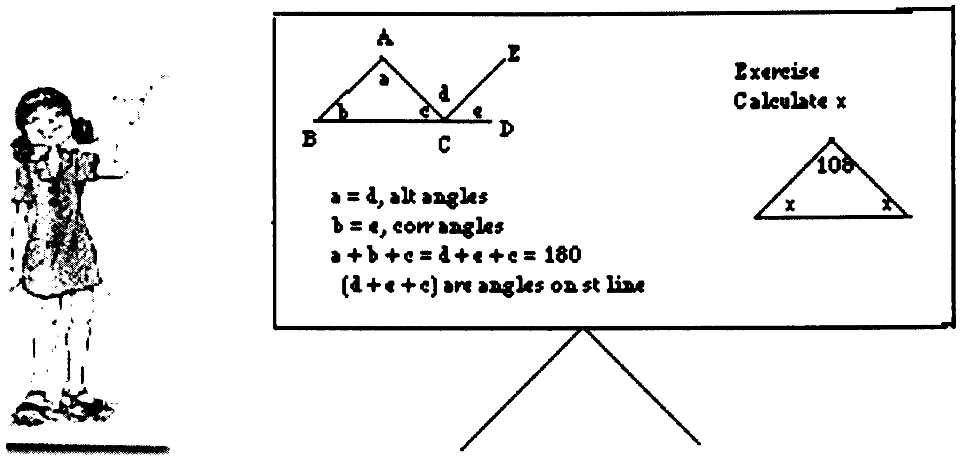
Mathematics classrooms offer a lot of opportunities for co-operative learning. You must however realise that your students do not naturally possess all the co-operative skills discussed above. Students need to be taught the skills so that co-operative groups can be productive.

You can structure co-operative learning for the following activities:

- class work
- revising for a test
- homework reviews
- projects
- problem sessions

Some ideas of how you can structure your classroom co-operatively are given in the following section. Try structuring at least one co-operative activity per week and increase the frequency as you go along.

Example 1: Class work



• After introducing some new idea, and solving an example on the board, you can give some application problems for your students to solve individually.

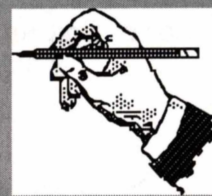
• Instead of marking individual work and reviewing the problems on the board, you can ask your students to discuss their answers in their groups and present their agreed answers on one sheet.

• The groups' work can be graded by either marking the groups' agreed solutions or by asking one member of the group to present the solution to the class and grade the work based on the clarity of the presentation.

Comments:

Asking students to present work on the board maximises the probability that each group will ensure that its members understand the solution since the teacher can pick anybody. Each member of the group receives the same mark based on the groups' work. Allowing students to work on the problems individually before group discussion is very important because it gives every student opportunity to have something to contribute to the group.

Points to ponder



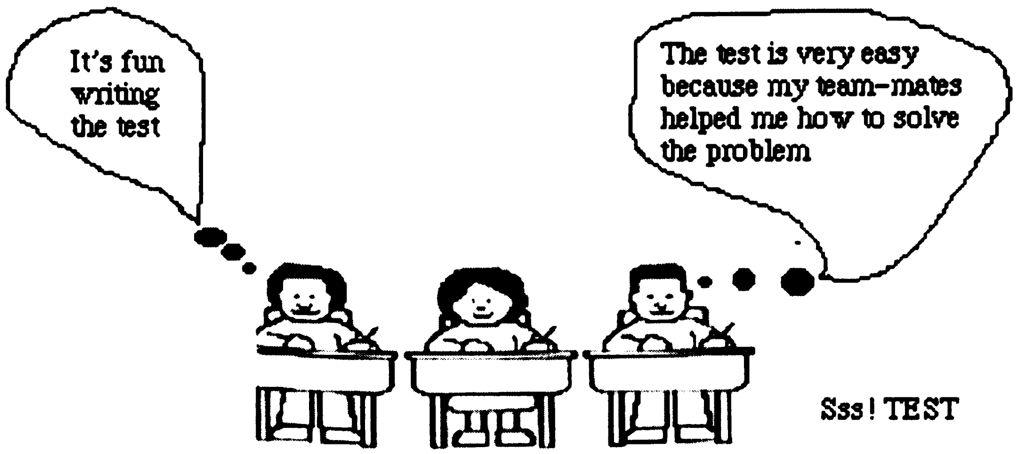
- How could the use of co-operative classroom activity promote the learning of boys and girls in your form?

- What do you think are the practicalities of using such an approach to your form?

- What would be the teacher's role? Do you think this approach reduces/increases the teacher's workload? How?

- Do you feel it is fair to give each member of the group the same mark? How would you distribute the marks amongst students to ensure that the marks reflect each member's contribution to the task?

Example 2: Revising for a test



• Teacher prepares a sample test for students to practice in preparation for the coming test.

• Ask students to work on the sample test individually before they discuss in their groups.

• The groups can then hand in one set of their agreed solutions for correction and clarification.

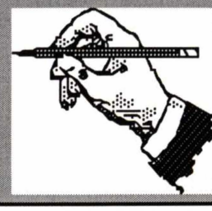
• The teacher explains to the students that every member of the group will receive the average mark of the group or a bonus of 5% of the groups' total marks will be added to each members grade.

Comments:

Teacher needs to stress to students that group's total marks will affect each member of the group. This increases students' commitment to prepare each other for the forth coming test. The fact that each student will write the test individually ensures individual accountability and commitment to participate in the group discussions so that s/he will do well on the test. You could also try giving group rewards or letting groups compete with each other so as to foster team spirit that they "swim or sink" together and therefore must be actively involved in maximising their own learning as well as the learning of group mates.

Points to ponder

• Can you think of other opportunities for structuring co-operative learning in your classroom?



• List some possible ways to use co-operative learning for homework reviews, projects, and problem solving.

SECTION 6

Classroom activities

Below are examples of some activities that have been adapted for use with co-operative learning groups. Attempts were made to make these activities relevant to Malawian secondary school mathematics. However, feel free if you prefer, to adapt them slightly to suit your individual circumstances.

You are asked to write down comments on how the activity went as you are working through the activities. These comments will be discussed during the teacher development workshop which is planned to take place a week before the start of third term.

Activity 1: Our size

• Teacher says: "I am going to give you a homework which will be done in groups. So why don't you divide yourselves into groups of about 6 each."

• After the students have arranged themselves in groups, the teacher explains the homework. "You will be given one measuring tape per group. Measure each others height and foot length and record your agreed results on the piece of paper as follows:

Name	Height (H)	Foot length (L)	Measured by
A			
B			
C			
D			
E			
F			

• Using your results, agree on the scale to use and plot the graph of H (height) against L (foot length) on the graph paper.

• Each member of the group should plot their measurements.

• Teacher asks: "Is there any relationship between the height and the foot length of a person?"

• Students hand in groups' solution for discussion tomorrow.

• Teacher says: "I will need a way of referring to each group, so agree on a name for your group and write it on your solution before you hand it in. I will choose any one to be a spokesperson for the group to explain the group's solution to the class. Points will be awarded based on the clarity of the explanation."

• On the following day, the teacher calls on any one person to explain the group's solution to the class. The teacher will then grade the group's work and every member of the group will receive that grade.

Comment for activity 1:

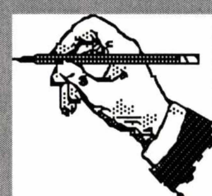
This activity is designed to foster positive interdependence amongst students. They will realise that it is difficult to measure ones own, or a partner's height without help from a partner helping to hold each end of the measuring tape. This will necessitate dependence and co-operation amongst each other. Having the group measure each other's height and length and plot the results creates an environment where students will value co-operation. Each student depends on all group members to co-operate to be measured. Since the spokesperson of the group is chosen by the teacher and the group members don't know who that one will be, all students must help one another understand the group's solution, and ensure that every member can measure and plot points.

The teacher will then ask the students to evaluate their co-operative skills by asking the following questions: "Discuss in your groups how well you worked together. How did you organise yourselves in your group? What were some of the difficulties you encountered? How did you sort out these difficulties? Can you think of a better way to have organised yourselves?

Points to ponder

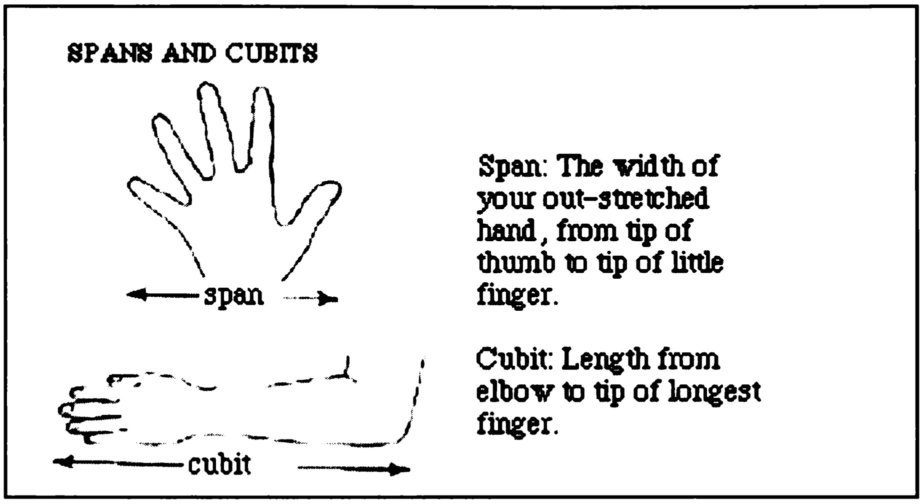
- If you were to try this activity with your class, what are some of the changes that you would make to suit your situation? Explain your answer

- After trying the activity with your students, what were some of your experiences?



Activity 2: Spans and Cubits

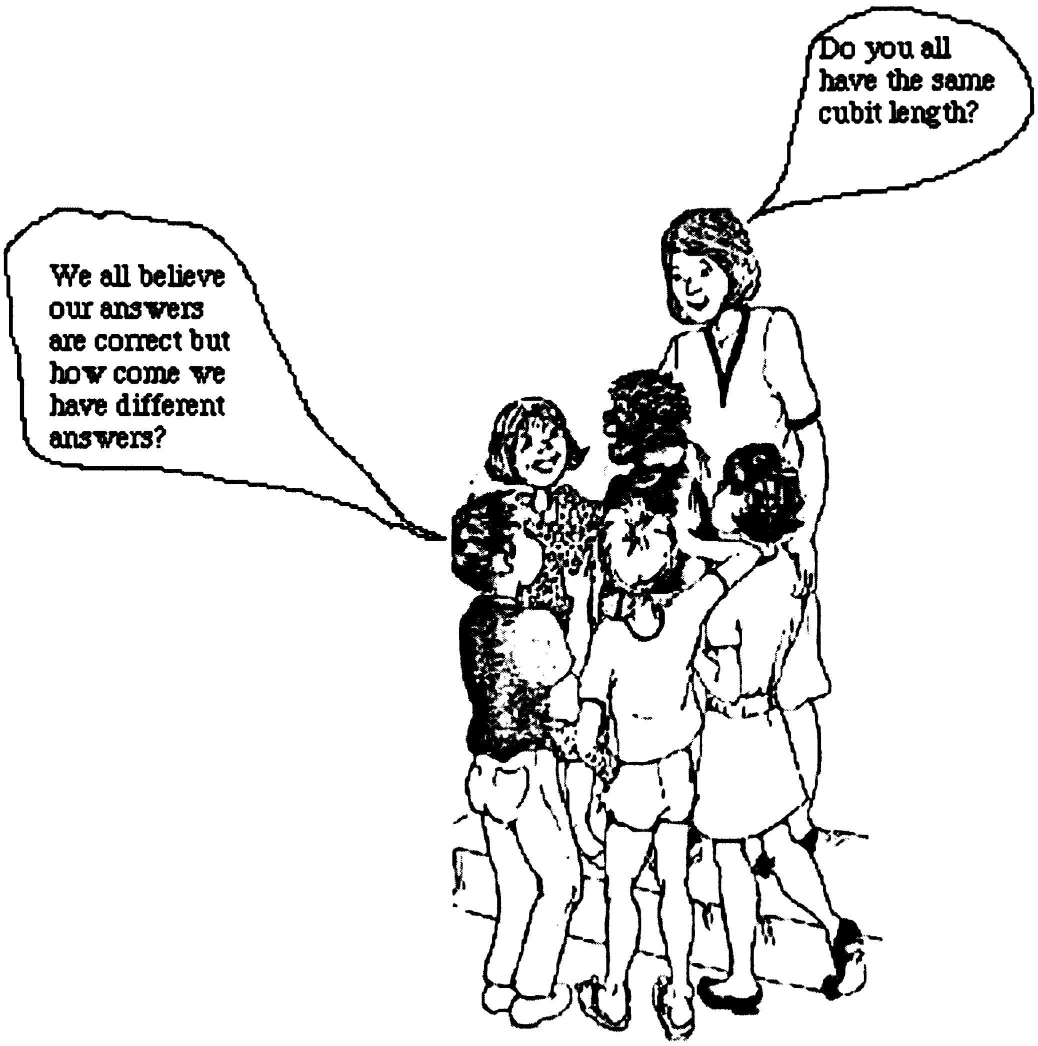
• Teacher defines *spans* and *cubits* to the class (see fig below). Teacher then asks students to measure their own hand spans and cubits using the meter rulers provided.



• Students are then given the following task: " In the book of Genesis 6:15, Noah was instructed to construct an ark 300 cubits x 50 cubits x 30 cubits, calculate the volume of the arc in cubic meters. Compare your answer with the one sitting next to you. Are your answers the same? What does your partner say? Did that convince you? or Can you convince your partner that your answer is correct? Teacher should be going round groups to listen to the levels of conversations going on between students. Teacher should note down how students resolve their differences. For example, students might decide to measure cubits or do calculations together to double check each others answers. Students may decide the boat is a cuboid or they may make adjustments for 'boat shape'.

• Teacher asks the students to calculate the ratio cubits to spans in pairs. Teacher asks, "is it constant? When you and your partner have agreed on all the answers, find another pair that is finished and compare your answers. If they are different, see if the 6 of you can figure out why. If you have made errors, correct them. Record your agreed answers on one sheet

• Hand in your work to me. Don't forget to put the name of the group on your work.

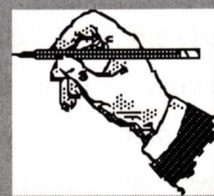


Comments for activity 2:

This activity creates an environment where students are given opportunity to practice some co-operative skills like sharing, communicating, resolving differences. Since there are not enough metre rulers for every student, they will have to figure out how they are going to share the rulers. The activity encourages students to engage in a dialogue with each other as they try to agree on different answers. As the students prove their answers to their partners, they are able to monitor their thoughts and the thoughts of their group mates. As a result, misconceptions, for example, poor measuring skills or inability to correctly convert cubits to meters are easily identified and immediately corrected by their partners or teacher where necessary.

Points to ponder

• If you were to try this activity with your class, what are some of the changes that you would make to suit your situation? Explain your answer



• After trying the activity with your students, what were some of your experiences?

Activity 3: Angle properties of a circle

This activity can be completed in two days.

Day 1

1. Teacher introduces the topic by drawing the circles below on the chalkboard. Teacher says: "Both diagrams show the same arc AB. In one, an angle is drawn from both ends of the arc to the centre. In the other, an angle is drawn from both ends of the arc to a point on the circumference. Angle AOB is known as *angle at the centre subtended by arc AB* and angle ACB is called *angle at the circumference subtended by arc AB.*

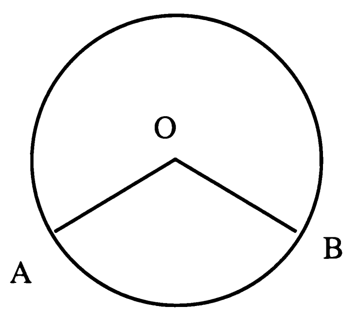


fig 1

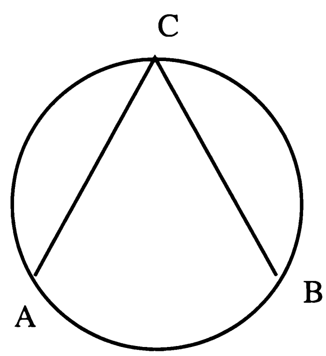


fig 2

fig 1 and fig2 can be combined together as shown in fig 3

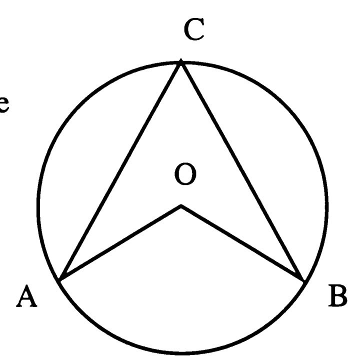


fig 3

2. Teacher says: "I am going to give you an activity which will be done in your usual groups. But I want everyone of you to draw your own circle with a compass and mark off an arc AB. From both ends of the arc, draw angles at the centre and somewhere opposite on the circumference (see figure 3). Measure the angles. Make sure that you don't use the same radii. It is very important that every member has accurate measurements for this activity. Discuss your results in your groups and record your agreed results as in table below:"

Name	Radius of circle	Angle at centre	Angle at circumference
A			
B			
C			
D			
E			
F			

What do you notice? Is it always true for any circle? Can you explain why?

3. Teacher should then randomly select one person from a group to explain the groups' solution to the class. Results from different groups can be compared on the board.

4. Teacher says: " Do the following homework question in groups (see Homework sheet on next page). Tomorrow, I will randomly select one person from a group to explain the group's solution."

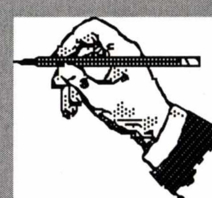
Day 2

Teacher randomly selects one person from a group to explain the group's solution on the board

Teacher gives the formal proof of the theorem on the board through class discussion followed by practice exercise.

Points to ponder

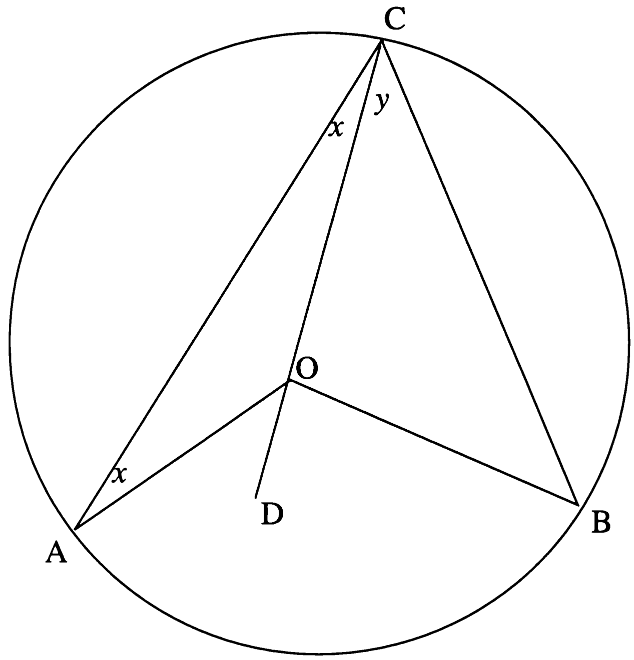
• If you were to try this activity with your class, what are some of the changes that you would make to suit your situation? Explain your answer



• After trying the activity with your students, what were some of your experiences?

HOMEWORK SHEET

The diagram shows an arc AB and angles drawn from the arc to the centre (AOB) and to the circumference (ACB)



1. Explain why the two angles marked x are equal.

2. Explain why the two angles marked y are equal.

3. Angle AOD is the exterior angle of triangle AOC. Write angle AOD in terms of x.

4. Explain why angle DOB = 2y.

5. Write angle AOB in terms of x and y.

6. Explain why angle AOB is twice the size of angle ACB.

Activity 4: Changing formula

Teacher says: "Today we are going to play a game where groups will be playing against each other. I will give everyone 5 bottle tops and each team will be given one empty tin.

The rules of the game are as follows:

1. Talking is not allowed while the game is on.

2. Each group will be given a pair of equations with the same solution, e.g., $x + 1 = 3$, $2x - 1 = 3$.
   Take alternate moves. Start with one equation. Each player does one operation and puts one bottle top in the team's tin to signal to the other team for their turn to play. You are not allowed to play if you have used up your bottle tops. The aim is to change one equation to the other with a minimum number of moves.

	e.g. $x + 1 = 3$
subtract 1 from each side,	$x = 2$
multiply each side by 2,	$2x = 4$
subtract 1 for each side,	$2x - 1 = 3$ (3 moves).

3. The winning team is the one that takes the fewest moves. Points will be awarded as follows:

winning team	2 points
draw	1 point each
losing team	0

4. Team-mates are allowed to confer after each game.

Comments:

This activity creates an atmosphere where group effort is encouraged. It is essential that you stress that students must surrender a bottle top after every move and that they must not talk to each other. If students were allowed to play as many times as they want, it would allow the more able students to dominate the game and solve the problem without helping the weaker students. Students will discover that it is not possible for the team to leave all the work to the able students as they will run out of bottle tops before the game is over. It is necessary for team-mates to help each member understand the material for the team to win the game. You can let the teams play 5 or more games, and making the problems harder each time, for example,

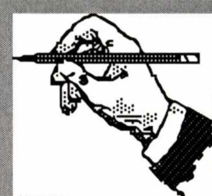
$(3x + 4)/ 3 - 1 = 1$

and $(6x + 3)/7 + 3 = 4$.

The winning team is the one with the highest points. You can reward the winning team by displaying the results on the notice as the team of the weak or give each member a ball-point pen or any small gift.

Points to ponder

- If you were to try these activities with your class, what are some of the changes that you would make to suit your situation? Explain your answer



- After trying the activity with your students, what were some of your experiences?

Activity 5: Mini–Jigsaw

• Teacher writes the six clues to the problem on cards or small pieces of paper. Write the clues carefully so that it is necessary to have all the clues to solve the problem. The statement of the problem to be solved should appear on only one of the cards (see cards below).

Card 1	Card 2	Card 3
The number has exactly two divisors besides itself and 1.	The number has 2 digits. The number is greater than 20.	The digit on the right is bigger than the digit on the left.

Card 4	Card 5	Card 6
The digits of the number add to 10	The number is less than 100	The number is even

• Place the clues into an envelope.

• Each team should receive one envelop, and each member of the team receive one clue.

• From the clues, teams must solve the problem. However, the only way to solve the problem is to have the team work co-operatively. Students may read their clues to each other but may not show each other the written clues.

Comments:

This problem can be solved by teams of 6. If for some reasons you prefer teams of 5 members, just give two clues to one member. Students will realise that co-operative skills are essential for them to solve the problem. It is essential that you stress that students can only talk about what is on their card, but they must not show their cards to team members. If students were allowed to see other clues, it would allow the more able students to dominate and solve the problem without consultation. Another example of a min–jigsaw problem is given below:

Card 1 Eight friends came to the party two at a time, but no one arrived with someone whose name rhymes with their own

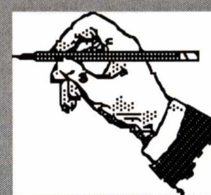
Card 2 Fern arrived after both Vern and Doris. Who came with Horace?

Card 3 Nat and Pat both arrived before Horace.

Card 4 Pearl and Merle both arrived before Nat and Vern.

Points to ponder

- Create your own mini–jigsaw.
- Try it with your class.
- Write a report about how it went.
- You can present your report to the workshop



Activity 6: Project

• Teacher asks each group to conduct a survey that answers a question or deals with an issue of interest to students.

• Teacher gives guidelines to students as follows:

- Decide on what you want to find out as a group.
- What sort of data are you going to collect?
- What type of graphs and statistics are you going to use to display your data?
- What have you discovered from your data?
- What would you like to do next to follow up on your ideas?

• Each group will present a report of their findings to the class.

Comment

Co-operative skills are essential for groups to accomplish the task. Members of the group must negotiate a topic that is of interest to all members of the group. Individuals may have to be working on their own some of the time to collect different pieces of data for the group.

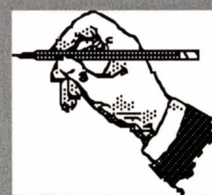
Some of the things that can be investigated include:

1. Students may decide to watch each person during study time for 2 minutes, counting the number of times the person looked up from whatever he or she was doing (the idea being that the people who looked up more were concentrating less, probably). Students can then find out whether male students or female students had better concentration when they are studying. Students could introduce many variations on this. For example, whether concentration was better or worse on days when the students had a particular meal in the dining room, or on days when they had sports and so on.

2. Students could investigate the interaction pattern of the teacher with boys and girls. They could record the number of times the teacher talked to a boy or a girl and find out whether the teacher interacts with one sex more than the other. More variables can be explored. For instance, who initiated the talk? How many of the talks were about mathematics? How many on discipline? and so on. Surprising results can come out of the study and it will be fun for both the teacher and the students.

3. Students can investigate a mathematical topic of their choice, Quadratic Equations for example. They could read from the library about the historical developments for Quadratic Equations, uncover the mathematicians who were instrumental in the development of the Quadratic Equations and investigate how the knowledge of Quadratic Equations is being utilised in the present world.

Points to ponder



- Have you ever asked your students to do a mathematical project? If so, was it done individually or in groups?

- If no, can you see yourself adopting such an approach in your mathematics class? Why?

- How would you use the information collected from students' projects?

- How would you mark projects done in groups?

- What do you consider are the constraints/benefits of giving co-operative projects to students in mathematics?

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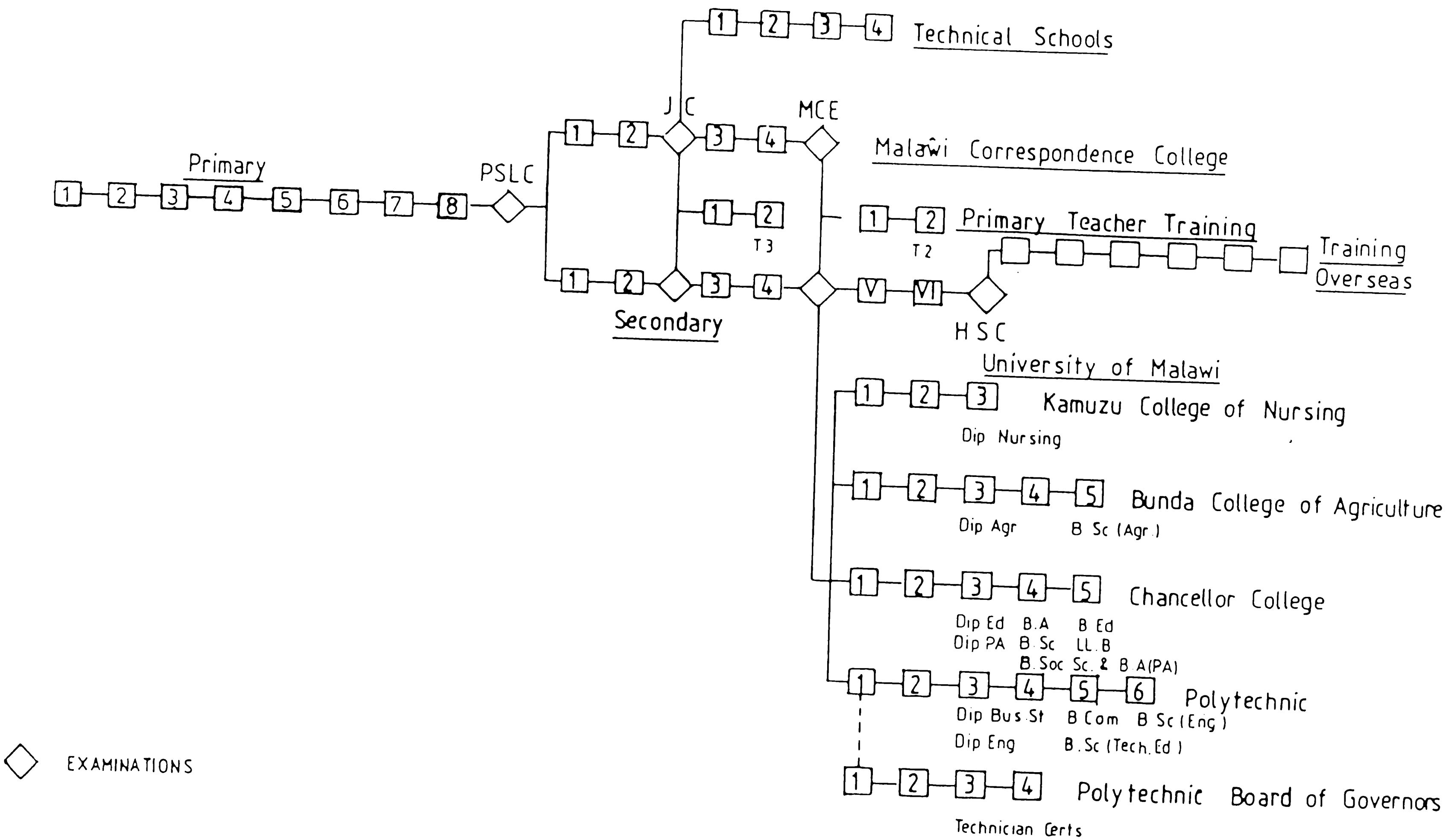
APPENDIX C

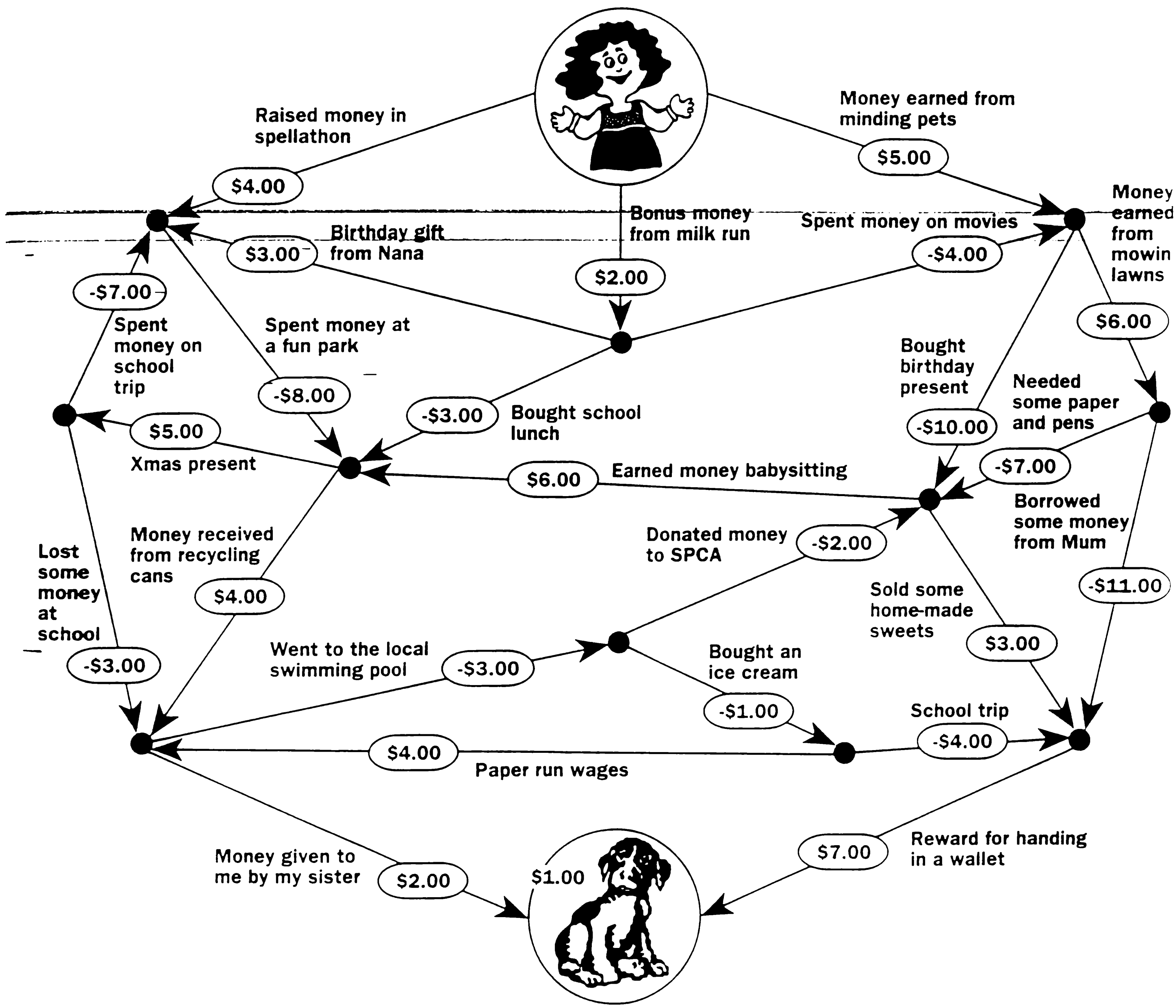
STRUCTURE OF EDUCATION SYSTEM IN MALAWI

STRUCTURE OF THE EDUCATION SYSTEM



APPENDIX D

CAN SARAH BUY THE PUPPY?



TASK
As a group, find the path where Sarah ends up with the greatest amount of money. Mark with a pen the path you chose. You have 20 minutes to find the path. After solving the problem, develop a list of skills you all used to solve the problem.

ROLES

You have the problem to solve as a group. As well as assisting one another in solving the problem you have the following role to play:

RECORDER:	Writes down decisions or discussion made by the group during the activity.
CHECKER:	Checks that the group is keeping to the task and time allocated.
REPORTER:	Organises information during the activity to report back to the whole group.
ENCOURAGER:	Makes sure everyone participates and provides positive feedback on their actions.

Notes for facilitator

Attach the 'task' without roles to one group and the 'task' and 'roles' to the other group.

Upon completion explain the differences between the two sets of envelops and discuss as a whole group:

APPENDIX E

ETHICS APPLICATION

CSMTER No.:

THE UNIVERSITY OF WAIKATO

APPLICATION TO THE SCHOOL OF SCIENCE AND TECHNOLOGY HUMAN RESEARCH ETHICS COMMITTEE

Research: **Teaching:**

Attach an agreed research design proposal, to which this application refers, signed by both supervisor and the applicant.

NB: This application must be in type (**not** handwritten).

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1. (a) **Name of applicant**: Catherine Panji Chamdimba

   (b) **Staff/DPhil/MPhil/MEd/MSc/MCMS/Directed Study/Other :DPhil**

   (c) **Course No.**

   (d) **Department:** Centre for Science, Mathematics and Technology Educational Research

   (e) **Phone number:** extention 8924

   (f) **Qualifications and Experience** (first applications only):

   MA (Mathematics Education), BSc (Hons), BEd

   (g) **Other personnel involved** (including titles and roles):

   Dr. Andy Begg, chief supervisor (July 1998-July 2000)
   Dr. Ken Carr second supervisor (July 1998-July 2001) & chief supervisor (2000-2001)
   Dr. Fred Biddulph second supervisor (July 2000-October 2002

2. **Title of Project:**

   Cooperative Learning: A possible strategy for improving Girls' achievement in secondary school mathematics in Malawi

3. **Description of Project:** (Describe the project using the following headings):

(a) **Justification (in terms of the relevance or importance of the knowledge gained)**:

The outcomes of the proposed research are expected to make a contribution to the long-term goals of improving the performance of girls in Malawi as well as to international theories of gender and mathematics.

(b) **Objectives:** To explore the effect of cooperative learning on the girls learning of mathematics.

(c) **Procedure for recruiting participants and obtaining informed consent. Attach a copy of information and consent forms if applicable. (NB: Information and consent forms should be on separate sheets).**

Permission from the Malawi Minstry of Education, Science and Technology, Headmaster/mistress of the school, teachers and students will be sought

(d) **Procedures in which research participants will be involved:**

The teacher(s) will be teaching the normal content but they will be expected to change their teaching strategies so as to include cooperative learning. The students will be engaged in their normal class activities but they will be expected to work cooperatively. The students will be expected to write journals. The teachers and students will be interviewed. The classes will be observed and the researcher will take field notes.

(e) **Procedures for handling information and materials produced in the course of the research:**

All data from students' journals, questionnares and field notes will be coded, analysed and written up as a part of PhD thesis. Interview tapes will be transcribed onto computer discs which will be destroyed after five years. Students' journals, field notes and questionnares will be destroyed after five years of thesis writing.

4. **Ethical Concerns:** (Outline ethical concerns and proposed solutions under the following headings):

(a) **Access to participants:**

Researcher will have access to students only in school and during the period of research

(b) **Informed consent**: An explanatory letter will be given to participants seeking their permission to be part of the research. Participants will be given opportunity to ask questions/clarifications before signing the consent slips. Teachers' permissions will be accepted in the place of the parents' permission because this is culturally appropriate and because the teachers are "in loco parentis" in the boarding school.

(c) **Confidentiality:**

Anonymous coding for the participants' work will be used.

(d) Potential harm to participants: No harm to participants is anticipated, instead, the research is likely to be beneficial to them.

(e) Participants right to decline: No participant will be forced to take part in the research if s/he is not willing, and any participant can withdraw at any stage and take their data with them.

(f) Arrangements for participants to receive information:

Participants will be given written information about the aim of the study. A brief (about one page) summary of the findings will be communicated to the school

(g) Use of the information: Data collected will be used for PhD thesis and related papers.

(h) Conflicts of interests*: None

(i) Other ethical concerns relevant to the research: None

* These can arise from various sources, eg through the professional relationship of the applicant to participants, through the source of funding of the research.

Ethical Statement

The applicant(s) should attach a statement on the basic ethical principles which will guide them in their research and to which they formally commit themselves. These may include codes of conduct or generally recognised statements from within a discipline or professional association. This statement should specify which principles of the codes of ethics apply to the research, and detail how the applicant(s) intend to follow, abide by, or apply them in the application of the research.

Rights of participants

The rights and interests of the participants will take precedence over the researcher and the reseach.

The researcher will ensure that the use of the collected information does not exploit the individuals concerned.

Legality and sensitivity

The purpose of collecting data and the collection method will be lawful, ethical, socially and culturally sensitive

Care will be taken to ensure that any form of harassment does not occur in the course of the data collection or any other part of the research.

Data collected

The purpose for collecting data, the name and address of the researcher, and the uses for which it is collected will be totally disclosed to the individuals from whom data is being collected.

As far as possible, no unnecessary personal data will be collected.

Data collected will be confidential and held securely.

The individuals shall be entitled to have access to any information given by them.

The school shall be given a summary of research findings.

5. **Legal Issues:** (Outline legal issues which may arise in the course of this research).

(a) **Copyright:** The researcher will have copyright on the thesis and any papers from it.

(b) **Ownership of data or materials produced:** The participant will own all the data but the researcher will own all the analysis of the data

(c) **Any other legal issue relevant to the research:** None

6. **Where the research will be conducted:** Malawi for collection of data, New Zealand for preparation and writing up.

7. **Has this application in whole or in part previously been declined approval by another Ethics Committee:** No

8. **For research to be undertaken at other facilities under the control of another Ethics Committee, has an application also been made to that Committee:** Not applicable

9. **Is any of this work being used in a thesis to be submitted for a degree at The University of Waikato:** Yes.

10. **Further conditions:**

In the event of this application being approved, the undersigned agrees to inform the Human Research Ethics Committee of any change, subsequently proposed.

Signed by the applicant:

Date:

Signed by the supervisor:

Date:

Signed by Chairperson of Department

Date: ....

The ethics application may proceed./The ethics application requires further work

Signed on behalf of the Committee: ....

(Chairperson of Committee)

Date:

APPENDIX F

QUESTIONNAIRE: STUDENTS'SURVEY OF COOPERATIVE LEARNING

This term, we have been learning using cooperative learning approach. We worked in small groups most of the times, working together, helping each other and learning from each other. I would like you to answer the following questions so I can find out what you think of this different way of learning.

1. Personal information
Name: ____ Sex: __________

Class: _____________________

2. Do you enjoy working in small groups? _________________________

3. If we use groups, how many people do you think there should be in a group? _________ Please give some reasons
____
____
____
____

4. Would you prefer to work in a girls only/boys only group or in a group of mixed boys and girls? _________________________________
Please give some reasons
____
____
____
____
____
____

Use the key below to answer questions 5 – 15. Please circle only one letter that best describe your feelings.

A (not at all) B (a little) C (sometimes) D (usually) E (always)

	A	B	C	D	E
5. During discussions I suggested an idea for the group to discuss.					
6. When we were discussing, everyone was given a chance to suggest something					
7. No ones' idea was ever just ignored – we talked about them all.					
8. My group found it hard to get started					
9. People in my group just wanted to try their own idea.					
10. Usually everyone just did their own thing					
11. I felt I could ask for help from my group when I was not sure.					

12. Rank the school subjects that you are taking according to your preference, starting with the most favourite. eg If Geography is your most favourite subject then you would rank it as 1st. Give reasons why you like the subject you have ranked 1st and why you like least the subject you have ranked last.

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