

Science and Mathematics Education Centre

Equity and Reform in Mathematics Education

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ABSTRACT

This study focused on two themes which have recurred in education since the 1980's: equity of educational outcomes for all students and reform in mathematics education. The problem addressed in this study concerned the apparent inability of large-scale reforms to meet equity goals. The purpose of the study was to increase understanding of this problem from both theoretical and practical perspectives. The study was influenced by feminist perspectives in the choice of theoretical framework and methodology. Focusing specifically on gender equity, the study was set in the context of a large-scale reform in the USA, Ohio's Statewide Systemic Initiative, *Project Discovery*.

There were three major objectives in this study. First was to synthesise the literature concerning gender equity in mathematics education to produce a definition of the ideal Connected Equitable Mathematics Classroom (CEMC). There were two parts to the literature review: one concerning explanations for observed gender differences in mathematics education, and another concerning initiatives implemented to try to bring about gender equity in mathematics education.

The second objective was to use the definition of the ideal CEMC, derived from the literature, to determine the extent to which reform had occurred in mathematics classrooms in Ohio. This was accomplished through the analysis of quantitative data collected from a random sample of teachers and principals across the state, and qualitative data collected from seven case study sites.

The third objective was to determine the barriers to and facilitators of the realisation of equity goals in middle-school mathematics classrooms involved in *Project Discovery*. This was accomplished through a cross-site analysis of data collected at the seven case-study sites, with the analysis framed around the characteristics of the CEMC.

The outcomes of the study are set out in terms of these three objectives, culminating in a discussion of the implications and challenges which the findings of this study pose for researchers, reformers, equity advocates and practitioners.

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CHAPTER ONE

INTRODUCTION AND OVERVIEW

INTRODUCTION

The study reported in this thesis focused on two recurring themes prevalent in educational research during the past two decades. The first theme concerns equity of educational outcomes for all students. The second concerns the efforts to reform mathematics education (e.g. through the implementation of national standards in the USA) not only by addressing inequities in the system, but also by modernising the curriculum, enhancing students' conceptual understanding, and making use of modern teaching aids such as computers and graphic calculators. This study examined the relationship between these two themes and the extent to which they are interlocked, building on major recent work by researchers trying to understand the forces that drive the reform process (e.g. Fullan, 1993a; Hargreaves, 1994), and on the very few studies that have examined the relationship between equity and reform in mathematics education (Knapp, Shields, & Turnbull, 1995; Silver, Smith, & Nelson, 1995). Previous research has indicated that although equity is at the heart of many reform efforts (Hargreaves & Fullan, 1992), large-scale reforms appear to be unable to meet equity goals (Apple, 1995; Secada, 1995; Grant, Peterson, & Shojgreen-Downer, 1996). The study reported here has addressed this major emerging problem. It aimed to increase understanding of the problem from both theoretical and practical perspectives, conceptualising explanations for the problem and suggesting practical solutions.

This research has been influenced by feminist perspectives who, like Marshall (1997), raise questions about the "white male dominance" (p. 1) of curriculum areas such as mathematics and about the ways in which social constructions of gender and of mathematics "limit and constrain human possibility" (p. 2). More specifically, this influence is evident in the choice of theoretical framework for the literature review, in the choice of a more qualitative approach to identifying issues, in ensuring that the voices of teachers and students

are heard, and in acknowledging the integral nature of socio-cultural influences on teacher and student behaviour in the classroom.

Consistent with this approach, the study paid particular attention to Secada (1995) who suggested that, to further the pursuit of equity objectives in mathematics education, researchers conducting equity-based analyses should “draw on multiple dimensions and voices, appropriate ideas as needed, and remain tentative in what is counted as central to the field” (p. 161). Further, because the impact of reform policies in the classroom is not yet well known (Knapp, 1997, p.228), it was considered important to focus the research on mathematics classrooms so as to better understand the implications for teaching and learning.

Thus, the purpose of this study was to explore the relationship between equity and reform as it occurs in the mathematics classroom. The specific focus was on gender equity in the context of a particular large-scale reform, namely the Statewide Systemic Initiative (SSI) implemented in Ohio USA during the period 1991 to 1996. In order to explore the equity/reform relationship, a number of broad questions were formulated within each of the two themes referred to above. In relation to the first theme (interpreted as equity of outcomes for all students in mathematics education) a major task for the study was to establish what is known about gender equity in mathematics education. Within this theme, questions focused on how to define equity in mathematics education, how equity objectives are operationalised in a classroom, and what is known and not known about achieving equity objectives in a classroom. In relation to the second theme—namely, reform in mathematics education—a major task for the study was to establish what is known about such reform. Within this theme, questions focused on the impact of both small- and large-scale reform initiatives on student outcomes, and on the identification of the facilitators and barriers to implementing reform in a mathematics classroom. Answers to these questions led to the identification of further gaps in knowledge about the interaction of equity and reform objectives, and to the formulation of ideas and suggestions in relation to the problem which was central to this study, namely the need to preserve equity goals in reform efforts.

This chapter provides some preliminary background in relation to each of the two recurring themes and their subsidiary questions. It begins by describing what is known about inequitable patterns of performance and participation in mathematics education. It then goes on to describe the history and context of reform, both in general, and, more specifically, in the Ohio SSI, which forms the

context for this study. This leads to a description of *The Landscape Study*, the evaluation of the Ohio SSI which provided the data used in the study reported here. Next, the specific objectives of the study are stated and the way in which each of those objectives was accomplished is outlined. The chapter concludes with a short discussion of the validity and reliability of the study, and the significance of this research.

EQUITY IN MATHEMATICS EDUCATION

History of Gender Equity Research

Concern about equity in mathematics education has been expressed in the literature for at least 30 years. Differential patterns of participation and performance for males and females were noticed prior to this—studies of educational achievement in the USA have reported gender differences in achievement in mathematics dating back to the early 1900's (Leder, 1992)—but these differences tended to be seen as unproblematic until the rise of the women's movement in the 1960's. Up until the mid-1960's the channeling of girls into a limited range of educational pathways that would suit their stated "preference" of careers: nurse, teacher, secretary or home-maker (Sadker & Sadker, 1994) was still widespread. In 1972, the Title IX legislation made it illegal to discriminate on the basis of sex in any program that received federal funding. Although this legislation originated because of disparities in funding between male and female sporting programs, it became widely used in the 1970's and 1980's as a way of giving impetus to efforts to broaden girls' education and make it more equitable. Thus, as noted by Weiner (1994), serious research into gender-based equity problems was not undertaken until gender was problematised as an educational issue, giving rise to contemporary research on gender differences in mathematics learning. The focus of some of this previous research was on documenting facts about existing inequalities through the investigation of enrolment and achievement patterns. A summary of such research is reported in this first chapter focusing on studies which identified differential patterns of performance and participation of males and females in mathematics education, particularly those which were relevant to the USA-based context of this study.

Gender Differences in Performance

Initially, interest in gender differences in mathematics performance was purely in gathering and synthesising information about existing inequities. A number of ground-breaking synthesis or meta-analyses of literature are discussed first in this section. Next, large-scale international comparative studies, starting with the First International Mathematics Study (FIMS), are reviewed. This section concludes with an analysis of recent trends in performance data overall.

Ground breaking synthesis

The research of Maccoby and Jacklin (1974), particularly their synthesis of studies about sex differences in achievement, is generally recognised as ground-breaking in this area. Maccoby and Jacklin studied not only quantitative and spatial tasks, but also verbal abilities. Although they noted the direction of any sex differences found, their analysis pre-dated meta-analytic techniques. They concluded that sex differences on quantitative and spatial tasks were fairly well established, and usually appeared in adolescence. Their findings were subsequently challenged (Hyde, 1981) when their evidence was re-examined and it was found that of all the quantitative studies used in the Maccoby and Jacklin comparisons, 47% showed no difference between males and females, 11% showed females to be superior and 42% showed males to be superior, thus questioning the educational significance of the finding that “males were superior on quantitative tasks”. It was noted (Willis, 1989b) that all of the studies used in the Maccoby and Jacklin analysis were done in the 1960’s and 1970’s when previous course-taking was typically not controlled for in studies of this kind. Thus comparisons were made between groups who had different mathematics backgrounds, because typically females studied fewer advanced mathematics courses in high school than males did. It is hardly surprising, therefore, that differences in males’ favour were found when comparing males with females without taking into account their differing mathematics backgrounds. The first clear demonstration of the effect of previous course-taking was provided by Fennema and Sherman (1977; 1978) whose research, along with all of the other theoretical explanations put forward in the literature to account for observed gender differences in outcomes, will be discussed further in Chapter Two.

Meta analyses

Two important meta-analyses of research were completed in 1989. Friedman (1989) examined sex differences in achievement on mathematical tasks,

including ninety-eight studies conducted over the period 1975 to 1987 covering all grade levels from elementary to pre-college. Effect sizes were calculated for each study and the weighted effect size, using the random effects model, was found to be -0.024, with the confidence interval covering zero. Given that this value is not educationally significant, she concluded that the average sex difference was very small. When the Maccoby and Jacklin (1974) studies were compared to this meta-analysis, Friedman concluded that sex differences in performance had decreased over the years.

A second meta-analysis (Linn & Hyde, 1989) synthesised research from many areas associated with science and mathematics education. Linn and Hyde split the literature into pre-1974 and post-1974 sections because they considered the Maccoby and Jacklin study, conducted in 1974, to be a turning point in the study of gender differences in achievement. They concluded that gender differences on cognitive and psycho-social tasks were small and declining; gender differences in spatial abilities were declining and amenable to training; gender differences were not general but specific to cultural and situational contexts; gender differences in cognitive processes often reflected differences in course enrolment and training; and gender differences in height, physical strength, career access, and earning power were much larger and more stable than gender differences on cognitive and psycho-social tasks.

Large-scale international studies

During the past thirty years, a number of large-scale comparative studies of mathematics achievement have been conducted internationally. In 1964, the International Association for the Evaluation of Educational Achievement (IEA) conducted the First International Mathematics Study (FIMS) (Husen, 1967) in twelve countries. After the results from all countries were combined at all age groups, and allowances were made for differing levels of mathematics instruction, the study found differences in favour of males in forty of the forty-two comparisons made. The differences increased with age, but varied across countries. Because sex differences were shown to be greatest in those countries with greater proportions of single-sex schools, these variations were hypothesised to be linked to the distribution of single-sex and co-educational schools. Generally, males in single-sex schools performed better than males in co-educational schools. However, females in single-sex schools performed better than their counterparts in co-educational schools only at age thirteen. Females in

co-educational schools at the pre-university level were superior in mathematics performance to their single-sex school counterparts.

The Second International Mathematics Study (SIMS) was conducted between 1980 and 1982 and involved twenty countries (Robitaille & Garden, 1989). The SIMS used only multiple-choice items, including some from the FIMS. At age thirteen, females outperformed males in four countries, while the reverse was true in nine other countries. Analysis of these results in terms of content found that boys tended to do better on transformational geometry, proportional thinking and standard units of measurement. All of these differences were attributed to differing background experiences of males and females: males tend to have more experience in these types of activities. Females generally performed better on computational tasks, fractions and algebra. However, no link was made between females' higher performance on these tasks and their background experiences (Robitaille & Garden, 1989).

The Third International Mathematics and Science Study (TIMSS) collected data in 1993 and 1994. At the time of writing this thesis, preliminary results had been reported. Australia and the USA were among only eleven countries out of 45 in which there were no significant gender differences in both mathematics and science at the eighth-grade level (Locan, Ford, & Greenwood, 1996; US Department of Education. National Center for Educational Statistics, 1996).

In addition to the IEA studies, the International Assessment of Educational Progress (IAEP) study was first conducted in 1988 (Gipps & Murphy, 1994). It used some of the items from the USA National Assessment of Educational Progress (NAEP) instruments. In contrast to some other international and national studies, the IAEP study found that males and females were performing equally at ages ten and twelve in the countries assessed. A further analysis (Keys & Foxman, 1989 as cited in Gipps & Murphy, 1994) found that females outperformed males in these age groups, although not significantly.

The second IAEP mathematics survey was conducted in 1990 in twenty countries. This time there were nine- and thirteen-year-old subjects in the study, and mathematics educators from a number of countries submitting items for inclusion in the tests (Gipps & Murphy, 1994). Although there were very few differences found in the nine-year-old age group, in seven countries males outperformed females. The largest differences were found in the nine-year-old group for procedural knowledge of number, with females outperforming males;

and in the thirteen-year-old group for measurement, with males outperforming females.

Large-scale national studies

In Britain and the USA, a number of large-scale national studies of mathematics achievement have also been conducted.

In Britain, the Assessment of Performance Unit (APU) conducted tests with students aged 11 and 15 over the period 1978 through 1987 (Foxman, Ruddock, & McCallum, 1990). In the first phase of their work, from 1978 to 1982, the APU found significantly more males than females in the top 20 per cent of attainers in the Concepts and Skills sections on the tests they administered. They also found males performed better on measurement questions, and females performed better on computation and on some aspects of algebra. In the second phase from 1982 to 1987, some important changes were noted: the female advantage in computation had disappeared at age 11; the gap in favour of males in Concepts and Skills had widened; and, at age 15, males had significantly higher scores in all concepts and skills areas except Modern and General Algebra.

In the USA, National Assessment of Educational Progress (NAEP) surveys have been conducted for a number of years. Mathematics has been assessed seven times since 1973. Samples used in NAEP surveys are representative of the whole USA, unlike other large-scale tests such as the Scholastic Aptitude Test (SAT) in which populations are self-selecting. There are two forms of information about performance available from the NAEP surveys. One concerns the general level of performance, which is scored over a 500-point scale. The other concerns performance on various subscales which refer to specific content areas and mathematical thinking skills. The content areas tested are numbers and operations, measurement, geometry, data analysis, statistics and probability, and algebra and functions. Mathematical thinking skills tested are conceptual understanding, procedural knowledge, and problem solving (National Science Board, 1996).

The NAEP studies are reported by the National Science Board (the governing board for the National Science Foundation in the USA) which reports to congress and is a policy advisor to the President. In its 1996 publication, *Science and Engineering Indicators* (National Science Board, 1996), the National Science Board found that over the period of NAEP studies since 1973, males have consistently outscored females in the 17-year-old age group, although the differences have been declining. In 1992, the difference was five points, which

was statistically significant. In the 13-year-old group, no differences in performance were found in 1992, as had been the case for the previous assessments. In the nine-year-old group, males slightly outscored females in 1992, with only a barely significant 3-point difference. Again, this trend had been evident in previous assessments. Looking at the various proficiency levels, the differences between males and females appeared only at the highest proficiency level, perhaps reflecting differing levels of participation in the highest levels of mathematics courses. In the 1990 and 1992 assessments, content and skill subscales were introduced. In 1992, twelfth-grade males outscored females on the measurement, geometry and estimation skills subscales. These differences, although statistically significant, were not very large. No significant differences in performance on content or skill subscales were found at the fourth- and eighth-grade level. In the 1996 assessment, males outperformed females in all age groups tested, and for the twelfth-grade group the differences between males and females were not significantly different from the 1973 results (Reese, Miller, Mazzeo, & Dossey, 1997).

Summary

Of the many studies investigating gender differences in achievement, the foregoing are the largest, and they provide enough information to make some broad generalisations. It appears that the earlier a research study was conducted, the more likely it was to find differences favouring males. Between-group differences were often small, and there were large within-group variations. Also, differences favouring males have tended to occur after age 13, and mainly in spatial or measurement items. Differences favouring females have tended to occur in computation and algebra items. It is of interest that Leder (1992), in her comprehensive review of studies undertaken between 1978 to 1990 investigating achievement in mathematics, reached similar conclusions. Specifically she found that between-group gender differences in performance were small and had been declining over the period reviewed. Further, the differences varied across time, content, and country, and could not be entirely explained in terms of any one factor. Leder concluded that the interaction of multiple factors would have to be considered when looking for explanations, a conclusion which was one of the important starting points for this study.

Gender Differences in Participation

In 1993, the International Commission on Mathematics Instruction (ICMI) hosted a conference in Sweden entitled "Gender and Mathematics". Presenters from around the world gathered to discuss the "... well-documented world-wide gender imbalance in mathematics learning and mathematics-related careers" (Hanna, 1996, p. 1). The book which resulted from this conference, *Towards Gender Equity in Mathematics Education*, includes sections from writers in Sweden (Grevholm, 1996), Norway (Hag, 1996), Finland (Finne, 1996), Germany (Niederdrenk-Felgner, 1996), France (Adda, 1996), England and Wales (Smart, 1996), Australia (Gafney & Gill, 1996), and New Zealand (Clark, 1996); all of whom provided data showing that there were far fewer females than males enrolled in advanced mathematics courses at the pre-university level in each of their respective countries.

These studies were by no means the first to document the gender imbalance, favouring males, in enrolments at the pre-university level in mathematics. The 1964 FIMS study found differential participation rates favouring males in pre-university-level mathematics courses in all twelve countries. The ratio of males to females varied from as much as 7:1 to 2:1. In 1982 the SIMS found that the pattern of enrolments in pre-university mathematics courses had changed for nearly all countries, with an increase of female enrolment relative to the previous findings in all countries except for Japan, where the relative number of females participating in these courses had further declined.

Enrolment patterns in secondary school mathematics courses have been exceptionally well documented in Australia (Australia. Department of Employment Education and Training (DEET), 1991; Dekkers, deLaeter, & Malone, 1991; Parker, 1992; Parker, Thomson, & Tims (Goodell), 1993). Generally in Australia, it has been clear that as soon as the study of mathematics is no longer compulsory (usually at Year 11) females choose not to enrol further in the more challenging mathematics subjects. In Western Australia a recent curriculum change in 1992, which had as one of its major aims to increase the number of females taking more advanced mathematics, did not alter the balance of male/female enrolments in *Calculus*, which is the most academically challenging of the mathematics subjects offered at Year-12 level. The ratio of males to females in *Calculus* has remained constant at approximately 2:1 for the last 20 years (Parker, 1984; Parker, et al., 1993). Figures for other Australian states show similar trends.

British mathematics enrolment statistics have not been well documented, but where available, show a similar trend. Gipps and Murphy (1994) for example, reported on the entries to A-level mathematics examinations, the pre-university examination, over the period of 1988 through to 1992. They found that there were twice as many male as female candidates over this period. They were unable to locate any data for mathematics for the period prior to 1988.

In the USA, the NAEP has also collected enrolment information for twelfth-graders since the 1987 assessment. Prior to that, the High School and Beyond (HS&B) study, as reported by the National Science Board, (1996) provided baseline data in 1982. These data showed that there had been a steady increase in the numbers of female students taking more advanced mathematics courses; so that, by 1990, no gender differences in enrolment were evident in trigonometry and calculus, although small differences still existed in other (less-academic) courses.

Summary

Although the ratio of females to males participating in higher-level mathematics courses in high school has shown some improvement, particularly in the USA, over recent years, most European nations and Australian states have not had the same success to date. As noted by Fennema (1996, p. 23), "We have come a long way. But we have a long way to go to accomplish equity in mathematics education."

REFORM IN MATHEMATICS EDUCATION

History of Reform

Large-scale educational reform has become a focus for study only in recent years (Fullan, 1993b; Schubert, 1993). Earlier reform efforts targeted various aspects of the educational system, such as science curriculum in the 1950s and 1960s (Welch, 1979), and a large range of initiatives have targeted teacher education, basic skills improvement and measurement-driven instructional improvement strategies (Knapp, 1997). Schubert (1993) provided an account of the emergence of the large-scale reform movement in the USA. He described how curriculum reform in the immediate post-war years was fueled in the USA by a great influx of ex service-men and -women, thereby broadening school and college populations considerably. Debate about what was appropriate and

necessary for this more diverse population was foremost. The next phase, through the late 1950's and early 1960's, was strongly influenced by the cold war and the government's desire to "catch up with the Russians" at all costs. The use of federal funds for education was justified on the basis of strengthening the future defense capacity.

During the 1960's the first large-scale educational reforms in the USA began to take place (Fullan, 1993b). These reforms included new curriculum materials that were thought to be "teacher proof": materials and teacher notes so prescriptive that teachers would not be able to misconstrue them. The problem with many of these programs appeared to lie with implementation. While these programs were seemingly well written and conceived, they were rarely if at all implemented as intended (Schubert, 1993). This was mainly because professional development for implementing them was virtually non-existent, leaving teachers often unaware of what was required of them, regarding their own methods as better. Thus, the 1970's saw not only a widening of reform goals to include school structures and administrative procedures, but also a heightened awareness of the need for evaluation of reforms and a monitoring of student progress through large-scale assessment.

Later, the 1980's saw the publication of *A Nation at Risk* (National Commission on Excellence in Education, 1983). This report stimulated a flurry of activity in many state legislatures and initiated much state-level reform (Schubert, 1993). The role of the state in educational reform increased, as did the calls for site-based restructuring and more local control. In some cases, these two opposing forces, namely the opposing goals of state control and local control, created a situation of confusion (Fullan, 1993a). As Fullan (1993b) pointed out, in order to allay this widespread apprehension of the change process and its possible problems and solutions, long-term studies of major reform efforts became especially necessary.

Barriers to and Lessons of Reform

Fullan (1993a) has captured the essence of forces behind educational change. His eight basic lessons highlight the inherent difficulties and paradoxes that have plagued those trying to effect reform. The lessons suggest ways to overcome these problems and make the reform process work. He stressed the need to consider his lessons in concert with one another, so that each lesson benefits from the wisdom of the other seven. The lessons are

Lesson One	You Can't Mandate What Matters (The more complex the change the less you can force it)
Lesson Two	Change is a Journey, not a Blueprint (Change is non-linear, loaded with uncertainty and excitement and sometimes perverse)
Lesson Three	Problems are Our Friends (Problems are inevitable and you can't learn without them)
Lesson Four	Vision and Strategic Planning Come Later (Premature visions and planning blind)
Lesson Five	Individualism and Collectivism Must Have Equal Power. (There are no one-sided solutions to isolation and groupthink)
Lesson Six	Neither Centralisation nor Decentralisation Works (Both top-down and bottom-up strategies are necessary)
Lesson Seven	Connection with the Wider Environment is Critical for Success (The best organisations learn externally as well as internally)
Lesson Eight	Every Person is a Change Agent (Change is too important to leave to the experts, personal mind set and mastery is the ultimate protection)

(Fullan, 1993a, pp. 21-22)

Fullan's lessons point to the need for reform to be multi-faceted and long-term. Scheurich and Fuller (1995) also emphasise many of the Fullan lessons. In their study of five reform efforts, they distilled three main points: first, hierarchical reform does not work (Fullan's Lesson 6); second, successful reforms are localised (Fullan's Lessons 5, 6 and 7); and third, everyone has to be involved (Fullan's Lesson 8).

The importance of teacher cultures in reform efforts has also been demonstrated by many writers. Elmore (1995) for example pointed out that structural reform does not work unless there are shared norms, knowledge of reformed teaching and assessment practices, and skill in implementing such practices. Elmore stressed the need for reform efforts to first focus on changing norms, knowledge and skills at the teacher level. Teachers would then be better able to develop organisational structures to suit their shared skills, expectations and beliefs.

At a more practical level, Wasley, Donmoyer and Maxwell (1995) discussed a project which instituted reforms in mathematics at a particular high school. Teachers were first given reform documents to examine closely, then required to design their own project to implement some aspect of reform in their school. The biggest barrier for the teachers in trying to implement reform was the

act of concretising the reform documents into “what do I do Monday morning”. The teachers wanted guidance but not prescriptions. Another impediment was lack of knowledge about district rules concerning high-stakes testing. In one particular district, although schools had always been allowed to set their own tests, teachers were not informed of this possibility. Other barriers included a lack of collegial support to continue reforms and a lack of materials to support reform ideas. Although there was only a small degree of resistance to reform, that resistance was thought to be worthy of consideration. Wasley et al (1995) concluded that these teachers were not so much resistant to change as “lost at sea”.

The importance of teachers to the reform process is also highlighted by Wallace, Parker and Wildy (1995), who reported the outcomes of a major curriculum reform project in high-school physics in Western Australia. The reform centred around school-based link teachers who played a leading role in the professional development activities which were central to the reform project. Wallace et al considered a number of interlocking themes which tie together issues raised in this project, including personal meaning, professional history, ownership, rewards, professional autonomy and gender. The message they distilled from this project was that to increase the influence of the education community on teaching practice, it is necessary to include teachers as partners in the curriculum reform process and delegate more authority to those teachers who are actually implementing reforms.

Fullan (1993a) also focused on the teacher as the central agent of change in education: “The individual educator is a critical starting point because the leverage for change can be greater through the efforts of individuals” (p. 12). He reminded us that systems change when there are many individuals pushing in the same direction for change, and thus the teacher is an important agent for change. Hargreaves (1992; 1994) put a slightly different focus on the importance of teachers in the change process. He pointed to the power of cultures:

...changes in beliefs, values and attitudes in the teaching force may be contingent upon prior or parallel changes in the ways teachers relate to their colleagues, in the characteristic patterns of associations. To understand the forms of teacher culture, therefore, is to understand many of the limits to and possibilities of teacher development and educational change.

(Hargreaves, 1994, p. 165)

Hargreaves proposed that there are four main forms of teacher culture in operation in schools today, the most powerful of which for effecting change is one he named “collaboration”. As he pointed out, “teachers learn from many

sources both inside and outside their own schools. But they learn most ... from colleagues in their own work place, their own school” (p.216). He argued that educational reform is not so much about changing schools and teachers, as it is about changing the culture of teaching from individualistic and balkanised to a collaborative culture which involves natural evolutionary processes and is development-oriented. He also cautioned against the bureaucratic equivalent of collaborative cultures, which he called “contrived collegiality”. These cultures are characterised by compulsory involvement, are forced rather than facilitated, are formal and scheduled, and are directed towards administrative priorities rather than teacher concerns.

From a professional development perspective, Darling-Hammond and McLaughlin (1995) pointed to the need for substantial professional development opportunities to enable teachers to “unlearn the practices and beliefs about students and instruction that have dominated their professional lives to date” (p. 597). Darling-Hammond and McLaughlin also stressed that, for professional development to be effective, teachers must be involved not only as teachers but also as learners, so that they too may experience first hand the struggle with uncertainty that they will confront their own students with in future.

From an equity perspective, Secada (1995) reminds us that barriers to equity goals being realised in reform efforts typically arise from reformers shared beliefs about and assumptions about research from an equity perspective. The urgency to implement reform has often led to a demand for equity goals to be written in such a way that ensures they can be achieved within the life of the reform project. Equity goals that cannot meet this criterion are often ignored. Teaching practices that successful teachers of students from a wide diversity of backgrounds often employ include things that are typically not considered part of mathematics teaching, and are also ignored. Secada also points out that the silencing of equity concerns can occur when

concerns about student learning are met with assurances that reform agendas will address equity, but the evidence to support such assurances cannot be seen except under the slogans that equity and excellence are compatible goals and that reform will help all students. How can anyone object to something that helps all students, without seeming irrational or biased?

(Secada, 1995, p. 157)

For Secada, the embodiment of equity goals in mathematics education reform has merely been given lip service. For equity to be achieved requires a new way of focusing the reform community on those equity goals that have been ignored and new ways of communicating these goals to mathematics educators.

As described later in this chapter, the specific project that formed the context for this thesis embodied many of the elements considered essential by Fullan; Hargreaves; Wallace, Parker and Wildy; Darling-Hammond and McLaughlin; and Secada.

Background to National Science Foundation (NSF) Systemic Initiatives

During the period 1991 to 1995, a number of states in the USA initiated content-driven, statewide-systemic reform projects. The common purpose of these reforms was to significantly improve the quality of curriculum and instruction for all children, including those often underrepresented in mathematics and science (O'Day & Smith, 1993). It was recognised that to effect such far-reaching change would require a multi-faceted approach; hence, the means by which each state approached its reforms differed widely. The NSF funded three levels of systemic initiatives: Rural Systemic Initiatives (RSI), Urban Systemic Initiatives (USI) and Statewide Systemic Initiatives (SSI). Despite their agreement on the general goals of reform, states varied in how they approached equity goals, with some states finding it difficult to even define what equity goals they were trying to achieve (Shields, Corcoran & Zucker, 1994).

The RSI program targeted those areas of the USA where there was low population density and high levels of poverty. The RSI areas were not defined by specific school districts or counties, but rather as collaborative efforts from groups that share common problems through similar backgrounds and cultures. Five counties in southern Ohio were part of the Appalachian RSI, along with a number of counties from Kentucky and West Virginia.

The USI program first identified the twenty-five urban school districts which had the largest number of school-age children living below the poverty line. All of these eligible cities received planning grants. To qualify for further funding, each city's planning group had to document the current state of their science, mathematics and technology education, and develop an implementation proposal. The three largest cities in Ohio (Cincinnati, Cleveland, and Columbus) were all eligible and did receive follow-up grants.

The SSI program was a major effort by the National Science Foundation (NSF) of the USA to bring together at the state level the most important groups in education in order to foster systemic changes that would contribute to lasting improvement in science and mathematics education across the nation. Twenty-five states, along with Puerto Rico, have been funded since the program's inception in 1991. Every program has been locally controlled, and the variety of

types of programs enormous, although equity goals have been fundamental to all (sometimes implicitly rather than explicitly). Knapp (1997) identified four underlying principles that have characterised many SSIs:

1. A major constraint on the quality of science or mathematics teaching lies in the lack of alignment among key elements of the system.
2. Better teaching of mathematics and science will result when all elements of the system that bear most directly on the classroom are aligned with challenging standards.
3. The lack of alignment is best addressed at its source—that is, at the level at which policies and structures guiding each systemic element are set.
4. Though driven by high-level policy action, systemic reform strategies are not incompatible with efforts to enhance local discretion and professionalism.

(Knapp, 1997, pp. 230-231)

As summarised by Knapp (1997), some clear patterns have emerged across a number of NSF initiatives. He found that even when reforms were designed to be systemic, their implementation was often disjointed, forcing teachers to return to what they were most familiar with. This was often not the intent of reformers. He also found that the context in which a teacher works can influence the extent to which this teacher is ready to hear the reform message. Schools with a high degree of cohesion amongst staff and collegial work practices seemed the most receptive to reform messages. In addition he acknowledged the importance of professional support networks in sustaining teachers during the implementation of reformed practices.

The Ohio SSI: *Project Discovery*

The SSI in the state of Ohio is known as *Project Discovery*. Beginning in 1991, it was resourced (over the five-year span of its first funding period) with both \$10 million in funding from the NSF, and a slightly higher amount from the Ohio General Assembly. *Discovery's* mission was to enhance the teaching and learning of middle-school science and mathematics through sustained professional development of teachers within the overall context of systemic change. In the project proposal submitted to the NSF, a major stated objective of the SSI was to “increase the level of achievement for all students, but especially for students from underrepresented groups” (Kahle & Wilson, 1990, p. 4). The project’s principal investigator continually referred to the importance of equity goals when communicating the goals of the project (see for example Kahle, 1997; Kahle & Rogg, 1996, 1997). There was also a major emphasis on learning by

inquiry and applying constructivist theories of learning to the teaching and learning of mathematics. These principles were continued throughout the life of *Project Discovery* in all of the institutes and through the formation of an “equity team” which provided additional support (through workshops) for equity principles.

The Ohio SSI was focused on the middle school years because it is then that students are filtered into the scientific pipeline (Kahle & Wilson, 1990; Oakes, 1990). Students who do not complete the necessary mathematics prerequisites in middle school are not adequately prepared to participate in higher-level mathematics courses in high school and beyond. Although there have been some improvements in enrolments in higher-level mathematics courses, Silver, Smith and Nelson (1995) pointed out that, overall, far too few students, especially females and students in disadvantaged urban communities, were adequately prepared for university if the whole pre-university population in the USA was considered.

The professional development aspects of the Ohio SSI built on work emphasising the importance of teacher content and pedagogical knowledge in influencing classroom instruction (such as that published subsequently by (Fennema & Franke, 1992; Hargreaves & Fullan, 1992), and on the reform literature presented earlier in this chapter. Further, because change is slow and “sensible professionals do not replace their strongly held views and behaviour patterns in response to fiat or the latest vogue” (AAAS, 1990, p. 211), the Ohio SSI acknowledged that a significant amount of follow-up would be required over an extended period, a point also noted by Joyce and Showers (1988).

The three broad objectives of Ohio’s SSI were as follows.

1. Initiate validated professional-development models designed to build a critical mass of teachers who are knowledgeable in content and skilled in equitable and exemplary instructional practices.
2. Develop an infrastructure to support these models and teachers.
3. Act as a catalyst for the lasting systemic reform of teaching and learning of science and mathematics.

(Kahle & Rogg, 1996)

The initial summer institutes in mathematics, life science, and physical science were offered to teachers across the state in the summer of 1992 and were aimed at grades five through nine.

The institutes were modeled on the successful course *Physics by Inquiry* developed at the University of Washington (Physics Education Group, 1990).

Conducted for six weeks during the summer, these institutes were content-based and set in an inquiry mode. A specialised “equity team” participated in many of the professional development activities, further emphasising the SSI’s commitment to equity goals. The instructors modeled inquiry teaching, Socratic questioning and alternative-assessment techniques throughout the institute. Teacher participants learned mathematics (or physics, or life science) content by inquiry during the summer. A major aim of the mathematics institutes was to assist teachers to implement the *Ohio Model Curriculum* (Ohio Department of Education, not dated) which had been developed from the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989) and *Professional Standards for Teaching Mathematics* (National Council of Teachers of Mathematics, 1991). (These mathematics education reform documents are discussed fully in Chapter Three of this thesis.) During the following academic year, six one-day “Academic Year Seminars” (AYS) were provided for participants which focused on pedagogical and assessment methods to support inquiry-based instruction and equity goals. Follow-up and feedback on individual progress, which were seen as essential to the success of the professional development program, occurred through classroom visits from academic leadership teams comprised of trained teacher leaders and university educators. Seminars given by a range of visiting faculty were also offered every two weeks. Participants could enrol for up to ten hours of graduate credit as a result of their involvement with the summer institute, AYS and bi-weekly seminars. Through the establishment of an electronic bulletin board discussion group, and the organisation of an annual *Discovery* Conference, there were also the opportunities to communicate with other teachers who were part of the SSI, and discuss ideas about implementing the strategies provided in the summer institutes and AYS. In 1995 and 1996, grade-appropriate institutes were begun in order to reach teachers at the local level. These were generally provided by previous SSI participants who had received extra training to become “Resource Teachers”. The Resource Teacher Institute (RTI) is described and evaluated elsewhere (Schnipper & Tims (Goodell), 1996). Over the five years of operation (1991 to 1996), over 4000 teachers in eighty-five of the state’s eighty-eight counties participated in *Project Discovery*’s wide variety of programs.

Although there has been limited documentation of the detailed goals of the Ohio SSI as they were implemented, frequent day-to-day consultation with the project director and intimate involvement with the activities of the project

indicated a shared vision of reformed and equitable teaching practices was held amongst the Ohio SSI staff at the host site where I was located. As also noted by Damnjanovic (1996), a focus on equity principles, inquiry teaching, and cooperative group work were central to *Project Discovery*, and these goals were emphasised at all times by instructors and project staff. In operational terms, this meant that teacher participants were encouraged to have high expectations of all students, ensure that all students had access to academically challenging curricula, and ensure that the learning environment encouraged students to construct their own knowledge through active participation. These were also major components of the CEMC as identified through the literature review and will be presented at the end of Chapter Three.

Further, one of the major goals of the Ohio SSI was to assist teachers to implement NCTM reforms, a major objective of which was to make connections between classroom mathematics and the real world. This was strongly apparent in the Academic Year Seminars (AYS) which focused on pedagogy and resources to support the new teaching styles being advocated in the institutes. A variety of teaching and assessment practices were also advocated in line with the NCTM goals. Both of these elements were identified as characteristics of the CEMC to be presented in Chapter Three.

Equity Teams that participated in the institutes ensured that teachers were well aware of potential sources of inequity in their classrooms: for example, the well-documented tendency for teachers to give more classroom attention to males, and the biases inherent in some curriculum practices and documents.

My own personal experiences contributed to the shared understanding of equity and reform goals. Some of the activities with which I was involved included:

- (i) developing (with a science educator) a four-week summer institute, known as the Resource Teacher Institute (RTI), designed to provide teachers who had already participated in a *Project Discovery* inquiry institute with the skills to train other teachers in their districts in inquiry teaching. This has been evaluated elsewhere (Schnipper & Tims (Goodell), 1996).
- (ii) evaluating a professional development activity in progress in 1995 in a small rural district, which was a pilot project for the RTI.
- (iii) attending some sessions that were part of a Mathematics by Inquiry institute, attending a number of the follow-up Academic Year Seminars (AYS) in two of the *Discovery* regions, and some of the Leadership Seminars conducted every two weeks for teachers enrolled in graduate-credit hours as part of their *Discovery*

follow-up. One of these sessions I attended was conducted by the Equity Team. The focus was on challenging stereotypes and tracking practices through role play situations where participants were assigned to a “smart” group or a “stupid” group based on their score in an unfair game in which some people had absolutely no chance to score. They stayed with this group for the remainder of the session and were treated as “smart” or “stupid” by the instructors and eventually the other participants as well. This activity demonstrated the injustice of labeling people based on some irrelevant characteristic or unfair one-off assessment, and encouraged participants to examine their own teaching in a new light.

Clearly, though, the Ohio SSI was quite deliberately not focused on curriculum development, and there was little mention, in the AYS, institutes or other events, of curriculum-related matters.

The Landscape Study

Towards the end of 1994, planning began for a comprehensive evaluation study, known as *The Landscape Study*, to assess the impact of Ohio’s SSI on teaching and learning middle-school mathematics and science. Because Ohio’s SSI operated on the premise that “systemic reform is dependent upon constant attention to equity issues” (Kahle & Rogg, 1997, p.11), the research directors decided that the site visits for *The Landscape Study* should focus mainly on schools in disadvantaged urban communities, with a high population (at least 30%) of minority students (who were mostly African American). My role in *The Landscape Study*¹ was as project manager for six months in 1995, and then as Collaborating Researcher for a further six months in 1996. *The Landscape Study* utilised a mixed qualitative and quantitative research design which involved administering questionnaires to large groups of teachers, students, parents and principals, as well as achievement tests to students. Short site visits were also made to a small number of carefully selected schools in order to conduct extensive interviews and observations. Some results from *The Landscape Study* have been reported elsewhere (Damnjanovic, 1996; Kahle & Damnjanovic, 1996; Kahle & Rogg, 1996; Tims Goodell, Kelly, Damnjanovic, & Kahle, 1997). From the science data analysis presented by Damnjanovic (1996) it would appear that SSI science teachers were considerably different to Non-SSI science teachers, with students in SSI classes reporting significantly different frequencies of

¹Because of the need to distinguish precisely the role of the writer of this thesis in *The Landscape Study*, the first person pronoun will be used at relevant times throughout the thesis.

reformed teaching practices than their Non-SSI counterparts. As will be seen in Chapter Eight, the comparison between the findings for the analyses of science and mathematics data informs the interpretations in this study, partly because of the considerable differences in the contextual factors affecting science and mathematics education in Ohio (specifically the existence of well-established standards and the mandatory proficiency test in mathematics education, neither of which were part of the science education context.)

The present study, based on data collected as part of *The Landscape Study*, used both primary data collected exclusively by me, and secondary data collected by other Collaborating Researchers. All analyses of these data reported here were conducted exclusively by me for the purposes of this study, with only data pertaining to mathematics used.

The analysis presented in this thesis describes the equity aspects of seven SSI classrooms in terms of a definition of what constitutes equity in the mathematics classroom. The definition is presented as “Steps Towards a Connected Equitable Mathematics Classroom” (CEMC) in Chapter Three. This definition was distilled from literature representing current thinking on how to achieve gender equity in mathematics education. Although it was developed after *Project Discovery* had commenced, much of the literature from which it was derived was published prior to the commencement of *Project Discovery*. Also, key members of the research team who developed the instruments for *The Landscape Study* were well versed in the equity literature. Hence, the definition of the CEMC reflected many of the goals of the Ohio SSI, and is reflected in many items in *The Landscape Study* instruments.

The wide range of qualitative and quantitative data collected as part of *The Landscape Study* was utilised in a cross-site analysis of equity- and reform-related issues identified by teachers involved with implementing the goals of the Ohio reform. In accordance with the methodology for analysing the issues associated with systemic reform proposed by Rossman (1993), issues were categorised as either Technical, Political, Cultural or Moral. The use of both broad-brush and fine-grain quantitative and qualitative data assisted in constructing an understanding of the many complex dynamics operating in those mathematics classrooms that were part of the Ohio systemic reform initiative.

SPECIFIC OBJECTIVES OF THIS STUDY

Introductory Comments

As indicated earlier, the overall purpose of this study was to investigate the relationship between equity and reform in mathematics education. Although this study focused on gender equity, some parts of the analysis of quantitative and qualitative data included issues associated with race. As mentioned previously, the site visits for *The Landscape Study* were conducted at sites where there were at least 30% minority students enrolled. It was therefore anticipated that there would be an interaction between race and gender, as had been identified in previous studies (Damnjanovic, 1996; Kahle & Damnjanovic, 1996). Further, the analysis conducted as part of this study took race/gender interaction into account, noting, as Clewell and Ginorio have pointed out, that

... causes of under representation of white women and girls in mathematics and science is not generalizable to women of color. Neither is research conducted on girls or women of one race/ethnicity or social class generalizable to those of other races/ethnicities or social classes.

(Clewell & Ginorio, 1996, p. 212)

Overall however, aspects of race reported here are restricted to those which increase an understanding of gender equity. A fully detailed exploration of race-related issues was recognised as beyond the scope of this particular study.

Three Objectives

In order to accomplish its overall aim, three specific objectives for this study were formulated:

1. To establish a detailed operational definition of gender equitable teaching and assessment practices in mathematics through a synthesis of the literature.
2. To determine, using data from questionnaires administered to a random sample of teachers and students, and data gathered during site visits, the extent to which reformed and gender-equitable teaching and assessment practices were practised in mathematics classrooms in Ohio, during the period following the initial stages of the large-scale systemic reform.
3. To conduct a cross-site analysis utilising primary and secondary data from seven case study classroom contexts. From a synthesis of the similarities and differences across sites, to develop an understanding of the facilitators and barriers to achieving equity in mathematics classrooms.

The next part of this chapter will outline the manner in which each of these objectives was accomplished in this study.

Objective 1

To establish a detailed operational definition of gender equitable teaching and assessment practices in mathematics through a synthesis of the literature.

The previous background of equity research which established a pattern of inequitable outcomes for males and females in performance and participation in mathematics education was presented earlier in this chapter. In this study, exploring explanations for previous inequities was an important first step towards defining the gender equitable mathematics classroom. Thus, in Chapter Two, a number of different theories that attempt to account for gender differences in achievement and enrolment are presented. It is noted at the outset that, for several reasons, biological explanations are not considered in this study.

Because of the variety in the perspectives of researchers working in this area, various frameworks which help to categorise and explicate the solutions offered by research are investigated and presented at the beginning of Chapter Two. The one chosen and used throughout the remainder of this study was that of Willis (1996), who framed problems of, and solutions to, gender justice in mathematics curricula within four distinct perspectives: Remedial, Non-discriminatory, Inclusive and Socially Critical. The Willis framework, which is explained in detail in Chapter Two, is integrated throughout this thesis as a guide to the analysis and explanation of equity problems and solutions encountered in Ohio classrooms.

The purpose of the literature review presented in Chapters Two and Three is to clearly define, in terms of current theories, how mathematics teachers can operationalise equity goals in their classrooms. Hence, after each section of the review, the application of the findings of that section to the ideal mathematics classroom will be outlined. The culmination of this will be presented at the end of Chapter Three as “Steps Towards a Connected Equitable, Mathematics Classroom” (CEMC).

The literature review in Chapter Two first discusses early research which equated equity problems with lack of participation: it was thought that, by encouraging females to study more mathematics, problems of performance would be solved. Student variables concerning mathematics-related attitudes and affective variables such as confidence, fear of success, usefulness of mathematics and attributional style, in conjunction with teacher and community attitudes, were

thought to be responsible for students' mathematics enrolment decisions. Three different models (Eccles, Adler, Futterman, Goff, Kaczala, Meece, et al., 1985; Fennema & Peterson, 1985; Kahle, Parker, Rennie, & Riley, 1993) which attempt to provide a coherent explanation of factors influencing learning behaviours and academic choices are discussed.

Researchers soon realised that merely increasing the participation of females would not necessarily lead to more equitable outcomes in mathematics education. Research shifted to include those variables associated with classroom learning environments. Variables that have been investigated as to their possible influence on inequitable student outcomes include differential teacher attention, differential teacher attributions, biased teaching practices, biased assessment practices and sexist curriculum materials.

In Chapter Three of this thesis the next phase of the literature review is presented. Here, many of the different types of interventions that have tried to overcome gender equity problems are discussed and analysed. The review reveals that equity-based interventions, generally localised and small-scale, have focused on three distinct areas: changing the students or their choices, changing the learning environment, or changing the curriculum. These categories correspond approximately to the first three perspectives of the Willis (1996) model: Remedial, Non-Discriminatory and Inclusive.

The culmination of Objective 1 is presented at the end of Chapter Three. The literature is synthesised into a definition of how, given current theory, the ideal mathematics classroom might appear in terms of gender equity. This definition, named "The Connected Equitable Mathematics Classroom" (CEMC), is used in the next phase of the study to judge the degree to which reformed and equitable practices were present in those Ohio classrooms selected for this study.

Objective 2

To determine, using the data from questionnaires administered to a random sample of teachers and students, and data gathered during site visits, the extent to which reformed and gender-equitable teaching and assessment practices were practised in mathematics classrooms in Ohio, during the period following the initial stages of the large-scale systemic reform.

Methodology

In order to determine the extent to which the reforms advocated by the SSI had been implemented, a large range of quantitative and qualitative data were collected by the research team as described in Chapter Four.

I was the project manager during the first round of this data collection in January to May 1995, responsible for ensuring all aspects of the data collection were carried out. *The Landscape Study* continued in 1996, collecting data from the same sources using the same instruments. During 1996, I was a collaborating researcher on the research team. Although the research team consisted of fifteen members, my role as project manager in 1995 ensured that I made a major contribution to the development of the quantitative instruments, and was the main organiser of data collection methods. I also conducted four of the eight site visits myself (I visited one site twice), and, conducted all of the analyses presented in this thesis, both quantitative and qualitative. For the cross-site analysis of the qualitative data, I used the original interview transcripts of the other three researchers and applied to those transcripts my own coding system which had been developed through my site-visit data analysis. The analysis of the qualitative data obtained from site visits, which includes interview transcripts, field notes and site-visit reports, was facilitated through the use of the qualitative data analysis software NUD•IST.

Data from only three of the five questionnaires used in *The Landscape Study* were analysed for this study. One of these, the Landscape Teacher Questionnaire (LTQ), had seven sections, each concerning a different aspect of teaching and learning. Only the first five sections were analysed for this study. The first response concerned what actually happened in a classroom (“frequency” scales) with the second addressing how important this practice was to the respondent (“importance” scales). Two separate factor analyses were carried out on these data—one for the “frequency” responses and one for the “importance” responses. Principal-components rotated-varimax factor analyses were conducted using the SAS statistical package on a main-frame computer.

Two other questionnaires were analysed for this study. First was the Landscape Student Questionnaire (LSQ) and second, the attitudinal items from the Mathematics Discovery Inquiry Test (MDIT). In the LSQ, students responded to statements about the frequency of particular behaviours or events on a five-point Likert scale. For the attitudinal items at the beginning of the MDIT, students responded to statements concerning their views about mathematics and reported their perceptions of the frequencies of certain classroom practices. All of these data were analysed by means of a principal-components rotated-varimax factor analysis using the SAS statistical package on a main-frame computer.

The mathematics achievement test used in this study was constructed from 1990 and 1992 National Assessment of Educational Progress (NAEP) public-

release items. All items were multiple-choice format, with most having three or four distracters. These tests contained items designed to measure students' performance on problem solving and conceptual thinking, and were given to seventh- and eighth-grade students in selected classes of the site-visit schools. This study employed three-way ANOVAs to investigate sex, race and group (SSI or Non-SSI) differences on this achievement test.

The qualitative data used for this study were collected during eight site visits to seven sites. It was decided to collect data at multiple sites rather than concentrating on one site for a longer period of time. This was partly due to the limited amount of time available to complete the project before the end of the school year, and partly due to the remoteness of some of the sites and the availability of researchers to conduct the site visits. The site visits involved observations of teaching situations and interviews with teachers, students and administrators. A constructivist methodology, derived in part from Guba and Lincoln (1989) was employed for the site visits. Issues pertinent to each site were allowed to surface through the interviews and observations. There were no interview protocols although each researcher used the teacher's responses to his or her questionnaire as the stimulus for discussion. Each site visit was written up as a case study; however only my own four case-study reports were included as data in the analyses reported in this thesis. The case study reports of the three other researchers were used to obtain demographic and background information about each site.

Analysis and Findings

Quantitative Data

In Chapter Five the results of the quantitative analyses are presented. Factor analysis, performed on the responses concerning the frequency of occurrence of the listed activities on the teacher questionnaire, identified one factor associated with specific teaching behaviours, one factor for the level of principal support, one factor for the level of parent support, and one factor associated with the degree of agreement with certain statements about the nature of mathematics. Factor analysis performed on the importance responses of the teacher questionnaire identified two factors associated with the specific teaching behaviours, one factor for principal support, one factor for parent support, and one factor associated with the importance of representing certain views about the nature of mathematics in the classroom. Comparisons were made between those teachers who had participated in the reform

project and those who had not, revealing that the teachers who had participated in the reform were very different to the teachers who had not participated in terms of their classroom practices, their views about the nature of mathematics, and the importance they placed on all of the factors identified in the questionnaire.

Student achievement data were analysed using three-way ANOVAs with ethnicity, gender, and teacher experience with the reform project as the independent variables. Ethnicity was included as a variable because, as indicated earlier, other research on the *Landscape* science data had found interactions between gender and ethnicity. Significant main effects were found for all three independent variables; however there were no interactions. Post hoc tests revealed that males outperformed females, Whites outperformed African Americans, and SSI students outperformed Non-SSI students. Using effect sizes, differences in performance on the MDIT between sub-groups were tested. The performance of African American females in SSI classes was found to be the equivalent of two school years ahead of their Non-SSI counterparts, while White females in SSI classes were the equivalent of one school year ahead of their Non-SSI counterparts. African American and White males in SSI classes were only marginally ahead of their Non-SSI counterparts.

The student questionnaire factor analysis identified six factors associated with reformed teaching practices and socio-cultural influences on teaching and learning in the classroom. Students in SSI classes did not report significantly different frequencies of occurrence of reformed teaching practices to their Non-SSI counterparts. However, although students of teachers who had participated in the reform did outperform their counterparts in other classes on the achievement test, males still outperformed females overall and Whites outperformed African Americans overall. Clearly students in SSI classrooms were advantaged, although the achievement gains in mathematics were not as great as those in science, where females were outperforming males, as demonstrated by Kahle and Damjanovic (1996).

The analysis of the quantitative data revealed that SSI teachers reported engaging in significantly different teaching practices compared to their Non-SSI counterparts, and their students, particularly females, were outperforming those not in SSI classes. The two groups of students, SSI

and Non-SSI, did not report significantly different levels of reformed teaching practices in the student questionnaires.

Qualitative data

In Chapter Six, the essential features of each site in terms of gender equity are distilled from an analysis of the raw interview transcripts, field notes and site-visit reports. The features of the connected equitable classroom, as presented in Chapter Three, were used to guide the analysis, with all of the documents coded with categories derived from this definition. The analysis of each site is presented separately. First, the contextual and demographic features of the site are described. Then the results of the analysis of observations of equity are presented in three sections: student interactions, pedagogy focus and curriculum. These categories were chosen to match the first three Willis (1996) perspectives as described in Chapter Three. Elements of the teachers' personal responses to the LTQ are also included in this analysis.

Objective 3

To conduct a cross-site analysis utilising primary and secondary data from seven case study classroom contexts. From a synthesis of the similarities and differences across sites, to develop an understanding of the facilitators and barriers to achieving equity in mathematics classrooms.

The cross-site analysis undertaken in this study was conducted using the methodology of Rossman (1993). As will be discussed in Chapter Four, Rossman outlined eight stages in the process of cross-site analysis. She also proposed a framework, consisting of four dimensions, for understanding the issues involved in systemic reform. These were named the Technical, Cultural, Political and Moral dimensions.

For the analysis conducted in this study, all interview transcripts and field notes were entered into the software, with all issues identified in those documents coded under one or more of the four Rossman dimensions. Thus, in Chapter Seven of this thesis, the culmination of the cross-site analysis is presented in the form of a discussion of each of the issues identified as either Technical, Cultural, Political or Moral. Technical issues include professional development, provision of resources, teacher support networks and teacher awareness of equity issues. Cultural issues include parent support, teacher attitudes, student attitudes and school culture. Political issues include principal support, teacher control over the curriculum and proficiency tests. Moral issues include tracking and resources.

The final section of Chapter Seven proposes a further dimension to the Rossman framework, that of personal philosophies of teaching and the ethic of caring. It was found for example that in many instances where teachers were facing barriers, a personal philosophy of teaching, based on the ethic of caring, enabled these teachers to overcome technical and cultural obstacles to implementing equity and reform objectives in the classroom.

The final stage of this study is presented in Chapter Eight. In this chapter, a synthesis of all of the results is presented, followed by a discussion of the implications of these findings for systemic reformers concerned about meeting equity objectives. The chapter concludes with a discussion of the future challenges for research methodology, equity advocates, reformers and practitioners. Major issues discussed include how to observe equity in action in a classroom, how to engage teachers fully in the process of reform, and how to ensure that equity goals are built into the whole reform process. The challenge for practitioners is presented as a descriptive “snapshot” of the ideal CEMC.

VALIDITY AND RELIABILITY ISSUES

In any study, there are issues of reliability and validity that must be considered. The complexity of this study in terms of its use of qualitative and quantitative data makes these issues particularly important to address. The more complex a study and the more human beings involved, the less likely it is that an individual researcher can control all design, implementation and analysis factors to the theoretically-desirable degree. Compromises are inevitable for political, logistical, social or cultural reasons. While every effort was made in the design, implementation and analysis of this study to make it totally rigorous, reality dictated a few compromises.

Further description of other issues and how they were addressed is provided in Chapter Four. In relation to the qualitative components of this study, issues discussed include transferability, credibility and dependability as suggested by Guba and Lincoln (1989). In relation to the quantitative components of the study, the reliability of the data collection and analysis procedures is discussed, as are validity issues related to the nature of the volunteers who participated in the SSI.

SIGNIFICANCE OF THIS RESEARCH

Many writers acknowledge that reform is essential in this post-modern age (Apple, 1986; Apple, 1995; Fullan, 1993b; Fullan & Hargreaves, 1992; Hargreaves, 1994; McKenzie, 1993; McLaren, 1989). Because many reforms involve equity (either explicitly or implicitly) it is important to develop, as this thesis has done, a clearer understanding of the essentials of equity in reform, providing valuable insights as to how to ensure gender equity goals are achieved. Although there are many effects of systemic reform, this study was restricted to what occurs in mathematics classrooms, thus providing evidence-based answers to some of the questions posed by many previous researchers.

This study has also made a major contribution towards understanding how equity objectives can be met in large-scale reform. The cross-site analysis used in this research has enabled a more complex understanding of the nature of gender equity in mathematics classrooms to be gained than would have been possible through examining individual case studies.

Through the cross-site analysis, this study has also increased the understanding of many of the issues identified by Knapp (1997). The first issue concerns how the messages of reform are transmitted and taken up by teachers; the second, how a supportive organisational culture comes into being and sustains itself; the third, how teacher professional learning pushes the reform in the desired direction; and the fourth, how effectively system-wide performance indicators could be used to judge the depth of a reform.

The study reported here is also significant because it emphasised the need to take account of the cultural and social positioning of those engaged in reform, using the Willis (1996) framework to identify the various perspectives adopted by researchers and practitioners searching for solutions to equity-based problems. The picture of the Connected Equitable Mathematics Classroom was based on research from multiple perspectives. It typifies a shift from viewing equity groups as deficient to a more complex view of all spheres of teaching and learning as requiring change if equity goals are to be achieved. Thus, the study helps to avoid the problem, raised by Secada (1995), which emanates from a tendency for questions of equity to unduly change into a focus on group differences, a focus which then legitimises the view that equity target groups are deficient or somehow worse off than the dominant group against whose performance the equity group is being compared.

At the classroom level, this present research is significant because it has provided a clearer picture of how equity goals can be operationalised in the mathematics classroom. It has provided a framework for analysing the success of such reforms, namely the detailed operational definition of the Connected Equitable Mathematics Classroom (provided in Chapter Three). Subsequent reformers will now have a clearly defined set of equity goals on which to focus the reform process from the beginning.

This study took heed of Rossman's (1993) reminder that an understanding of the complexities of systemic change, which she saw as founded on concerns about social justice and providing democratic education for all, requires syntheses of case studies which provide rich descriptions and general patterns. The results of this study and the challenges posed for future reformers and practitioners have been derived from such a synthesis.

CONCLUDING COMMENTS

This chapter has outlined the scope and focus of the study reported in this thesis. First, the research revealing inequitable patterns of participation and performance in mathematics education was presented. The chapter moved on to discuss the three main objectives of the study and the way in which those objectives were accomplished. The chapter concluded with a short discussion of the validity, reliability and significance of the study as a whole.

CHAPTER TWO

THEORETICAL FRAMEWORK: EXPLANATIONS FOR INEQUITIES IN MATHEMATICS EDUCATION

INTRODUCTION

The patterns of unequal participation and inequitable outcomes in mathematics education for males and females have been identified in Chapter One of this thesis, and the point has been made that the mathematics classroom is an appropriate starting point from which to address these inequities.

This second chapter presents a review of the literature which has attempted to provide explanations for observed inequities in mathematics education, as the first stage in identifying those elements which appear to be essential for equity in the mathematics classroom. Throughout the review, the differing perspectives on equity held by various researchers will be identified by focusing on the solutions posed by each researcher. These solutions will be integrated into the definition of the Connected Equitable Mathematics Classroom that will be presented at the end of Chapter Three (after the second stage of the literature review), representing the culmination of Objective 1 for the study as outlined in Chapter One.

As indicated in Chapter One, biological explanations for gender differences in mathematics achievement are not considered in this study for a number of reasons. Biological explanations have periodically been prominent, especially following the research of Benbow and Stanley (1980; 1988). Benbow and Stanley posited that there was a biological basis for gender differences in achievement on the Scholastic Aptitude Test-Mathematics (SAT-M) by talented youth who were part of the Study of Mathematically Precocious Youth (SMPY). Their findings have been challenged on many grounds by numerous researchers (Egelman, Alper, Leibowitz, Beckwith, Levine, & Leeds, 1981; Stage & Karplus, 1981; Tomizuka, 1981). Studies linking spatial abilities to biological differences involving a recessive spatial superiority gene found on the X chromosome (Gray, 1981) were reviewed by Kahle and Danzl-Tauer (1991) who concluded that inconsistent interpretations had been made. Others (Ben-Chiam, Lappan, &

Hourang, 1988; Koblitz, 1996) have uncovered substantial evidence to suggest that spatial ability is not fixed, can easily be improved with training, and varies considerably across cultures. Biological explanations are strongly refuted by the majority of researchers now working in this area, not only for the reasons just stated, but also because biological explanations provide little help for educators trying to improve educational outcomes for females. Instead, this study focuses on the social, psychological and cultural explanations and centres on the mathematics classroom.

The first part of this chapter presents an overview a number of different models describing the stages of development of an equitable mathematics curriculum. Next, a model which describes four perspectives on gender justice and the mathematics curriculum, that of Willis (1996), is explicated and then used to frame a review of the literature concerning explanations for the differential patterns of participation and performance outlined in Chapter One. For the purposes of this study, the mathematics curriculum is defined as the mathematics content, teaching, and assessment methods; and the way in which the content is structured, sequenced and packaged, in some instances differentially for certain groups of students (Willis, 1996).

The remainder of this chapter reviews the literature, explaining gender differences in mathematics in three broad categories: student-related explanations, teacher-related explanations, and curriculum-related explanations. After each category, the solutions suggested by the researchers to investigated problems are synthesised into those essential features of an ideal (in the gender-equity sense) mathematics classroom. These short summaries will be presented in italics, and integrated in the definition of the Connected Equitable Mathematics Classroom (CEMC) presented at the end of Chapter Three.

TOWARDS DEFINING EQUITY: EMERGING THEORETICAL FRAMEWORKS

Fennema (1990a) suggested that there are various interpretations of what constitutes equity in the mathematics classroom. She identified three main questions that should be asked by equity researchers:

- Is there equal educational opportunity to learn mathematics (the problem of participation)?
- Are there equal educational outcomes (the problem of performance)?
- Is there equal treatment in the classroom?

Since the early 1960's, equity in mathematics education has received a great deal of attention from researchers, with the writing of many synthesising chapters and meta-analytic reviews (Friedman, 1989; Leder, 1992; Linn & Hyde, 1989) hypothesising solutions to equity problems. The sequence of this research is important because, as Fennema (1993) observed, research associated with equity and mathematics education has been undergoing something of a paradigm shift in recent years. Early research was largely objectivist and quantitative, and focused on the student. Interest focused on the participation and achievement of females in mathematics courses (Parker, 1984). Interventions focused on convincing female students and their parents that mathematics was important for their future, and that they should take more mathematics courses in high school (Fennema, Wolleat, Pedro, & Becker, 1981). The research then moved on to how students were treated in classrooms (Leder, 1990) and what socio-cultural and attitudinal differences affected females' learning (Eccles & Jacobs, 1986). More recent research uses more qualitative research methods and is influenced by feminist writers. These more recent lines of research raise different questions to those of earlier work, asking for example, questions such as "How is the curriculum involved in producing and maintaining gender differences?" (Willis, 1995a), and "How do women experience mathematics?" (Damarin, 1995) .

At the same time, feminist research has also grown in sophistication and stature (Leder, 1996), with many feminist writers subscribing to the notion of framing research from different perspectives. A Habermasian perspective was adopted by Dunne and Johnston (1994), for example, who framed their analysis of the literature around Habermas' three ways of knowing: empirical-analytic, historical-hermeneutic and critical. They identified three strands of research. The first was concerned with finding and documenting sex differences using quantitative methods. The second attempted to find explanations for the apparent differences between the sexes by appealing to biology. The third strand looked at social explanations. Their use of this three-tiered model allowed them to focus more clearly on specific types of problems and to distill messages from the solutions offered to these problems.

Other areas of research have used stages or levels to help practitioners understand how curriculum change can have a developmental nature. Banks (1995), a leader in multicultural education research, conceptualised four levels of approaches used to integrate ethnic content into school curricula. Level One was the contributions approach, where the contributions of ethnic peoples are recognised and occasionally celebrated. Level Two was the additive approach,

where certain concepts and content are added to the curriculum without any change to its structure. Level Three was the transformation approach, where the structure of the curriculum is changed in order to enable students to understand and take on different perspectives from diverse ethnic and cultural groups. Level Four was the action approach, where the structure of the curriculum is changed, and social action based on personal, social and civic problems is integral.

Equity researchers have also adopted the stage, or generations, approach in order to understand the potential benefits and drawbacks of hypothesised solutions. These methods can help to make clear the philosophies underlying the research and proposed solutions. The next section will review a number of different ways of viewing equity research.

Evolving Feminist Perspectives

Generations of feminist research have been delineated by many writers in quite similar ways. Kristeva (1981) noted three tiers of feminism: a demand for equal rights with men, an emphasis on women's radical difference from men, and a reconciliation of the first two. Noddings (1990) also used the first, second and third generation notions. In the first generation, women seek equality with men; in the second, they reject uncritical assimilation into the male world; and in the third, they critique what they accomplished in the first two generations by synthesising those accomplishments and seeking solutions from this synthesis. In another three-tiered model, Kenway and Modra (1992) used the terms "liberal", "social" and "radical" feminisms. Liberal feminism can be thought of as corresponding to Noddings' (1990) "first generation", and radical feminism to Noddings' "second generation". However, social feminism refers to a more neo-Marxist approach that seeks to deconstruct power relationships at work.

More recently, Mura (1995) used the terms "feminism of equality", "radical feminism" and "feminism of difference" to describe three types of feminism. Mura defined feminism of equality as one which demands legal and actual equality between women and men, and identifies sexual division of labour as the main source of women's oppression. According to Mura, radical feminists refuse to define themselves in comparison with men. They identify patriarchy as a social, political and economic system that oppresses and exploits women individually and collectively; sexually and economically. Feminists of difference do not wish to eliminate gender distinctions. They insist on the recognition of difference; they see women as possessors of specific knowledge, culture and experiences and the feminine as an affirmation of life.

Mura categorised the four perspectives of Kaiser-Messmer and Rogers (1994) as following one of the three trends in feminism identified in the preceding paragraph. The perspectives were

the “intervention perspective”, which locates the problem in the student; the “segregation perspective” in which the interaction between girls and boys is often the primary focus; the “discipline perspective” in which the nature of mathematics itself is problematized; and the “feminist perspective” in which a critique of the gendered nature of teaching and learning mathematics leads to an examination of the use of power and authority in the mathematics community.

(Kaiser-Messmer & Rogers, 1994, p. 304)

For example, the intervention perspective which seeks to redress the gender imbalance can be thought of as a feminist-of-equality issue. The segregation perspective can be thought of as a feminism-of-difference issue because it is acknowledged that boys and girls learn differently and should therefore be treated differently. Segregation can also be viewed from a radical-feminist viewpoint which recognises the unequal distribution of power that boys have over girls in the classroom and advocates that girls should be able to develop autonomously without reference to boys. The discipline perspective, which criticises the nature of mathematics itself as the artifact of gender imbalance and aims to change mathematics to make it more relevant to girls, can be seen as a radical-feminist argument in that mathematics, as currently conceived, is a product of men for men. The feminist perspective can be seen as a feminist-of-equality issue which demands non-sexist teaching, and the fair treatment of female and male students. Feminists of difference specify that fairness must take into account difference, and that equal treatment does not necessarily constitute equity. Radical feminists favour a pedagogy that addresses the subject of women’s oppression and liberation explicitly in the classroom. This pedagogy seeks to minimise hierarchical relations between teacher and students, empowering female students and forcing male students to give up their dominance in the classroom.

The evolution of these different feminist perspectives has facilitated the development of initiatives that attack equity problems in many different ways.

Feminist Curriculum Development Frameworks

Several frameworks have been presented for viewing the stages of curriculum as they develop towards equity. Schuster and van Dyne (1984), for example, identify six stages of curriculum development. First, the absence of women is noted; second, there is a search for missing women; third, women are recognised as a disadvantaged group; fourth, women are studied on their own

terms; fifth, women are seen as a challenge to the discipline; and sixth, the curriculum is transformed and balanced. At each stage of this model, Schuster and Van Dyne pose questions about the experience of women, examine the incentives behind why these questions would be asked, discuss the means by which questions will be asked, and define the outcomes of each stage. Kreinberg and Lewis (1996) discussed the application of this model to the work of the McClintock Collective to reform mathematics and science education in Victoria (Australia) over the last ten or so years, concluding that, in 1996, the McClintock Collective was somewhere between the fifth and sixth stage of the Schuster and Van Dyne model.

Lustig (1989) traced the evolutionary reconceptualisation in Australia of curriculum approaches in relation to sexism and education. She outlined the gradual transition of the aims of curriculum reform from non-sexist or neutral models, through inclusive models and counter-sexist models, to the most recent paradigm, and the most radical model, the “Feminist Education” curriculum paradigm.

Kaiser and Rogers (1995) used a model proposed by McIntosh (1989) to frame the chapters in their book *Equity in Mathematics Education*. McIntosh proposed five phases of curriculum reform. First, is womanless mathematics; second, women in mathematics; third, women as a problem in mathematics; fourth, women as central to mathematics; and fifth, mathematics reconstructed. Kaiser and Rogers use these headings as section themes and, in their introduction, discuss how the ideas of each chapter correlate with these five phases.

Allard, Cooper, Hildebrand and Wealands (1995) used a four-phase model with reference to science education. They proposed multiple frames of reference, using the metaphor of “seeing things differently through someone else’s spectacles”. They named the spectacles “Ace”, “Val”, “Dif” and “Soc”. “Ace” referred to access and equity and was derived from a liberal-feminist perspective; “Val” referred to valuing women’s experience and was derived from a radical-feminist perspective; “Dif” referred to recognising and valuing the differences between males and females, and challenges the beliefs about what is acceptable feminine or masculine behaviour or what is supposedly inextricably linked to our biological differences, thus encouraging a real appreciation of diversity; and “Soc” referred to challenging current paradigms and was derived from a post-structural-feminist perspective. Hildebrand (1995) also described the types of questions each of these perspectives gives rise to and how multiple frames of reference help researchers focus on how to enable a curriculum to be developed

which will challenge current paradigms. She made the point that each of these frames of reference allow the viewer to see science, the curriculum, and assessment practices in a different way.

The Willis Framework

More and more mathematics educators are using the approaches of postmodern feminism to critique the mathematics curriculum. Among these is Willis (1996), who developed a framework for use in reviewing a range of issues associated with addressing gender differences in mathematics education. Because of its specific relevance to mathematics education, this framework provided an appropriate initial conceptual model for the study reported in this thesis.

For each perspective, Willis outlines how the mathematics curriculum is viewed, who the problem of disadvantage lies with, what the solution could be, and what the educational task is. This framework is presented in Table 2.1.

In this study, it was recognised that the use of such a framework may oversimplify reality. As noted earlier, the categories are overlapping, and it is sometimes difficult to identify the researcher's perspective, especially when more than one research question has been posed. Thus, the categories should not be thought of as discrete or linear, but rather as a more fluid continuum. It is possible, and even desirable, that researchers propose solutions that rest on more than one perspective at the same time. It will also be possible for the same researcher to hold multiple positions. The value of such a framework is to highlight differences in viewpoints so that a broader understanding of problems and solutions can be gained.

In the next four sections, the elements of each perspective are explained. The remainder of this chapter then uses these perspectives to assist in understanding the reasons that have been suggested for observed gender differences in participation and performance outlined in Chapter One, and to distill the essential elements of the CEMC.

Table 2.1

Disadvantage and the mathematics curriculum

	Perspective 1 Remedial	Perspective 2 Non-Discriminatory	Perspective 3 Inclusive	Perspective 4 Socially Critical
The mathematics curriculum is...	a given, including what is to be learnt, how it is taught and how it is assessed.	a given with respect to what is to be learnt, but how it is taught and how it is assessed are not.	a selection from all possible curricula and therefore neither given nor unchangeable.	actively implicated in producing and reproducing social inequality and in being one of the ways in which dominant cultural values and group interest are maintained.
The problem of disadvantage lies with...	the children, some of whom by virtue of their race, ethnicity, gender, social class or disability are less well prepared than others to get the full benefits of the curriculum.	pedagogy and assessment practices which favour or relate to the experiences, interests and cultural practices of some social grouping of children more than others.	curriculum content and sequence which reflect the values, priorities and lifestyles of the dominant culture and match the typical developmental sequences associated with their children.	the way the mathematics learner is constructed through the curriculum and the way mathematics is used inside and outside schools to support and produce privilege.
The solution is to...	help such children to become better prepared for school mathematics.	change pedagogy and assessment practices to ensure children have real equity of access both to the mathematics and to the means of demonstrating their learning.	rethink who 'the typical child' is for whom our curriculum is developed, what school mathematics is, what should be learned, by whom and when.	challenge and modify the hegemony of mathematics and use mathematics explicitly in the services of social justice.
The educational task is to...	provide children with the missing skills, experiences, knowledge, attitudes or motivations.	draw upon and extend children's experiences, provide a supportive learning environment and more valid assessment opportunities.	provide children with curricula which better acknowledge, accommodate, value and reflect their own and their social groups' experiences, interests and needs.	help children develop different views of who does mathematics and what it means to be good at it, to understand how they are positioned by mathematics, and how to use it in the interests of social justice.

(Willis, 1996, p. 47)

The Remedial perspective

The first perspective, which Willis names “Remedial”, can be related to Kenway and Modra’s (1992) liberal feminism in that it is concerned with how much access to the curriculum girls and other minority groups have. Documentation of the access and success of women and minorities is the main focus of this kind of research. Much early work on gender and mathematics can be characterised as coming from this perspective.

From the point of view of the Remedial perspective, the problem of “disadvantage” is located with the student. Specifically, there is perceived to be some kind of deficit in the student’s background, confidence, or future aspirations that could be identified and corrected by changing the student. As Walkerdine has commented

“...continued research [which] reveals a ‘lack’ in girls when it comes to mathematical and scientific reasoning, persists in the idea that girls lack something and yet wants them to contain and nurture the very reason that they are accused of not possessing.”

(Walkerdine, 1994, p. 66)

Those researchers who take a Remedial perspective view usually give explanations for observed differences in performance which focus on cognitive variables such as spatial abilities; and affective variables such as confidence, sex-role congruency, perceived usefulness, fear of success, and attributional style. From the Remedial perspective, the deficit lies with the student, and interventions to correct the problem involve giving the student the necessary training to improve their skills, background experiences or attitudes. When interventions are designed from the Remedial perspective, there is usually little attention given to changing teaching or assessment practices or the curriculum.

The Non-Discriminatory perspective

The second perspective Willis calls “Non-Discriminatory”. It can be thought of as coming from a radical-feminist point of view, one that is concerned with promoting the positive aspects of feminine experiences. It seeks to encompass women’s as well as men’s experiences. This perspective locates the problem of low participation and achievement of females with pedagogy and assessment practices which do not take into account the interests and experiences of females. It draws on the work of liberal feminists as defined by Kenway and Modra (1992) who seek to create a feminist pedagogy which will enable women to have access to and success in the educational sphere. Certain groups of students are seen as disadvantaged by the way in which they experience the curriculum

through classroom practices that are unfavourable to their social practices and cultural norms. From this perspective, it is considered that equity will be achieved when those practices which prevent access and success of disadvantaged groups are changed. Tracking has been strongly criticised as one such practice that has been responsible for producing inequitable outcomes, especially for minority students in urban schools (Guiton & Oakes, 1995).

From a Non-Discriminatory perspective, the curriculum itself, however, is not challenged. Variables receiving attention in the literature which attempt to explain the patterns of performance and participation, include differential patterns of teacher attention and teacher attribution; the different learning styles of males and females; and how the format, content and context of assessment tasks affect performance.

The Inclusive perspective

The third Willis perspective called “Inclusive”, is loosely related to both socialist-feminist and radical-feminist perspectives. The Inclusive perspective is concerned with reforming the mathematics curriculum so that it is more reflective of the range of experiences and interests of the diverse student body in today’s classrooms. This perspective draws somewhat from the liberal feminist position, as described by Kenway and Modra (1992), in which the traditional curriculum is implicated in

“...undervaluing the social contributions and cultural experiences of girls and women generally and working-class and minority racial and ethnic women in particular.”

(Kenway & Modra, 1992, p. 141)

Willis (1996) argues that the mathematics curriculum will inevitably reflect the values of the dominant culture, and that students from non-dominant social groups will be forced to learn mathematics that is inconsistent with their cultural and social experiences. In her view, this is how school mathematics is used to produce advantage for the dominant group relative to the other groups. Willis (1996) also cites the example of *Calculus* being far more highly valued than other branches of mathematics. Females choosing other mathematics subjects over *Calculus* are forced, because of the way the overall school curriculum is structured, to take low level courses that do not challenge them academically and are not publicly valued. Characteristics such as logical thought processes, abstract thinking and rationality that are identified with the dominant group which, in the case of mathematics, is white males, are thus privileged by

school mathematics. From this perspective, the content and sequencing of the curriculum is the problem to be addressed.

The Socially Critical perspective

The fourth Willis perspective, “Socially Critical”, is related to socialist-feminist concerns that seek to expose those social structures and discourses that position women and minorities outside traditional mathematics. This perspective draws on the work of the radical-feminist position, where social injustices of the oppressed are linked to masculine-centred practices embedded in schools generally, and mathematics and science in particular. The Socially Critical perspective focuses on challenging the hegemony of high-status areas of study such as *Calculus*. The way in which status is produced and maintained in school science subjects has been investigated by Parker (1994) who developed a theory about the gender coding of school science subjects. She presented a detailed analysis of performance data in science subjects collected over more than 20 years in Western Australia, and clearly demonstrated that science subjects in senior secondary school have a “gender code”. High-status subjects such as *Physics* and *Chemistry* are characterised by strong framing and classification (in Bernstein’s [1971] terms) and have formal assessment (in Broadfoot’s [1984] terms). These subjects are associated with maleness. Low-status subjects (in the Western Australian curriculum) such as *Human Biology* and *Senior Science* are characterised by weak framing and classification, and have informal assessment. These subjects are associated with femaleness. A parallel can be drawn between science subjects and mathematics subjects. An examination of the participation rates for males and females in mathematics subjects in Western Australia (Parker, et al., 1993) revealed similar trends in *Calculus* and *Physics* (Parker, 1994). Although space does not permit a full comparison and analysis of the gender code of mathematics subjects here, it would be reasonable to assume that *Calculus*, a high-status mathematics subject with low numbers of females, has many of the same framing and classification properties as does *Physics*, while *Modeling With Mathematics*, a low-status mathematics subject favoured by females, has many of the same framing and classification properties as *Senior Science*. The high-status subjects associated with maleness appear to be alienating to females.

From the Socially Critical perspective, the curriculum is seen as being responsible for transmitting those dominant cultural values that exclude women from mathematics. One way that this is accomplished is through the process of abstraction. Walkerdine (1994) criticises the abstracting of academic discourse on

the grounds that abstraction is merely a way of forgetting the practices which have formed us, of forgetting the historical forces of power and oppression, the forces of “Unreason” as Foucault called them. She points out that

“... abstract reasoning is not the ultimate pinnacle of the intellectual power to abstract, a power essential to the modern world, but a massive forgetting which props up a fantasy of omnipotence of scientific discourses that can control the world. In other words, forgetting, meanings, practices and the constructed character of the subject, produce a very special form of power and it is this power, the power of ‘western rationality’, which has understood nature as something to be controlled, known, mastered.... Thinking for a post-modern age needs to dismantle such fantasies and recognise that thinking is produced in practices replete with meaning and complex emotions, that thinking about thinking is deeply connected to the way that power and regulation work in our present social order.”

(Walkerdine, 1994, p.74)

In Walkerdine’s terms, what is defined as “abstract thinking” in itself is a power structure, one that is deeply embedded in our western culture. It is through abstraction that the power of mathematics is constructed, with only those select few who possess this power of abstraction having access to the power of mathematics.

From the point of view of the Socially Critical perspective, Willis (1996) argued that the task for mathematics educators is to help students understand the processes which marginalise certain groups. In doing so, the hegemony of mathematics will be challenged, thereby enabling the curriculum to better serve the needs of all students, not just the privileged few who have traditionally been successful at school mathematics.

TOWARDS DEFINING EQUITY: USING THE WILLIS FRAMEWORK

The four perspectives of the Willis (1996) framework were used in this study to assist in understanding and evaluating the various strategies suggested by the literature presented in Chapters Two and Three for addressing gender differences in school mathematics.

The remainder of this chapter is devoted to exploring the literature which has attempted to find explanations for observed gender differences. This is presented in three sections which correspond to the first three Willis (1996) perspectives. The Remedial perspective locates the problem with the students; hence the first section of the chapter considers student-related explanations. A sub-section is included at the end of this part to describe three models which attempt to link together the many affective variables which have been identified as important in explaining the interaction of the variables and mathematics

achievement. These models, although focused on the student also acknowledge the importance of external factors and set the scene for the Non-Discriminatory perspective. The Non-Discriminatory perspective locates the problem with pedagogy and assessment practices; hence the next section considers teacher-related explanations. The Inclusive perspective locates the problem with curriculum content and sequence; hence the last section of the review considers curriculum related explanations.

A similar synthesis for the Socially Critical perspective was not possible because there was little literature which could be located which directly related to school mathematics and how the mathematics learner is constructed. However, some of the curriculum-related explanations presented in the Inclusive perspective section have elements of a Socially Critical perspective in the way these writers talk about the influence of the content and sequence of the traditional mathematics curriculum. Thus, the emerging Socially Critical perspective literature is amalgamated with the Inclusive perspective.

After each major section of literature is presented, a small summary given in italics outlines the characteristics of the ideal Connected Equitable Mathematics Classroom (CEMC).

EXPLANATIONS FOR GENDER DIFFERENCES

The Remedial Perspective: Student-Related Explanations

Research conducted from a Remedial perspective takes the view that gender differences in achievement arise because of some kind of deficit on the part of that particular group of students. In mathematics, gender differences in achievement were often attributed to gender differences in personal characteristics influenced by affective variables and spatial abilities. Typically the proposed solutions take a Remedial perspective by suggesting that the deficit be corrected by helping those students become better prepared for further mathematics. More recently, differences in personal learning styles have been seen by some researchers as explaining why some groups of students (in the case of mathematics, male students) participate more and achieve better results than others. It was thought that traditional mathematics appeals to only one learning style. The solutions offered in this instance are usually from the Non-Discriminatory perspective, suggesting that using a range of teaching styles, which appeals to more learning styles is the most appropriate response.

Research about affective variables

Differences in performance in mathematics have often been explained in terms of affective variables such as confidence, fear of success, usefulness of mathematics, and attributional style. Myer and Koehler (1990) and Leder (1992) reviewed the literature associated with this area. They showed that studies about confidence and related variables most often find that low confidence is related to poor performance and is also predictive of gender differences in participation.

The Myer and Kohler (1990) and Leder (1992) reviews also highlighted that studies about the perceived usefulness of mathematics to students' future lives have demonstrated that males see mathematics as more useful to their future than do females. Leder (1989) surveyed students' attitudes to mathematics and found that more males than females believed mathematics to be worthwhile, necessary, and useful. These studies, though unable to establish a link between usefulness and achievement, related the desire to continue the study of mathematics beyond the compulsory years and the tendency to persist with more difficult problems in mathematics classes, to the perceived usefulness of mathematics. In addition, fear-of-success studies have shown that females, more so than males, perceive mathematics to be incongruent with their sex role, and as a result, fear success in mathematics. In the case of females, the desire to conform to societal expectations is stronger than the desire to succeed.

All of the above research could be linked to the Remedial perspective in that the problem is located with females who lack confidence, have a weak desire to succeed, and fail to see the usefulness of mathematics to their futures. Interventions based on this line of research are aimed at improving confidence in mathematical ability and attitudes towards mathematics.

Attributional style has also received a lot of attention as a variable strongly related to gender differences in mathematics. Two types of attributional style have been identified (Kloosterman, 1990). "Learned-Helpless Students" attribute success to the ease of a task, and failure to lack of ability. They therefore do not expect success on similar tasks and, as a result, make no effort to succeed. "Mastery-Oriented Students" attribute success to inherent ability and failure to a lack of effort. This leads them to expect success on similar tasks and to therefore make continued efforts to succeed. Gender differences in attributional styles were widely reported in early studies, but Kloosterman (1990) in his summary and review of the literature concluded that there was little difference in the attributional style of males and females. Fennema, Hyde, Ryan and Frost (1990a),

however, pointed to a lack of research about attributional style in mathematics, and noted that the effect sizes for the few studies they located were quite large.

In a recent meta analyses on 100 studies of gender differences in mathematics performance and 70 studies of gender differences in mathematics-related attitudes and affect, Frost, Hyde and Fennema (1994) found that there were small non-significant effect sizes favouring males for mathematics performance, and small and non-significant effect sizes for females' negative attitudes and affect. However, males were found to hold a much more stereotyped attitude of math as a male domain, the average effect size being very large at -0.90. Frost et al concluded that "ability" did not explain the lack of females in advanced-mathematics classrooms and mathematics-related careers. They saw the problem of low participation as the result of negative mathematics-related attitudes and affect. Although differences in affect were small, females were consistently shown to have more negative attitudes. It was acknowledged that the cumulative effect of such differences over time was unknown; however it was not thought that attitudes alone were a sufficient explanation of the lack females in mathematics-related careers. Frost et al suggested sex discrimination in education and employment is a potential reason, but did not go so far as to implicate teaching practices. Their perspective moved past the Remedial, but stopped short of considering the curriculum or mathematics itself as the potential problem.

In the CEMC, students are confident of their abilities in mathematics, see mathematics as useful to their future, and hold positive attitudes towards mathematics. Teachers would help less-confident students become more confident by ensuring that the less-confident students experienced success and made academic progress. The usefulness of mathematics could be made obvious to those who did not consider it so through an appropriate choice of real-world problems and contexts. Positive attitudes towards mathematics might more likely be developed in students who are confident and see mathematics as useful to their future.

Spatial abilities

Spatial abilities have been long associated with mathematical abilities, and gender differences in spatial abilities, as a cause of gender differences in mathematics performance, have received a great deal of research attention over a long period, dating back to a review in 1925 cited by Tartre (1990). Although McGee (1979) found some evidence to suggest that sources of variance on spatial tests may be heritable, no evidence to support the X-linked recessive gene

hypothesis (Gray, 1981) for the mode of genetic transmission was found by McGee. Fennema and Tartre (1985) studied the responses of high- and low-spatial ability and high- and low-verbal ability students and found that low spatial-orientation-ability female students performed significantly lower on spatial problem-solving tasks than any other group. It seems that poor spatial skills affected females more than males in terms of their overall achievement. In a later study, Tartre (1990) concluded that the possible link between spatial ability and mathematical ability was a lot more complex than had been previously thought.

Perhaps what has appeared to be a fundamental difference between males and females in spatial skill level as it relates to doing mathematics has instead been a wide-ranging problem for a specific group of people who tended to be female.

(Tartre, 1990, p. 57)

Others have shown that achievement on spatial-ability tests can be improved with training in spatial problems (Ben-Chiam, et al., 1988), and that greater male achievement on spatial tests can be attributed to males' greater out-of-school experiences with spatial activities such as sports and toy blocks. Interventions based on this research are clearly located in the Remedial perspective, where spatial skills are improved through training.

In the CEMC, students with poor spatial skills are given opportunities to improve their skills through a variety of hands-on practical experiences.

Learner variables

Intellectual and moral development theories have begun to be noticed by mathematics-education researchers of late. Becker (1995) reviewed the early work in this area and pointed out that, all too often, conclusions based on work with only male subjects were presented as though they were valid for all persons. Kohlberg's (1969) theories about moral development and Perry's (1970) theories on intellectual and ethical development are two notable examples. Both of these (male) researchers used only male subjects in their studies. With so much research based on all-male samples, theories tended to be developed which portrayed women as inferior or lacking. This deficit view of female development was challenged by Gilligan (1982). She was the first researcher to postulate that women's moral development follows a path different to that of men's and is based on different values. She described how the recognition in early adulthood that knowledge is not absolute is driven by different forces for women and men. In women, caring by not hurting others develops into a recognition of the need for personal integrity. In men, the desire for truth and fairness develops into an ethic

of generosity and care. For both sexes, a new understanding of responsibility and choice is arrived at through different paths.

Belenky, Clinchy, Goldberger and Tarule (1986) continued the work of Gilligan, Perry and Kohlberg. They included in their interview schedules

... questions we devised for assigning Perry's (1970) epistemological positions and also standard questions developed by Gilligan (1982; also see Lyons (1983) and Kohlberg (1984) for coding moral orientation stage. We included their questions so that we might place our women on their maps of intellectual and ethical development and assess the adequacy of the maps themselves.

(Belenky et al, 1986, p.11)

They interviewed 135 women, exploring their experiences and problems as learners. Belenky et al described how women in the study viewed reality and drew conclusions about truth, knowledge, and authority. Differences were noted as to how this study compared with previous models derived from research based on all male subjects. From the interview transcripts, they identified five distinct "Ways of Knowing".

Building further on this work, Baxter Magolda (1992) worked with both males and females in her longitudinal study of college-age students' intellectual development. She identified four patterns in students' intellectual development, which she also termed "Ways of Knowing". Within each of the first three patterns, she also found two strands which were more often preferred by one sex or the other. Rather than suggesting how to change the students, she suggested both a number of ways of teaching responsively to students who have different ways of knowing, and several teaching strategies that can build connection with students. These will be discussed in Chapter Three of this thesis.

Gilligan, Belenky et al, Baxter Magolda and Becker clearly took a Non-Discriminatory perspective with their solutions and responses to catering for different ways of knowing. By acknowledging that certain students have different learning styles, they concluded that students should be taught in a way that is sympathetic to their particular style. Although their research focused on students, their solutions were clearly on teaching strategies. They all called for a type of pedagogy which has become known as "Connected Teaching". The teaching strategies of Connected Teaching are often referred to as "Gender Inclusive Teaching Strategies" (Lewis & Davies, 1988). This term, although widely used, should not be taken as equivalent to the "Inclusive perspective" of the Willis (1996) model. The Willis perspective of Inclusive is related to curriculum content and sequence, not pedagogical practices in the classroom.

In the CEMC, different learning styles are taken into account through the use of a variety of teaching strategies, so that all students are taught at least some of the time in a style that suits them.

Linking the Remedial and Non-Discriminatory Perspectives: Explanatory Models

A number of affective variables have been incorporated into three models which attempt to explain the interaction of these variables with mathematics achievement and decisions to enrol in mathematics courses. Two of these are the Autonomous Learning Behaviours model (Fennema & Peterson, 1985) and the Model of Academic Choice (Eccles, et al., 1985).

Although both of the first two models clearly focus on students' behaviour, external as well as internal factors are seen to be important. This sets the scene for the development of a Non-Discriminatory perspective in which change can be effected not just by influencing student-related factors, but by external factors as well. Where there are problems in participation and performance in mathematics, these models would suggest that applying intervention at the student level is probably not enough. However, although there are outside influences, ultimately change must come from the within the student, through changing either internal beliefs or goals. These suggested solutions correspond more with the Remedial perspective than any of the others, since there is no suggestion in either model that changing teaching practices, assessment practices or the curriculum can improve the performance or participation of females.

In relation to the first of these models, Fennema and Peterson (1985) described autonomous learning behaviours as those behaviours which enable a student to take control of his or her learning environment by working independently to accomplish high-level mathematical tasks. Success at a particular task is depicted as strengthening a student's internal belief system, allowing the student to continue with that task and thereby increasing autonomous learning behaviours. This model exemplifies the influence of external and societal factors on internal motivational beliefs such as confidence, usefulness, sex-role congruency and attributional style. Both motivational beliefs and societal influences are seen to affect autonomous learning behaviours, which in turn produce sex-related differences in high cognitive-level skills.

In the Model of Academic Choice, Eccles, Adler, Futterman, Goff, Kaczala, Meece and Midgeley (1985) attempted to explain how specific factors

influence the choices students make in their academic course selections. Eccles et al suggested that there are two paths which influence the achievement behaviours of persistence, choice and performance. The first path starts with the influence of the cultural context which influences a child's perception of socialisers, attitudes and expectations; and the socialisers themselves, which in turn influence the child's goals and general self-schema, perception of task value and, ultimately, achievement behaviours. The second path starts with those agents which influence past events and which in turn influence the child's interpretation of these past events. A child's task-specific beliefs will include self-concept of ability and perceptions of task difficulty, both thought to influence expectancies of current and future events, and ultimately achievement behaviours. This model emphasises the connection between attributions of failure and self-concept of ability. These connections in turn influence the individual's expectation of success. Sex-role congruency is incorporated into this model through the concept of self-schemata, which describes how a person should behave in order to conform to social norms. Mathematics is seen as a largely male activity and in conflict with a female's sex-role identity. Engaging in such an activity is seen as having a negative effect on a person's perception of the task value, affecting persistence, choice and performance. This model also acknowledged the importance of the influence of socialisers such as parents and teachers, regarding the child's perception of the attitudes of these socialisers as an important factor in shaping long-range and immediate goals. If a child thinks that a parent or teacher is not in favour of the child continuing the study of mathematics, the child will alter his or her goals.

The third model, proposed by Kahle, Parker, Rennie and Riley (1993), links the socio-cultural influences on students and teachers. This model, although developed more in relation to science education, still has relevance to mathematics education (Rennie, Parker, & Kahle, 1996). The model demonstrated how teachers' beliefs and attitudes influence their behaviour through the provision of resources, opportunities to learn, assessment methods, reinforcement and feedback. It also emphasised the importance of the cultural context in which both the teacher and student are placed, and places the role of teacher as central to the change processes. The perspective here is more Non-Discriminatory, focusing on improving teaching and assessment methods as the way to improve student outcomes. Rennie, Parker and Kahle (1996) pointed to the critical role of the teacher in the change process.

In the CEMC, teachers would hold beliefs that allowed them to challenge traditional masculinist mathematics. They would interpret and react to student behaviour in a manner that would value females, their contributions, and achievements. They would provide feedback which would confirm students' positive beliefs about themselves.

The Non-Discriminatory Perspective

Research conducted from a Non-Discriminatory perspective locates the problem of gender differences with pedagogical or assessment practices which are discriminatory towards females. The solution is to change those practices, or include a variety of practices so as to cater for both males and females at least some of the time.

Pedagogy

Pedagogical explanations have centred on differential teacher attention towards males and females, differential teacher attributions and expectations of success and failure, the construction of female-friendly learning environments, and the use of stereotypes in language

Teacher attention

Teachers' treatment of students in the classroom has been well researched. Two important reviews of research about teachers attention, one by Koehler (1990) and the other by Kelly (1988), reached many similar conclusions. Overall both reviews revealed that males received more attention from teachers in terms of help, interactions and informal contacts. Boys received both a higher proportion of criticism for their behaviour and a greater amount of work-related criticism. Patterns associated with age were noted: younger girls received a lower proportion of instructional contacts. Patterns associated with the sex of the teacher were also noted. Male teachers directed fewer interactions towards girls than female teachers, and the differences were larger in science, mathematics and social studies than in other subjects. Kelly's review also revealed a large amount of variation in the amount of teacher attention males and females received across the studies examined. In 31% of the classes, girls received less than 45% of the attention. However, in 4% of the classes, girls received 55% of the interaction time. Some researchers have suggested that when there are more than a certain number (critical mass) of females in a class the problem of differential treatment

is alleviated. Kelly did not provide demographic details of those classes where girls received more than 50% of the teacher's attention.

An obvious question to ask is how does differential treatment affect student outcomes. Unfortunately, very few studies have tried to answer this question. Koehler (1985 as cited in Koehler, 1990) found no clear-cut link between differential treatment and educational outcomes. Clearly the interaction of many factors in the classroom cannot be easily quantified and recorded. Observable teacher and student behaviours do not fully reflect the complexity of classroom context. Ever more sophisticated coding schemes have been used to try to capture the complexity of the situation, but researchers are still unable to quantify important contextual classroom factors.

It is apparent, however, that males are advantaged by the structure and climate of many mathematics classrooms, even those which are taught by caring and highly competent professionals, as they were in Leder's (1989) study. Other evidence suggests (American Association of University Women, 1992) that these patterns of interaction are not confined to one subject or grade level, but are pervasive across many subjects and grade levels. Overall, the pattern of interactions experienced by females is one of male domination, the cumulative effects of which are not known because the link between teacher attention and student achievement has not been properly researched. However, Non-Discriminatory interventions often arise from research of this nature, the focus being on improving certain aspects of the classroom climate by making teachers more aware of interaction patterns.

Teacher attributions and expectations

Teachers' attributions and beliefs about male and female students were studied by Fennema et al (1990b). Thirty-eight first-grade teachers were asked to identify their two most- and least-successful girls and boys in mathematics. They were then asked to attribute causation of these students' success and failures, and to describe their characteristics. Teachers' choices of most- and least-successful students were compared to mathematics test scores of their students. Teachers were more inaccurate when selecting their most successful boys as compared to girls. Teachers tended to attribute causation of boys' success and failures to ability and girls' successes and failures to effort. Teachers thought their best boy students, when compared to their best girl students, were more competitive, logical and adventurous, volunteered answers more often to mathematics problems, enjoyed math more, and were more independent in mathematics.

Teacher expectations about how well females are likely to achieve in mathematics were once thought to affect achievement significantly. Fennema (1990b) and Secada (1992) reviewed this research and concluded that the link between teacher expectations and student success was not clearly established, particularly as it relates to gender, although teacher expectations probably stem from students' expectations of themselves. When linked to studies showing females having less confidence, it is likely that teachers who don't expect more of their female students than these students expect of themselves are underestimating them. Both Fennema and Secada acknowledged that the whole area of teacher expectations and how these were related to teacher behaviour and student achievement was complex and under-researched.

Friendly learning environments

As well as teacher attention and expectation, other aspects of teacher behaviour have been examined in the literature. Eccles (1989) reviewed a number of studies that examined classrooms in which females appeared to be less disadvantaged, where there were fewer sex differences and more positive attitudes towards mathematics. These classrooms were characterised by less social competition, more cooperative activities, more hands-on learning and more career guidance. In contrast, Eccles (1989) concluded that activities that are not conducive to females learning and motivation include competitive activities, public drill and practice, social comparison and domination of classroom interaction by a few students.

Stereotypes, language and discrimination

One aspect of teacher behaviour that is thought to create an unfriendly environment for women in the mathematics classroom is the use of stereotypes that portray mathematics as a male domain (Koehler, 1990). Always using male names and masculine contexts in test questions is another form of teacher behaviour that has been found to be problematic (Koehler, 1990). Although some forms of discrimination can be subtle, such as sexist humour, any form of discrimination observed in mathematics classrooms can have detrimental effects on females' attitudes towards mathematics (Solar, 1995).

In the CEMC, the teacher monitors the frequency and type of her or his interaction with students on a regular basis. The teacher has high expectations of all students, and encourages them to have high expectations of themselves. Curriculum material and language usage is examined for balance in the use of male and female names. Stereotypical portrayals of males and females are

eliminated where possible or brought to the awareness of students. A range of learning activities is provided, including cooperative, hands-on activities.

Assessment-related explanations

Interest in this area of research began in the late seventies. Some British researchers (e.g. Harding, 1979; Murphy, 1982) began noticing patterns of performance for males and females when comparing different types of assessment tasks. In looking for an explanation for these patterns, it was necessary to look past the characteristics of the group towards the characteristics of different types of assessment techniques. Current research is concerned with three different effects.

Format effects occur when groups of students of the same ability exhibit differential performance on assessment items which have different formats but cover the same content. This area has received considerably more attention in the past few years, particularly as it relates to the differential performances of males and females on multiple-choice questions as compared to extended-response questions. Sometimes format effects are confounded with the test-taking situation. Males have tended to do better on externally set assessments, which usually consist of timed, unseen questions completed under examination conditions. Internally-set school-based assessment which has tended to favour females is often untimed, take-home work on which students may reflect at length.

Context effects occur when groups of students perform differently on questions set in different types of contexts. Typically either concrete contexts or abstract contexts are considered. This area has only recently become of wider interest in the literature.

Content effects occur when groups of students perform differently on different content set in the same format. This has been the focus of many studies in the USA where large-scale multiple-choice testing is widely used. Differential Item Functioning (DIF) is the name given by psychometricians to this particular field. DIF techniques concentrate on identifying by statistical means those items which "function differently" for particular groups of students, usually identified by race or gender. In the USA, when large-scale commercial tests are constructed, trialing of items is meant to ensure that few items that exhibit DIF are included in the final version of the test. Many sophisticated statistical techniques have been developed to try to identify items which may be biased against one group or another. However, panels of people are still consulted to judge whether or not

items are potentially biased (Cole, 1981; Englehard, 1990; Skaggs & Lissitz, 1992).

Format effects

In Britain, Harding (1979) was among the first to report that both the format of an examination, and the context of questions used in an examination can influence outcomes differentially for males and females. R. Murphy (1982) analysed the examination results of males and females on objective (multiple-choice) and written sections for those subjects that had both components. It was found that males scored higher than females on the objective sections of these examinations.

Bolger and Kellaghan (1990) also found gender differences to be a function of the method of measurement when they compared the performance of fifteen-year-old males and females in Irish schools on multiple-choice and free-response tests of mathematics, Irish and English achievement. Males performed significantly better than females on multiple-choice tests compared to their performance on free-response examinations.

In a review of studies in this area, Forrest (1992) considered literature associated with gender differences in achievement in Britain from 1928 to 1990. He concluded that format had a profound effect, with males having an advantage on multiple-choice questions, and females having an advantage on written and extended-response questions.

In the USA, multiple-choice testing has been the most widely used form of educational assessment for many years. Only recently have researchers there been interested in format effects. At the college level, Anderson (1989), Mazzeo, Schmitt and Bleistein (1991), and Linn and Kessel (1995) all found significant format effects. Although the magnitude of these differences varied across ethnic and racial groups in the different subjects, the pattern of discrepancies remained essentially the same, with males performing better than females on multiple-choice sections as compared to other sections. Linn (1991), in a review of studies that documented national tests, individual studies, and course grades, found that test format was a significant factor in females' achievement. She noted that, although females earned better grades than males in mathematics courses, their scores in college-entrance exams like the SAT-M were still significantly lower than those of males. She concluded that females were disadvantaged in multiple-choice tests, because they had lower confidence, relied on algorithmic as opposed to short-cut methods, and tended not to guess answers as often as males.

In Australia, multiple-choice tests have rarely been used in mathematics at the upper-secondary level. In Western Australia, for example state requirements for secondary graduation and college entrance are satisfied by students taking a state-wide externally set and graded exam. The numerical score from that examination is then combined with a numerical score obtained from school-based assessments. This system has been in operation since 1986. Parker and Tims (Goodell) (1993; 1995) compared the results of males and females on school-based assessment and external exams in mathematics and science subjects and found that females performed better on school-based assessment and males on external examinations.

Kimball (1989) presented an examination of the little noted (in the USA) sex-related difference in classroom grades. In contrast to standardised measures of mathematics achievement, females received better math grades than did males. Also in the USA, Linn and Kessel (1995) found that women were earning higher or equal grades in college courses. This generalisation held across all mathematics courses in a diverse range of universities.

With many of these studies, the emphasis is on test-taking skills that females lack: speed, the ability to take short cuts, or the confidence to guess. The solution varies according to the perspective of the author. Those who hold a Remedial perspective will suggest that females should somehow be given those skills that they lack, through training or some other (usually unspecified) method. Those who hold a Non-Discriminatory perspective will suggest that the assessment method be modified so that females are not disadvantaged.

Context effects

The effect of setting questions into different contexts has also received attention. Some of the variables that have been investigated with respect to context are the use of personalised contexts, same-sex story characters, and concrete or real-world contexts.

As early as 1978, Wood (1978, as cited in Forrest, 1992) reported that context can have an effect, with both males and females performing better on contexts with which they were either more familiar or preferred. Harding (1979) also acknowledged the effect context can have on the performance of males and females. Anand and Ross (1987) found that students preferred personalised and concrete contexts over abstract ones, although they did not look for gender-related effects. Other studies investigating context effects have found that students prefer stories that are about their own sex, (Bleakley, Westerberg, & Hopkins, 1988;

Murphy & Ross, 1990) or that are personalised (Davis-Dorsey, Ross, & Morrison, 1991).

Some studies have investigated the effect of couching mathematics word problems in different cover stories: masculine, feminine, and neutral (Chipman, Marshall, & Scott, 1991; McLarty, Noble, & Huntley, 1989). No items were found to have sex bias in any context. No effect of sex-typing was found, but there were familiarity effects.

The role of context in enabling students to translate a word problem into a mathematical problem is discussed by de Lange (1987). He calls this process "mathematisation". A real-world problem is presented to the student and the student is then expected to select the mathematical tools required to organise, structure and solve the problem. He found that there are certain types of contexts that can hinder a student's attempts at solving a problem. These include artificial contexts; emotionally-disturbing contexts such as war, defense, illness or ethnic affairs; contexts that are too neutral and therefore not motivating; and contexts where students are required to have prior knowledge. He did not discuss gender-related effects.

Caldwell and Goldin (1987) also investigated the relative difficulties of concrete versus abstract, and factual versus hypothetical, verbal problems in mathematics for secondary-school students. They found that factual problems were considerably less difficult than hypothetical problems, but did not look for gender-related effects. However, gender-related effects were found by Doolittle and Cleary (1987). Their study found that males performed better on mathematics usage tests when the task was related to a real-world situation, whereas females performed better when the task involved the application of an explicit operation and was not embedded in a real-world context.

The 1981/82 round of the APU surveys found females were ahead of males in written tests of problem-solving strategies (Gipps & Murphy, 1994). Females were also found to be significantly ahead of males where tasks required students to devise or ask questions. The conclusions drawn from the APU work were that differences in performance were largely attributable to the way in which the question was being asked. Question format was typically either multiple-choice or extended-response. Question context was typically either domestic or warfare. It was concluded that it would be possible to engineer or remove group differences by manipulating the format or context of items used.

Generally, research about context seems clear on at least one point: students will do better on a task if it is set in a context that they can connect with,

and is not distracting. Although males seem more able than females to ignore the context and just concentrate on the mathematics of the task, Lane, Wang and Magone (1995) found that girls' performance in real-world contexts is enhanced by receiving their classroom instruction in context. The implications of this line of research are reflected in the ideas of "Connected Teaching", a concept that has been mentioned in the section on learner variables, and will be developed more thoroughly in Chapter Three.

Content effects

While a number of researchers (Doolittle & Cleary, 1987; Kim, Plake, Wise, & Novak, 1990) have found evidence to support the claim that females perform better than males on routine and computational tasks, Lane, Wang and Magone (1995) found that females did better on tasks involving number sense, estimation, patterns and ratio/proportion.

Evidence to support the claim that males are better at geometry tasks, problem solving, and questions involving speed, ratio and proportional reasoning has been provided by a number of researchers. As early as 1984, Edwards (1984) reported on the patterns of performance of males and females in the Australian Mathematics competition. She concluded that, in general, more females than males had severe misunderstandings of proportional reasoning involving speeds and ratios. Doolittle and Cleary (1987) found geometry and mathematics reasoning to be relatively easier for males. Kim, Plake, Wise, and Novak (1990) found that males had an advantage on application of concepts. Lane, Wang and Magone (1995) found that males performed better on a geometry tasks involving reflections and on proportional-reasoning tasks.

Becker (1990) analysed results from the Scholastic Aptitude Test (SAT) and found, in contrast to many other studies, that algebra items were easier for males. However, the study did not indicate whether the amount of mathematics instruction a student had received was considered, nor did it take into account the fact that the SAT population is self-selective, and that entrants are required to pay a fee. Arguably, all three of these factors would impact the differential performance of sub groups.

The Assessment of Performance Unit (APU) surveys (1975 - 1989) used various types of instruments, unlike most international surveys where only multiple-choice format has been used (Gipps and Murphy, 1994). Their surveys demonstrated that males performed better than females on measurement and ratio problems.

Although there appears to be a small degree of agreement about what types of content appear to advantage females, it is difficult to make global generalisations when so many of the studies reviewed provide very little detail about how items were classified and whether course-taking had been controlled for.

Summary and explanations for differences

A number of different reasons for differences due to the method of measurement have been put forward, but none has been fully substantiated or repudiated. It seems most likely that they are due in each particular situation to a combination of factors working in concert to produce the observed effect.

Murphy (1988; 1994; 1996) discussed some of the factors which lead to gender bias in assessment, such as differences in out-of-class experiences, differences in ways of experiencing the world, differences in problem perception and differences in styles of expression. She also made the point that females interact differently than males with the context of questions and tend to focus on “irrelevant” details in the wording of a question, becoming distracted from the inherent mathematical task. Females seem less able than males to ignore context and just concentrate on the mathematics in the task. Tims (Goodell) and Parker (1995) added further support to this hypothesis. They interviewed fifty-four twelfth-grade mathematics students about their preference for assessment format and context. It was revealed that many students, both male and female, preferred questions to be set in context, because the context gave them some idea of the usefulness of the mathematics. However, there were a number of students, mostly female but some male, who expressed a dislike for contextual questions. These students saw the context as a distracter, something that interfered with their understanding of the mathematics. The solution offered was from the Non-Discriminatory perspective: use a variety of contexts so that the effect of any particular one is lessened.

In terms of format effects, the male advantage on multiple-choice tests is attributed to the male tendency to be more prepared to take risks and use short-cut methods, thereby enabling them to work faster and complete more of the test (Linn & Kessel, 1995). Girls are seen to be disadvantaged by the multiple-choice format because it requires students to work quickly, and this penalises girls who are, according to Linn and Kessel (1995), generally less confident and more inclined to use standard methods of calculation rather than short cuts. Solutions offered include those from the Remedial perspective, where the solution is to train

girls to work faster; and those from the Non-Discriminatory perspective, where the solution is to change the format of tests to make them more female friendly.

Males have also been shown to guess more answers they don't know (Ben-Shakhar & Sinai, 1991; Hanna, 1986), thereby giving them an advantage on those multiple-choice tests where guessing can pay off by scoring points. However, generalising risk-taking behaviour has been questioned by Forgasz and Leder (1991). The usual solution offered to this problem is to change the scoring of a test so that there is no advantage to guessing, or to change its format to something other than multiple-choice.

Male advantage on certain real-world or physical-science contexts is attributed to differing background and out-of-school experiences. Female advantage on biological, social or domestic contexts is attributed to the same cause. Again, the solution is to vary contexts so that all interests are catered for.

In the CEMC, the teacher is aware of the possible bias inherent in certain assessment formats, and therefore uses a variety of formats in order to avoid this. In terms of the context of assessment problems, the teacher would ensure that contexts which appeal to the interests and background experiences of all students are utilised wherever possible.

The Inclusive Perspective: Curriculum-related Explanations

One of the first hypotheses to attempt to explain differential performance, briefly alluded to in Chapter One, was “the differential course-taking hypothesis”, put forward by Fennema and Sherman (1977). They documented sex-related differences in achievement and participation in Grades 6 to 12, finding that males participated to a much higher level than females in advanced mathematics courses, with male achievement also much higher. They combined these two findings, about participation and achievement, and concluded that if females participated in mathematics to the same level as males, gender differences would disappear. The studies from which this hypothesis was developed have become among the most quoted of educational research studies (Fennema, 1996). The importance of this work cannot be overstated. It changed the way research was conducted: since then, most studies have attempted to control for the amount of mathematics instruction a person has received. It also gave a great deal of impetus to equity workers trying to involve more females in higher-level mathematics courses. The problem was that females, by virtue of their nonparticipation, did not have access to the same amount of mathematics instruction as males. One way to improve the situation was to increase the participation of females. Evidence

presented in Chapter One of this thesis showed that over the period 1975 to 1992 females in the USA improved their participation rates in high-school mathematics (National Science Board, 1996) to almost equal with that of males in most high-school courses. Other evidence presented in Chapter One showed that there were still some gender differences in mathematics achievement in the older age groups, but that these differences had been declining. Thus, the link could be made between greater participation and declining gender differences.

However, the practice of providing differentiated curricula for different groups of students, often called “tracking” in the USA, has been recently examined by Guiton and Oakes (1995). Using data from the Second International Mathematics Study (SIMS), they showed that there were significant differences in groups characterised by race and social class with respect to both preparedness to take Algebra in ninth grade and equal access to math classes at various levels. From their analysis of the SIMS data, they concluded that course placement practices skew enrolments in favour of White and Asian-American students. They attributed lower performance to lack of access caused by school-based placement practices. Greater access to more advanced curricula was seen as the answer to this problem.

The most recent body of literature that attempts to explain inequities in mathematics education—low participation and performance of women—centres around the whole curriculum. This is not to say that some of the reasons proffered so far (biased or sexist teaching and assessment practices) are not elements of the curriculum. Some of these researchers reviewed in this section are bordering on a Socially Critical perspective, but since they have not gone as far as questioning “the way in which the mathematics learner is constructed” (Willis, 1996), they should not be categorised as Socially Critical. Thus, the remainder of this section focuses more on those arguments that challenge the value of learning mathematics and suggest that it is not sufficient to attempt to change only some elements without considering the content and structure as well. Many argue that the whole curriculum is implicated in producing inequity. Damarin (1995), for example, believes that

...instructional research and practice related to the improvement of the mathematical conditions of women must at every level honour the individual gendered student... [and that at least] some of the answers to ‘the problem of women and mathematics’ will be found at the level of the global structure of the curriculum

(Damarin, 1995, p. 249)

A gender-inclusive curriculum, which encompasses all aspects of the curriculum, not just gender-inclusive teaching strategies, is what is advocated. This is derived from an Inclusive perspective and emphasises a more global approach to overcoming gender biases in the traditional mathematics curriculum. This approach characterises most of the literature presented in this section.

Lustig (1989), for example, challenged the current mainstream curricula in mathematics on the grounds that these did not challenge patriarchy or recognise the importance of female-centered study. She cited Jan Harding's work in the United Kingdom as an example of an inclusive curriculum, because it was designed within a social context, and included issues relevant to women's lives. However, Foster (1992) made the point that women's experience had yet to be the category of analysis guiding curriculum development. Apple (1995) took this idea further and suggested that students' actual experiences are rarely considered when constructing a mathematics curriculum. He asserted that a curriculum constructed around present work patterns ignores an increasing world trend towards low-wage, part-time, non-unionised service-sector employment. Apple did not mention that this sphere of work has always had a much higher proportion of women, and that, despite this situation, issues pertaining to these aspects of work do not appear to have been considered in most mathematics curriculum development.

Foster (1989) was also concerned with inclusive human representation in the curriculum, but thought that teachers were not aware enough of the complexity required for a curriculum to be an effective agent for educating girls. She asserted that, in the same way as the present curriculum has been designed and redesigned over the last century to be an effective agent in educating boys, a large number of changes will immediately become possible when teachers became more aware of the importance of inclusivity.

Using mathematics to challenge the existing social order was more a concern of Frankenstein (1995), although she was also concerned with the human and social aspects of the mathematics curriculum. She argued for reforming the curriculum to include problems based on economic, political, and social issues. However, she felt the mainstream mathematics curriculum did not empower students, but instead produced a mathematically-disempowered person, who avoided numbers, and was not able to deal with the statistical data that are essential to gaining an understanding economic, political, and social issues. These mathematically-disempowered students, according to Frankenstein, are not able to delve deeply enough into school mathematics problems to reflect on the picture

they present of our society. Frankenstein challenged the hegemony of mathematics as a tool that “imparts an image of neutrality and naturalness to particular societal arrangements that obscure the class structure of our society”, a point echoed by Apple. He stressed the need for new educational strategies to become “pedagogies of social change” (Apple, 1995, p.338).

For Kenway and Modra (1992) the interaction of gender and schooling through the curriculum, the learner and the teacher was the way in which the curriculum perpetuated inequity. They pointed out how the traditional curriculum highlighted the experiences and interests of white males to the exclusion of all other groups. Chavarria (1993) also criticised the traditional mathematics curriculum as one which was socially and historically disconnected, decontextualised, abstract, and competitive. She also described how it values objectivity and devalues subjectivity, emphasises what the student does not know through assessment techniques, does not validate experience, and values only one approach—deduction. She advocated that a more connected mathematics is called for, one which allows women to contribute to its definition and determination.

Of more concern to Burton (1995) was the re-positioning of mathematics in a cultural context. She pointed out that, if the body of knowledge known as mathematics could be shown to have been derived in a manner which excluded non-Europeans and their mathematical knowledge, then why not conjecture that the perceived maleness of mathematics is equally an artifact of its production and its producers? She argued that a means by which students could be challenged to make this realisation would be through adopting a social constructivist approach to the curriculum. Social constructivism posits that it is through interaction between individuals, society, and knowledge that mathematical meaning is created. Challenging the masculine basis from which mathematics has been constructed was her solution to the problem of making the mathematics curriculum more equitable.

In the ideal situation, all students have access to academically challenging curricula. If females choose not enrol in more advanced mathematics courses, then the reasons why they so choose should be sought and dealt with appropriately. If females are denied access through restrictive scheduling or tracking practices, these should be eliminated where possible. The curriculum would empower students to challenge the hegemony of traditional mathematics through recognising the importance of female-centred study. A connected, equitable curriculum includes the experiences of all students, connects mathematics to the real world, and includes aspects of social action.

Concluding Comments

There is a developmental sense to the research reviewed in this chapter, with much of the early investigations focusing on identifying problems with students. That is not to say that research of this nature is inherently bad or obsolete, since the first step in acting on inequities is recognising that they are there, in other words focusing on observable differences. This often starts with noting differences in student outcomes, then examining teacher inputs and finally looking towards the curriculum itself. It is relatively easy to conduct a thorough and insightful analysis of a mathematics curriculum or examine student achievement outcomes, students' and teachers' behaviours in the classroom, and teachers' assessment methods. It is not so easy to examine the impact a particular curriculum is having in the classroom. It is much easier to suggest how to change students' and teachers' behaviour in the classroom or assessment methods, but to suggest how to change the whole curriculum is much more difficult.

Although a move to a more social constructivist mathematics curriculum has been occurring for some time, as noted by Burton (1992), it has yet to be fully realised as shown in the review presented here. Recently, Parker (1995) provided an explanation for why progress has been so slow. Using the definitions of absolutist and social-constructivist paradigms suggested by Burton (1992), Parker linked the absolutist paradigm with the Willis (1996) Remedial perspective, and the social-constructivist paradigm with the Willis (1996) Inclusive perspective. Willis (1996) pointed out that, in her experience, it is rare that a person sees equity problems from more than one perspective at once, and that it is difficult for most people to change their perspective from one to another. This leads to the conclusion that a major paradigm shift in mathematics education, from absolutist paradigm with passive students receiving knowledge, to a social constructivist paradigm with active students constructing their own knowledge, is necessary at all levels of curriculum policy and practice before equity goals can be fully achieved.

The solutions offered by the research presented in this chapter, which try to make mathematics education more equitable, have come from a variety of perspectives. A number of implications for the CEMC have been synthesised. The next chapter will look first at the body of literature that examines the many small-scale initiatives that have tried to address gender inequities in mathematics education. The final part of Chapter Three will be a synthesis of all of the literature presented concerning gender equity in mathematics education,

culminating in a definition of an ideal Connected Equitable Mathematics Classroom.

CHAPTER THREE

EQUITY INITIATIVES AND THE CONNECTED, EQUITABLE MATHEMATICS CLASSROOM

INTRODUCTION

As indicated in Chapter One, a major aim of this study was to develop a set of criteria which define the essential elements of the Connected Equitable Mathematics Classroom (CEMC). In Chapter One, inequitable participation rates and outcomes of mathematics education for females and males were reviewed. In Chapter Two, theoretical explanations for observed inequities were explored, with implications for the CEMC distilled in each section. The next part of this study examined the literature concerning previous equity reforms in mathematics education, and the results of that analysis are presented in the first part of this chapter. As in Chapter Two, the implications of the findings of the reform literature for the CEMC will be presented in each section. The culmination of the first objective of the study is presented at the end of this chapter as a list of features of an ideal connected, equitable mathematics classroom. These features are then used in the remainder of this study to guide the analysis of the qualitative and quantitative data.

EQUITY BASED REFORMS

In this study, while attempting to review all types of reforms conducted in the name of equity, one of the most difficult problems to overcome was that only a limited number of these initiatives have been documented in the literature, and even fewer properly evaluated, a point also noted by Davis and Rosser (1996). Further, success in an initiative will be defined in many different ways, as will its evaluation. Often, the evaluative component of a project is the last consideration, and finding effective ways to measure or document success is not seen as central to the project, and is therefore not properly included.

There are exceptions to this situation however. For example, Clewell, Anderson and Thorpe (1992) reviewed 168 middle school equity reforms, from

which they identified not only particular barriers to female and minority participation in mathematics and science, but also some common characteristics of effective programs. The reforms presented in their book were categorised as either targeting improved performance, or encouraging positive attitudes towards mathematics and science. Their views reflected mainly a Remedial perspective, as was the case for most interventions conducted during the period up to and including the 1980's. It is only since that time that equity reforms have shifted to include Non-Discriminatory and Inclusive aspects.

In the review presented here, because of the diversity of approaches now found in equity interventions, such interventions are described and critiqued under three headings: (i) changing choices, (ii) changing the learning environment, and (iii) changing the curriculum. These headings reflect approximately the first three Willis (1996) perspectives which were presented in detail in Chapter Two, and represent various perspectives on the solutions to inequities in mathematics education. Changing choices arises out of a Remedial perspective; changing the learning environment arises out of a Non-Discriminatory perspective; and changing the curriculum arises out of the Inclusive perspective. In a discussion of initiatives, however, all aspects of a program will not necessarily correlate to only one perspective. Thus, the purpose of using the Willis perspectives is to aid the clear interpretation of the philosophical bases of the strengths and weaknesses of particular initiatives.

As previously mentioned, few programs have been rigorously evaluated, making it difficult to gauge the degree of "success" of such programs. There were no papers found in the literature search that reported unsuccessful work, and, because of the variety of programs reviewed with such a wide range of goals, the success of each program had to be judged against its own stated goals.

(i) Changing Choices

The Remedial-perspective view was evident in most of the interventions analysed which had the aim of changing the choices of females and minorities: to encourage these students to continue with the study of mathematics, especially at the secondary-school level. For the most part, there was no evidence in the report of the intervention that much thought was given to what would happen to students in the mathematics courses they subsequently enrolled in. Further, the question of what had made mathematics so unappealing to students in the past seemed not to have been considered.

Interventions in this category have taken different paths towards the same end of involving more females and minorities in mathematics. Some have tried to make mathematics seem more enjoyable through after-school clubs and other extra-curricula activities (Campbell, 1995; Keynes, 1995; Sanders, 1993; Stage, Kreinberg, Eccles, & Becker, 1985); some have tried to raise awareness of the importance of mathematics through career information (Campbell, 1995; Fennema, et al., 1981; Stage, et al., 1985); and some have tried to increase the confidence and skills of prospective students so that they will have the “courage” to continue with mathematics (Clewell, et al., 1992; Thompson, 1995).

Increasing enjoyment of and achievement in mathematics

Programs which seek to enhance the participation of females and minorities in mathematics have often involved students attending a special class, designed specifically for females students, where enjoyment of mathematics is a primary aim and increasing mathematics performance a secondary aim. Stage et al (1985) described a number of such programs. For example, the Lawrence Hall of Science *Math for Girls* project aimed at increasing positive attitudes towards mathematics and increasing problem-solving skills. The eight one-and-a-half-hour sessions included activities on problem solving, logic strategies, pattern, spatial visualisation, creative thinking and estimating. The sessions, which established a cooperative recreational atmosphere, were taught by a young woman who used mathematics in her career. The program was successful in its goal of increasing the number of women in the programs of the Lawrence Hall of Science. However, this Remedial perspective program did not consider what would happen to the women once they entered the target program, the aim of the intervention being only to increase participation. Math for Girls did, however, evolve into the EQUALS program, which will be discussed later in this chapter.

In another example, Stage et al (1985) described the *Accelerated Program for Mathematically Gifted Girls*. Using an informal cooperative style with girls-only groups, the program was conducted by three female teachers over a three-month period during summer vacation time. The aim was to help the girls continue with an accelerated mathematics program after the summer course was over. Girls from this special program were just as successful as boys from a similar program that was coeducational; however, girls from the coeducational program were far less likely to continue with an accelerated program. Again, this Remedial perspective intervention was only concerned with encouraging girls to continue with existing courses. No changes to the courses were envisaged

Sanders (1993) described another such program that was successful in getting thousands of girls into mathematics. Although the aim of the program was to increase participation of girls in computing, mathematics and science, the program focused on teachers. In order to reach as wide a student group as possible, the program offered grants to 200 teachers from across the USA. The teachers traveled either to California or Massachusetts for an initial week-long seminar. This was followed up, nine months later, with a three-day seminar. A small amount of money was paid to each teacher and her/his respective school. The seminars were about equity issues in mathematics, science and computing, and were designed to raise awareness of the issue of low female participation in these areas and discuss strategies for increasing enrolments. Teacher participants went back to their schools and presented workshops (written by Sanders) to their faculties. Many participants designed other interventions to suit their own situations. These included bringing female role models into the school to talk to the girls, taking girls to a college where college students and professors talked to them, starting girls-only computer clubs, and helping teachers to be aware of boys' domination in the classroom. Again, this intervention was situated within a Remedial perspective, aimed mainly at increasing participation. Although there were some Non-Discriminatory features—an occasional concern with changing teaching practices—these aspects remained minor, and only occurred in a few of the interventions which teachers designed for their own situations. Considering the number of students who were affected by the program (Sanders was not specific about actual numbers, but referred to “thousands”), this project planted a seed for changes to happen. However, follow-up and feedback on progress occurred only during the first year after the initial input, and any further progress of this project was not reported.

The Remedial perspective view was also evident in the *EUREKA!* mathematics program (Campbell, 1995), a four-week, non-residential summer program run by the Brooklyn College Women's Center. Classes operated in a relaxed environment and concentrated on thinking- and problem-solving skills. At the conclusion of the program, girls reported enjoying and understanding mathematics much more than before. Despite girls increasing their mathematics-course-taking plans after the *EUREKA!* program, no follow-up was cited, and thus again, this element of evaluative evidence is not available.

Some programs offered what were called “enrichment programs” for talented mathematics students. Most of these programs were specifically aimed at increasing enjoyment of mathematics, and encouraging talented students to

continue with the study of mathematics. Keynes (1995), for example described a supplementary after-school program for talented mathematics students in Minnesota, USA. The students attended two-hour classes one afternoon each week for thirty weeks in the school year. Their involvement could then have continued (if they elected) for another five years, including a three-year component of university honours-level calculus for which they could gain credit towards university courses. Each year, of the approximately 1400 students tested, about 150 were accepted. In the first few years of the program, there were few girls and minorities in the program. Coordinators appeared to take a Remedial perspective view of solving this problem in that they changed certain enrolment and testing procedures and provided more and better information about the program to girls and their parents. Subsequently, the number of girls and minorities in this program did increase substantially, although there may have been other factors influencing this trend. However, once girls were in the course they were less persistent than their male counterparts, a problem which was addressed by the coordinators from a more Non-Discriminatory perspective. A series of social and enrichment activities were conducted, with some of the pedagogical practices used in the course being made more “girl-friendly” (Eccles, 1989) by making activities and classroom atmospheres more cooperative and less competitive. To help increase the performance of girls in the course, regular monitoring of the girls’ progress was conducted by maintaining telephone contact with the girls and their parents. This proved so successful that it was then offered to all students. The changes however did not go as far as the content aspects of the curriculum, which remained constant throughout the life of the program.

Raising awareness of the importance of mathematics

The second type of intervention program commonly undertaken from the Remedial perspective involved the provision of extra-curricula activities for women such as “Expanding your horizons in math and science” conferences (Stage, et al., 1985); visits to non-traditional work places or visits from speakers who had non-traditional jobs; use of media campaigns such as one in Western Australia to convince students (particularly girls) that “maths multiplies your choices” (Willis, 1995a); and the use of videotapes that highlighted the variety of careers that require mathematical competence, such as the *Multiplying Options and Subtracting Bias* series described by Fennema et al (1981). These programs attempted to raise awareness of the importance of mathematical competence in the workplace. Girls were encouraged to break stereotypes and not let the fact that

they were female stand in the way of pursuing any career option. The focus was on highlighting the importance of mathematics to girls' post-school options.

Campbell (1995) referred to two such programs which she had helped evaluate. The first was the Douglas Science Institute (DSI), a two-week residential program for high-school girls entering Year 11. Typically, girls of this age have already made up their minds about their future course plans in mathematics and science, so the DSI had little impact on these girls' plans. However, participants reported feeling a greater commitment to pursuing a career in mathematics or science. This commitment was later manifested for 65% of the DSI participants who entered college and enrolled in mathematics, science or engineering courses, although Campbell did not indicate that there had been any follow-up with these girls to monitor their progress through their courses. The second program Campbell discussed was a career-exposure day. Women in non-traditional occupations were invited to attend and interact with girls. Campbell did not provide any details about the age of the girls, but success was reported in terms of an increased measure of interest in mathematics and science as compared to prior to the day. This Remedial-perspective program located the problem of low participation in non-traditional occupations with girls and their lack of information about such careers. Once sufficient information was provided to the girls, it was assumed that they would select these careers more often. The solution was to change girls so that they became more interested in mathematics. Although the result was that more girls enrolled or were more interested in mathematics courses, changes to the course content or pedagogy was not considered as part of the initiative.

Programs to enhance mathematics-related attitudes and affect

The third type of Remedial-perspective program seeks to enhance the self esteem and confidence of girls, thereby allegedly making it easier for them to take risks and continue with the study of mathematics. Some programs also included in this group have aimed at improving attitudes towards mathematics. Thompson (1995) described a program of this type in some detail, namely the Metro program which operated on the west side of Chicago. The program aimed to encourage academic achievement, especially in mathematics and science; to aid students' personal development; and to instill a spirit of community service. Three age groups were catered to, with different strategies employed for each group. The Metro program was able to increase participants' confidence in their ability to succeed but unfortunately Thompson gave no details about actual achievement. A

minor amount of follow-up was undertaken with graduates of the program, all of whom reported that Metro had helped them develop their mathematical ability. However, one student reported that, although the program had helped her enrol in a high-level class, she had been unable to remain in courses at that level. No reasons were given for this, but, as no change to pedagogy or curriculum had taken place in the high-level courses, it could be that this student was alienated by the environment and so withdrew.

Other programs in this category are described in four case studies, by Clewell, Anderson and Thorpe (1992), of a number of mathematics intervention programs conducted in the USA during the 1980's.

- (i) The *Family Math* project, an off-shoot of the *EQUALS* group, aimed to increase parent awareness of the importance of mathematics, to build positive attitudes towards mathematics, and help families become involved in their children's mathematics program. Courses for parents were run outside school hours, typically for four to eight weeks, and consisted of mathematics activities that were enjoyable and non-threatening. Linking mathematics to the workplace and modeling good teaching practices that parents can use with their children were important components. This project was subsequently conducted in many other countries around the world including Australia. Although no details have been given about the impact of the project on students (children of parents attending *Family Math*), the program has reported great success with improving parents' attitudes towards mathematics.
- (ii) The *Mathematics, Engineering, Science Achievement (MESA)* project was aimed at identifying minority students who have interest and some facility in mathematics and science, with a view toward keeping them focused motivated and informed, so that they will have the necessary background for university study in mathematics, science or engineering when they graduate high school. The program offered on-site after-hours study assistance during the school week; activities to involve parents, usually once a month; and a summer enrichment program. Evaluations indicated that more than 90% of MESA-secondary-program graduates went on to college or university, with two-thirds of that group participating in engineering, computer-science or related technical fields.
- (iii) *Project SMART* aimed to help girls acquire an attitude of scientific inquiry toward everything they do. The project operated at the *Girls Incorporated* (formerly *Girls Club of America*) sites. They offered programs in

mathematics, science, technology and computers, and provided girls with access to resources in the community. The program consisted of hands-on activities in problem solving which involved exploration, inquiry, questioning and risk-taking. Sketchy details are given about evaluation of the program.

- (iv) *Project Interface* targeted underachieving minority students, helping them to make the transition from general mathematics and science classes to college preparatory courses. The project students participated in small-group study sessions, went on field trips, interacted with academic counselors and role models, and received incentive awards. Evaluations indicated that enrolment in more advanced mathematics courses did increase as a result of the project, but, as with many programs, no details of follow-up were given.

It is emphasised that although these programs may have increased interest and enjoyment in mathematics, as noted by Campbell (1995), the programs appear to be aimed at changing the girls and little else. The problems of poor participation and performance in mathematics were located with the females or minorities, and solutions focused on changing these groups. There was no indication that consideration had been given to other solutions such as changing teaching practices or the curriculum. Furthermore, few of these projects followed up students after they had left the special program and entered traditional mathematics courses. Arguably, just getting the students there does not ensure that they stay. If the aim has been to increase the number of women successfully completing higher degrees in mathematics, in terms of overall numbers, evidence suggests that men still outnumber women in PhD degrees in mathematics in the USA by more than four to one, although there has been a doubling of the number of women in these courses over the period 1975 to 1990 (National Science Board, 1993).

College-level interventions

College-level program and curriculum interventions were reviewed by Davis (1996), who also noted the lack of any formal evaluation of these programs. One type of program reviewed included research internships, which provide funding for postgraduate students to continue with research. As Davis (1996) pointed out, the problem with this type of support is that it does not attract new people to the discipline, supporting only those people already interested in mathematics and science. Davis also reported that, although role models were

somewhat effective in attracting females into non-traditional courses, merely having women faculty did not guarantee greater female enrolment. On a more positive note, she described living and learning communities where a small number of people live and work together in a supportive community. Such groups were found to help women develop confidence in themselves as learners. Further, although she concluded that mentoring programs were often ineffective, professional and social support networks, such as those that many men establish through sporting and social clubs, when extended to include women through professional social networks, were found to be very helpful. None of these initiatives, although aimed at making the university environment more friendly towards women, challenged any of the pedagogical practices or curricula in mathematics.

Summary

Because the Remedial perspective frames equity problems in terms of some type of deficit within the person, these interventions, as noted by Willis (1995a, p.188) “may actually reinforce the notion that ‘the problems’ of girls and mathematics lie outside the classroom and school”. This perspective tends to assume that providing access and ensuring all students have the necessary background skills and behaviours will be sufficient to ensure equity. Interventions designed from this perspective act rather like treating a disease by relieving its symptoms. The symptoms may improve, but, if the underlying cause is not dealt with, the symptoms are likely to return. That is not to say that programs of this nature are inherently bad and have no place, but they are limited to the one view that helping students gain more skills, enabling them to participate and to achieve better results will lead to equity. Further, Willis (1995a) made the point that interventions such as these, which encourage girls to participate further in traditionally-structured mathematics classes, but which continue to present a masculinised view of mathematics, may even lead to negative or destructive experiences.

Parsons (1993) explained the Remedial perspective as one which would allow the system to be blamed for females not acquiring the same background knowledge as males, and therefore being unprepared for certain subjects, such as science, which draw heavily from male experiences for contexts. More specifically, Kenway and Willis (1993) criticised initiatives aimed at changing girls, or changing the choices of girls, through role-modeling; advertising non-traditional fields via talks, posters and T-shirts; self-esteem-building activities;

and single-sex classes. While they acknowledged that these activities have certain strengths, they also suggested some weaknesses. They pointed out that changing girls, or their choices, places responsibility for change on the girls themselves and fails to challenge the need for change in those agencies actively involved in the production of inequity, namely schools and teachers. In the ideal situation, teachers and schools are also involved in change.

In the CEMC, teachers provide career information, emphasise the importance of mathematics to students, provide activities that are enjoyable, and provide activities which enhance the basic skills and build the confidence of all students.

(ii) Change the Learning Environment

In order to change the learning environment to make it more suitable or appealing to the different learning styles of females, many interventions have focused on helping teachers learn to use cooperative groups, teach problem solving and use inquiry methods in their teaching. These methods, which often use real-world problems as their focus, have always been favoured by feminist teachers trying to connect women with mathematics (See for example (Morrow & Morrow, 1995) and have been advocated for all students by the National Council of Teachers of Mathematics (NCTM) through their teaching, curriculum and assessment standards for school mathematics (National Council of Teachers of Mathematics, 1989; 1991; 1995).

The NCTM *Professional Standards for Teaching Mathematics* outline a vision of mathematics teaching encompassing teaching, evaluating teaching, and professional development. The five tasks facing teachers in the classroom listed in the Standards are to:

- (i) shift toward classrooms as mathematical communities and away from classrooms as simply a collection of individuals;
- (ii) shift toward logic and mathematical evidence as verification and away from the teacher as sole authority for right answers;
- (iii) shift toward mathematical reasoning and away from the mere memorization of procedures;
- (iv) shift toward conjecturing, inventing, and problem solving and away from merely emphasizing finding the correct answer;
- (v) shift toward connecting mathematics, its ideas, and its applications and away from treating mathematics as a body of isolated concepts and skills.

(National Council of Teachers of Mathematics, 1991)

Although the standards documents explicitly state that mathematics should be for all students, mathematics educators should not assume that implementing the NCTM standards will ensure that all equity objectives are met. Wilbur [as cited in AAUW (1992)] analysed the NCTM reform documents and found that the inclusive, affirming and integrated approaches, which she considered essential for equity, were not specifically dealt with by the NCTM documents.

The ideas of constructivism can also be recognised in the reform agenda, the main thrust of which is that people create their own knowledge in situations that are personally meaningful. Davis (1996) describes this as a building up of personal knowledge based on new input. This is then assimilated with information already known so that mathematics is performed by integrating a collection of pieces of knowledge, both new and old. The constructivist teacher is concerned about non-verbal signals from students, and with how students are thinking. The idea that new information has to be constructed in situations that are personally meaningful leads to recognising the importance of context in mathematics problems. Fundamental to this model of learning is that students must be able to personally relate to a context in order for it to be meaningful.

Connectedness is a major thread running through both of these reform agendas. That is, students must be connected to the mathematics, and teachers must be connected to the students in order for meaningful learning to take place. Thus, most of the interventions reviewed in the following sections emphasise the need for connectedness, although the authors may not use this term.

Connected teaching, according to Belenky and her colleagues (Belenky, et al., 1986), involves both the teacher and the student in the learning process. Teachers are called on to make transparent their modes of thinking: illuminating right and wrong turns in a path towards finding a solution to a problem. The teacher's role is analogous to that of a midwife, helping students to bring out their own ideas. This is in contrast to the typical role of a teacher, as more like a banker who deposits knowledge in the learner's head. The atmosphere in a connected teacher's class is one which provides a culture to support growth, where students support each other's ideas, and do not apologise for or criticise uncertainty. Truth is constructed through consensus not conflict, and diversity of opinion is welcomed. The power structures of student and teacher are somewhat changed in the connected teacher's class. Although the teacher is involved in the learning process along with the student, the teacher still retains an authoritative role, though not one of power over students. Rather the teacher's role is one of authority based on cooperation instead of subordination.

Becker (1995) has applied the Belenky et al (1986) framework to her research in mathematics education. She outlined how the ideas of connected teaching apply to teaching and learning mathematics, making the point that mathematics needs to be taught as a process, not a universal truth. In connected teaching, teacher and student engage in the process of thinking and discovering mathematics together. Alternate methods of solution are encouraged and groups are created in which members can nurture each other's thoughts to maturity. Diversity of approach is welcomed in discussions. Truth or knowledge is constructed through consensus, not through conflict. Connected teachers are portrayed as trusting their students' thinking and encouraging them to expand upon it. These pedagogical techniques shift the focus of learning from the teacher as provider of knowledge to the student as participant in constructing his or her own knowledge.

Support for the effectiveness of connected teaching in improving equity outcomes for females has come from a very recent study in the UK. Two schools taught the same content in completely different ways: one using a very traditional textbook approach, the other using an open, project-based approach which Boaler (1997) described as a "connected" approach. Boaler (1997) found that the textbook approach was associated with females under achieving, whereas the open, connected approach appeared to produce equity of achievement among females and males.

Baxter Magolda stresses the need for connection with students as a way of helping students confirm their way of knowing. "Confirmation sets the stage for students to become creators of knowledge, rather than recipients of it" (Baxter Magolda, 1992, p. 269). She advocated the use of three principles that should ensure that confirmation is balanced by some contradiction, which aids in "adjusting one's way of knowing to account for new experience" (Baxter Magolda, 1992, p. 270). The principles are "validating the students as knower, situating learning in the students' own experience, and defining learning as jointly constructing meaning" (Baxter Magolda, 1992, p. 270). Baxter Magolda also discussed the importance of linking all three concepts. She pointed out that validating the student as knower is largely achieved through developing student voice. By situating the learning in students' own experience, a link is provided so that students can connect with the subject as well as the teacher. The process of jointly constructing meaning in the classroom is marked by attachment and connection and will not occur in a classroom characterised by separation or abstraction. If the joint construction of meaning is to be successful, teachers

should respect and not necessarily blindly accept students' ideas. Noddings (1991) would characterise this respect as an essential element of being a caring teacher. Noddings placed the idea of caring at the centre of the teaching relationship. She described the caring teacher as one who receives not only what students say, but also the students themselves. In other words, caring is central to being able to connect with students on more than a superficial level. The importance of caring was reiterated by Darling-Hammond (1996), who reported on a study of teachers who were successful in developing understanding in students. One finding was that these teachers had a caring approach, and developed strong relationships with students and parents.

Interventions aimed at changing teaching practices

One of the first large-scale programs to attempt to change classroom practices and encourage more girls to continue with mathematics was the EQUALS program (Kreinberg & Lewis, 1996). It began in the mid-1970's and was developed by the Lawrence Hall of Science, a public science centre at the University of California at Berkeley. It was a thirty-six-hour course given in six sessions throughout an academic year. The activities included teaching strategies to encourage problem solving, cooperative learning, use of alternative assessment strategies, career information, role models, discussions of class, gender and culture issues and managing change in schools. The success of the project was documented in a number of publications (Kreinberg and Lewis, 1996, p.186), along with evaluation studies carried out with teachers and students (Kreinberg and Lewis, 1996, p.188).

In the United States, a number of projects have focused specifically on helping teachers to implement the NCTM (1989) standards. Of particular note is *Project LINC*S. Swafford, Jones and Thornton (1995) from central Illinois USA described this project, a three-year intervention program focused on forty-eight middle-grades teachers. Although equity was not a stated goal of *Project LINC*S, some equity goals were embedded in this project because of the equity goals implicit in the NCTM reform agenda. This project adopted a Non-Discriminatory perspective towards improving outcomes for students: a belief that updating teachers' pedagogical knowledge would lead to changes in the learning environment. Changes in content knowledge, beliefs about confidence, and instructional practices were evident in the participating teachers at the end of the three-year project, but only after extensive and ongoing exposure to new pedagogies, as well as time to reflect on their current practices in an atmosphere

of collegial support and collaboration. Six case studies revealed changes in classroom practices among all teachers, but to varying degrees and at various rates. These findings highlighted the importance of allowing teachers time to absorb and reflect on new pedagogies.

Another reform project focusing on implementing pedagogy to enable students to become active constructors of knowledge was the *QUASAR* project, described by Silver, Smith and Nelson (1995). The project was developed at six sites in six different states across the USA. Geographical diversity was matched by diversity in racial and ethnic populations across the sites. This project was started around the same time that the NCTM standards were published, with clear elements of the NCTM standards in its goals. The authors stressed the need for mathematics to be more connected to students' lives, a common goal of most current reforms.

Although there is a strong desire to have students learn more mathematics, the intent of the current reform effort is not simply to give students more of what they are now offered in mathematics. It will be insufficient for students to take more mathematics courses, if those courses teach content that is too limited, if they fail to connect mathematics to students' life experiences, and if they fail to empower students to use mathematics in a wide variety of settings.

(Silver, et al., 1995, p. 22)

The *QUASAR* project was focused on changing instructional programs for middle-school mathematics, and was based "...on the premise that it is both necessary and possible to develop mathematics education in a way that serves all students well and provides avenues for them to develop their intellectual potential" (p. 11). *QUASAR* focused on individual schools, rather than on districts or individual teachers, as the starting point for systemic educational reform. The Non-Discriminatory perspective was evident in the way the project aimed to change the learning environment by changing teaching and assessment practices. The project used instructional practices that supported the goals of thinking, reasoning, and problem solving, and aimed to create classroom communities that value thinking and reasoning and provide a safe environment for students. One of the main vehicles for making sure that all students were able to access high quality mathematics instruction was the elimination of tracking at *QUASAR* schools. Teachers implemented cooperative learning and supported mathematical thinking and communication. School-wide efforts were instituted to create trust and mutual respect, an atmosphere which was often missing in the classrooms targeted by *QUASAR*. The relevance of school mathematics was also enhanced in the project by teachers making sure that students' life experiences were valued and used as contexts during instruction and assessment. Silver et al did not

provide any information about formal evaluation of the project, although they did mention that teacher participants reported anecdotal evidence of increased student achievement, interest and enjoyment of mathematics.

Another example of discovery teaching methods based on constructivist principles was reported by Clewell, Anderson and Thorpe (1992). *Project SEED* was based on the idea that minority students often do poorly in school because their teachers have low expectations of them. The view was that the way in which teachers viewed students was a major factor contributing to poor achievement, and the solution to the problem of under-achievement was to change the learning environment. To help these students experience success and overcome their problems, *Project SEED* used mathematics specialists four or five times a week to teach small classes of students using discovery methods. The methods reflected constructivist principles, where students were encouraged to explore a concept for themselves and therefore construct their own knowledge. The *SEED* specialists were often from industry or research and not classroom teachers. They were chosen because they had a thorough grounding in advanced mathematics. Intensive training was given to the specialists before they started teaching classes, and ongoing in-service training and evaluation continued throughout their involvement with *Project SEED*. There were also spin-off professional development activities for regular classroom teachers enthused by the success of the methods used by *SEED* specialists. Evaluations conducted with the students by the project team leaders indicated very positive results for *SEED* students, both in terms of achievement and attitudes towards mathematics. The project was successful in its goal of increasing the achievement of minority students. The authors concluded that the use of constructivist methods was a major contributor to the success of the project.

Similar success with “teaching for meaning” was reported by Knapp, Shields and Turnbull (1995). Their study examined the teaching practices of 140 teachers in high-poverty elementary classrooms. They found clear evidence that students of teachers who had adopted essentially a constructivist approach, which they called “teaching for meaning”, were likely to demonstrate a better grasp of advanced skills at the end of the school year. They pointed out that teaching for meaning is especially appropriate and effective for the culturally-diverse classroom, because it helps students connect their out-of-school experiences with classroom learning.

The ideas of connected teaching observed in action were documented by Rogers (1990). She used the term “Inclusive Pedagogy”, and cited the example of

Potsdam College which has been very successful in attracting female mathematics majors. At the time of her study, the College had only one female among its fifteen-member mathematics faculty. However, many of the staff saw themselves more as coaches than lecturers, and did not subscribe to the “banking” analogy of education: that students come to school to have knowledge deposited in them by teachers. Rogers critiqued the lecture mode of presentation as a pedagogy which perpetuates traditional power structures in mathematics and turns many girls off. She described the classroom created by the faculty at Potsdam College as one of connectedness, where all students are empowered to find their own voices. In Baxter Magolda’s (1992) terms, this helps students move from being transitional to independent knowers. The faculty at Potsdam were examples of empowering teachers: those who develop student voice by helping students to learn to think and to speak the truth. The teacher shares the journey of recreating mathematics with students. In a truly open and supportive environment such as the one at Potsdam College, women are involved in mathematics to the same extent as men.

Rogers (1995) described the success of a feminist mathematics pedagogy used in her own practice, which she again termed “inclusive”. Although the pedagogy described by Rogers (1995) had many of the elements of connected teaching, it was still only a new pedagogy, not a new curriculum as well. Hence, it does not fit into the Willis Inclusive perspective. Some of Rogers’ techniques include using lectures sparingly, substituting “think-write-pair-discuss” activities; whole-group dialogue; student-directed board work; brainstorming; student-generated problem posing investigations; small-group work reading exercises; and forward-backward proof techniques. Her classroom community was characterised by safety and trust, which she noted as essential for risk-taking. Her method of teaching constantly included students, often to a level of involvement that some students found hard to adjust to. Her assessment techniques included formative assessment, ongoing throughout the course; homework assignments where collaboration was encouraged in the initial stages, but individual write up was required; and participation credit where students had to demonstrate participation either by visiting the lecturer, presenting assigned readings in class or participating in class activities. Tests, which covered a small section of the course, were given regularly. Students were able to improve their grades by resubmitting parts of the test. Examinations which covered the whole course were also given because she believed that students must be given a chance to pull all the threads of the concepts together. Rogers made sure that she had enough feedback during the semester for her to know her students well. She allowed her students to become

full participants in the learning process, connecting with them on a much deeper level than would have been possible using traditional methods.

Fullerton (1995) also described how she facilitated her pre-service teachers making a connection to mathematics. Nearly all of these student teachers were female and had low self-esteem with respect to their mathematics ability. She set up a discussion group which had them talking about mathematics, using mathematical language, exploring ways to become more confident learners of mathematics, and discussing how to make mathematics more relevant. Throughout the course of the discussion group, she distilled four issues that all of these women identified with. First, none of them knew how to talk about mathematics, or had ever been involved in any mathematical discussions. Second, none of them knew the appropriate language of mathematics in order to carry out a mathematical discussion. Third, none of them saw any relevance for mathematics beyond using simple arithmetic in obvious situations. Fourth, none of them had any confidence in their ability to learn mathematics. Her study highlighted the importance of four important teaching points that could prevent students from becoming maths-phobic: (i) allow students time to discuss mathematics; (ii) use a mathematics vocabulary in the classroom to enable students to identify with it and use it themselves; (iii) make the mathematics relevant to the students' lives by connecting it to their own experiences; (iv) affirm female students' abilities and build confidence. After Rogers had changed her own teaching practices in these ways, she noted her students making substantial gains in their ability to understand mathematics. She argued that through enhancing female learning, ultimately all students benefit. The message of this project was how to enhance female learning through changing pedagogy, in order that all students connect with mathematics and develop more positive attitudes towards it.

Taking a slightly different path towards achieving equity were Carey, Fennema, Carpenter and Franke (1995). They made the point that equity in the mathematics classroom will only be achieved when classrooms are structured so that all students, regardless of race, class, gender, or any other characteristic, will be able to learn mathematics. They discussed the techniques of Cognitively Guided Instruction (CGI), which focus on analysing the way children intuitively solve mathematical problems. Teachers, once they come to understand the way a certain child thinks, are able to design a mathematics program around this child's experiences and thought patterns. The child is then able to make connections between formal, intuitive and school-based knowledge so as to form a bridge

between school and the outside world. Initial trials with first-grade African-American populations have shown that children are able to realise their potential for engaging in thoughtful problem-solving tasks, and successfully bridge the home/school gap in mathematical knowledge and application. To date, the program has only been developed for lower primary grades (K-3). The CGI program empowered students to make decisions for themselves about what is appropriate for them in terms of context and content of mathematics. It did, however, require a lot from teachers, and has been criticised for this. Struggling with the implementation of CGI appeared to be the norm for teachers trying to use the program, but, as Carey et al (1995) pointed out, this struggle for an equitable classroom seemed to be worthwhile for teachers and students alike. The importance of students connecting with mathematics is once again emphasised in this project.

Culturally-relevant teaching, or multicultural education as it is sometimes known (Banks, 1995), has also emphasised the concepts of connected teaching, but does not use this terminology. Ladson-Billings (1995) cited the example of one teacher who was particularly successful with African American children in her classroom. The teacher employed techniques such as constantly praising students and telling them they are smart, focusing on mathematics for the entire lesson, helping them to make the transition from what they know to what they don't know, getting to know each student in depth, and extending students past what they already know. Lipman (1995) described the efforts of three teachers in reforming schools and their attempts to make their classrooms relevant for African-American children. Methods they employed included setting high standards; helping students connect their experiences to academic knowledge; challenging students with academic content; respecting students; relating prior knowledge to new content; and impressing upon students their potential to make a difference for themselves, their families and society as a whole.

Tate (1995b) described the efforts of one teacher in the USA to make the curriculum more relevant by presenting a problem and allowing the students to work through all aspects of solving it. The students were concerned about the number of liquor stores near their school; so they researched all the by-laws and codes associated with the situation and then devised a plan to deal with it. Central to the teacher's approach was direct communication between teacher, students, and outside bodies; cooperative group work; investigative research; questioning content, people and institutions; open-ended problem solving connected to student experiences; and social action.

Tate, Lipman and Ladson-Billings all emphasised the importance of connecting mathematics to students' experiences, the vehicle for which is changing pedagogy and sometimes curriculum as well.

There is, however, one caution to be made about transferring ideas from feminist scholarship into reform agendas. Many reform efforts in mathematics education have failed to identify where the initial push for cooperative learning and connected teaching has come from (Apple, 1995; Secada, 1995), and in so doing may have lost the potential for improving classroom outcomes of females and minorities.

There is a long history in educational scholarship of borrowing perspectives from other disciplines—taking them out of their self-correcting context. Thus, we are then unaware of the debates over their empirical, or political status and, hence, may risk importing these dangers into our own activities and research.

(Apple, 1995, p. 340)

In addition, it has also been recognised that using cooperative groups as a teaching method, without due concern about potential power differentials within groups, can be counter-productive (Davis & Rosser, 1996). Simply using group work in the classroom will not necessarily lead to a more equitable classroom, and has been shown in some cases to reinforce existing power differentials (Clark, 1990; Higgins, 1995). Group work must be closely monitored by the teacher to ensure that there is equality of power and effort in the groups.

Finally, if the aim of reform is to make mathematics more meaningful to all students, efforts to connect mathematics to students' experiences will be counterproductive if the background experiences of one particular group of students are used as material for real-world contexts in the classroom to the exclusion of all others.

Changing assessment practices

Changing the way in which students are assessed as a way to make educational outcomes more equitable is a relatively new reform strategy (Silver, 1992). Assessment-driven strategies which are intended to change mathematics instruction are limited, particularly in the USA, because of the widespread use by state education authorities of externally-mandated testing. The cost of operating such systems is huge, and multiple-choice tests are much less costly to administer to large populations. Other issues, such as the technical difficulty of constructing reliable, valid alternatives to multiple-choice items, and the likelihood that changes in assessment alone will not lead to the educational reform being sought, have also hampered efforts to reform assessment practices. The assessment

literature reviewed in Chapter Two showed that “performance assessments” were more likely to favour females. These have also been shown, however, to require much greater financial and human input, particularly if they are to be used as high-stakes accountability measures. The literature review also clearly showed that multiple-choice testing favours males, and although the move away from this form of testing is underway in the USA, for the reasons outlined above, it seems unlikely that multiple-choice testing will be abolished in the near future.

Equity objectives are most often not the driving forces behind the impetus to change assessment practices, and resultant changes in outcomes that are attributable to changes in assessment practices have been to a large extent serendipitous. Further, recent examples from Australia and the UK demonstrate that changes in assessment practices which initially led to improved performance for females, were subsequently changed in a manner which again made them favour males, although there were other stated equity reasons why these systems reverted.

In the Australian example, in recent years the state of Victoria has made major changes to their assessment system in pre-university mathematics, which have impacted differentially on equity outcomes. A much broader range of assessment styles was introduced to the Victorian Certificate of Education (VCE) in 1991 to include four major Common Assessment Tasks (CATs). There were two CATs that required extended written responses and could be completed in the student’s own time, and two that were completed in a limited time and administered under traditional examination conditions. Cox (1993; 1994) analysed the results of the 1992 and 1993 mathematics CATs. For the 1992 data, he found that the extended-response CATs favoured females, and the traditional examination CATs favoured males. However, in 1993 the system was modified to exclude one of the extended-response CATs, due officially to difficulties involved with authenticating students’ work and the heavy workload imposed on students by having to prepare for four CATs. This was shown to have a detrimental effect on females because apparently it meant that two-thirds of the final assessment was in a format that seemed to favour males, while only one-third favoured females, whereas prior to the changes, the system had been more balanced.

The example from Britain is somewhat similar. Typically, the mathematics General Certificate of Secondary Education (GCSE), taken by approximately 80 per cent of the age cohort (Gipps, 1994), includes a performance assessment which consists of investigative work. In 1991, the proportion of coursework allowed in the mathematics GCSE was reduced to a maximum of 20 per cent.

This change was made in controversial circumstances (Smart, 1996), because it was thought it would have a detrimental effect on females' performance. Smart (1996) attributed these changes to a recession in the British economy at the time and a consequent conservative backlash against feminism: the establishment no longer saw a need to encourage women into mathematics and science and manipulated the system to reverse the gains that had been made over the previous decade. Gipps (1994) attributed these changes to concerns raised by parents that students from middle and upper class families were more likely to get help with performance assessment, and were more likely to have better resources at home such as computers, access to books and a quiet place to study, that would advantage them on the assessment task. This problem was alleviated to a small degree by having students complete the assessments in more controlled conditions at school and by the teacher certifying that the work was completed by the candidate.

Whatever the reason, manipulating assessment systems can clearly influence educational outcomes of both females and males. Until many more of the problems posed by using performance assessments in high-stakes testing situations are overcome it seems unlikely that performance assessment will be the norm in the USA in the near future.

Single-sex classes

Many researchers and practitioners consider that another way of making the classroom more female-friendly might be to segregate males and females. A number of studies have investigated various aspects of single-sex classrooms. Parker and Rennie (1996) synthesised the previous research into single-sex groupings. They found five contexts in which single-sex education research had been conducted:

1. Challenges to coeducation.
2. Studies which set out to compare single-sex and coeducational school or classroom environments.
3. Studies of the amalgamation of a boys' and a girls' single-sex school into a coeducational school.
4. Studies of women's colleges in the USA.
5. Studies of the implementation of a single-sex grouping in coeducational schools.

(Parker & Rennie, 1996, pp. 2-3)

In the context of the fifth category, Smith (1986) reported on a five-year project in an English secondary school. The achievements of two intakes of

students were compared on a variety of assessments both internal and external, measuring quantitative ability and attitude towards mathematics. The first intake, the control group, was taught mathematics in a coeducational setting for five years. The second intake was taught mathematics in single-sex classes for five years. Comparisons were made between four groups of students: mixed boys, segregated boys, mixed girls and segregated girls. These groups were matched on ability, as measured by standardised tests administered before the start of the project. There was little difference between the two boys groups in either attitudes towards mathematics or achievement. For the girls, segregated girls perceived maths to be significantly less useful than did mixed girls, with little difference between the girls groups in other attitude or achievement measures. Both groups of girls perceived maths to be more difficult than the two boys groups. Both groups of boys performed better on the external exams than did both groups of girls, although the differences were not statistically significant. Teachers at the school who had experience with both mixed and segregated groups found that segregation was most beneficial for younger girls, and least beneficial for older boys where discipline problems were most likely to occur.

Rowe (1988) investigated the relationship between single-sex class type and achievement. A small relationship was found between confidence and achievement: class-type did affect confidence in learning and using mathematics, and being in a single-sex class significantly increased the likelihood of subsequent participation in further mathematics courses.

Parker and Rennie (1994; 1995) presented the findings of the monitoring of a large-scale project trialing the use of single-sex classes in mathematics and science in mixed-sex high schools. Although there were mixed findings, both the girls' attitudes and the girls' and boys' achievement benefited from a single-sex environment:

“... girls in mixed-sex classes perceived themselves to participate less, to be less extroverted, to have less interaction with the teacher and to receive more harassment from other students than girls in single-sex classes”

(Parker & Rennie, 1995, p. 66).

Boys in single sex classes felt the most harassed, and girls in single-sex classes the least. However, in the interviews and the extended response section of questionnaires administered to students in the trial, a number of girls expressed their dislike of the single-sex environment. Parker and Rennie concluded that, overall, the single-sex environment is most beneficial for those girls who receive a lot of harassment from boys in mixed-sex classes and least beneficial for high-

achieving girls and boys who benefit from the competitive environment offered by the mixed-sex classes. There were also some negative effects upon certain boys in those classes that became particularly difficult to control in the single-sex environment. Parents of these boys were at times particularly vocal about their perception that their sons were being penalised by being in single-sex classes. Teachers of these boys-only classes found it necessary to be more structured and insistent about written and oral communication with the boys. Dealing with behaviour problems in the boys' classes was the most problematic issue in this trial, and the one most likely to be associated with schools withdrawing from the project.

Clearly, a single-sex environment is beneficial for some students in some situations, although it could be argued these are artificial situations. Mura (1995) criticised segregation on the grounds that it reinforces the gender stereotype that males and females think differently, and exaggerates the tensions between males and females. She also reminded us that single-sex education has traditionally not been implemented with feminist goals in mind, and that females have often received an inferior education as a result. Parker and Rennie (1996) on the other hand, pointed out that some groups see single-sex education as a way to cater to differing learning styles and maturation rates of males and females. Given all of this, as a short term initiative that helps underachieving girls with mathematics in a supportive environment, single-sex education nevertheless appears to have some merit.

Summary

The outcomes of those interventions aimed at changing teaching practices presented in the preceding section have contributed a number of elements to the definition of the CEMC. The most significant of these was the importance of connecting classroom mathematics to the lives of the students in the class. This could be accomplished through using real-world problems set in personally meaningful contexts. Baxter Magolda's three principles to enhance confirmation of self and enable students to construct their own knowledge were also very important aspects of the CEMC. These were "...validating the students as knower, situating learning in the students' own experience, and defining learning as jointly constructing meaning" (Baxter Magolda, 1992, p. 270). The use of cooperative learning and a range of assessment techniques were two more aspects that were important elements in many of the successful interventions analysed here.

(iii) Change the Curriculum

The projects described in this section have all had the common theme of wanting to provide a more equitable curriculum for all students. Because of the differences in the education systems of the countries selected for inclusion, this section will be dealt with by country. Australia, Britain and the USA were selected because these are the three countries which have been actively involved in curriculum development with an equity focus over the recent past.

Australian projects

The blueprint for gender equity policies in Australia in the 1990's has been the *National Action Plan for the Education of Girls 1993-1997* (Australian Education Council, 1993). This document represents the culmination of many years of national reports about the status of gender equity across the whole curriculum in Australia starting in 1975 with *Girls, Schools and Society* (Australia Schools Commission, 1975). The *National Action Plan* focused attention on analysing existing practices, with a view towards making changes in schools which would redress those biased practices which have tended to limit the horizons and reduce the self-esteem of girls. The National Action Plan also helped teachers to assist both boys and girls in coping with a world where gender no longer dictates life patterns and in which the social roles of the sexes are becoming increasingly fluid. Its policy statement provided a focal point for schools and teachers who were concerned about equity in their school.

Prior to the *National Action Plan*, but anticipating its philosophy, the Education of Girls in Schools project was an attempt to increase the participation of girls in upper secondary mathematics and science, specifically through the provision of non-sexist curriculum materials both intellectually challenging and mathematically related to the real world (Willis, 1989a). A series of mathematics books were produced for senior secondary calculus entitled *Investigating Change* (Barnes, 1991, 1993). Barnes and Coupland (1990) described the development of this gender-inclusive calculus curriculum, the origin of which lay in the needs of a group of mostly female mature-age tertiary students for more calculus in order to pursue science-based tertiary courses. For the *Investigating Change* series of text books (Barnes, 1991, 1993), Barnes found contexts relevant to women's lives and provided connection to the contemporary world by examining the history of the development of calculus. Teaching notes available with the text books suggested the use of cooperative groups and student-centered inquiry methods to help students understand the role of intuition, imagination and creativity, and recognise

the importance of the process by which mathematics is derived. The teaching notes also suggested that teachers use a variety of presentation methods including lectures and small- and large-group discussions. Discovery learning was viewed as the key to helping students construct their own understandings of calculus. Materials in this curriculum presented mathematics as a human creation which was developed both to satisfy intellectual curiosity and to solve practical problems. This curriculum demonstrated the relevance of mathematics to the interests of women as well as men and valued the contributions of women to society. Willis (1995a) described the success of this curriculum project and how it made calculus more real to students' lives. Although most students who participated in the trial of these materials enjoyed the experience, there were a few vocal males who were unhappy with the group work and the contextualised nature of the course, which involved a lot more reading than a traditional mathematics course. Overall however, these materials appealed to a much wider range of students, as demonstrated by the comments made by students in the evaluations.

Practical, real-world contexts have also been successfully integrated into bridging-course materials. Because mathematics is a required pre-requisite for many science-based university courses, the provision of bridging courses for students who have had little previous success with mathematics and need additional mathematical skills to further their study was undertaken by Marr and Helme (1990). The materials developed by Marr and Helme for these bridging courses were an attempt to reach females through adopting an Inclusive perspective. The project encouraged students to learn through interaction and cooperation and to use practical activities and hands-on materials. It taught concepts in a context relevant to adult students, raised awareness about social and economic structures influencing students' lives, and acknowledged differences between students in their backgrounds and levels of mathematical skill. Basic mathematical skills in number and problem solving were emphasised throughout the course. The materials were published and adopted by many secondary teachers who gave very positive feedback to the project leaders. Unfortunately, Marr and Helme did not provide evidence of any formal evaluation of the project with either teachers or students.

Also at the secondary level, the impact of recent changes to the senior secondary mathematics curricula in Western Australia was investigated by Parker (1992). The rhetoric of the planning committees involved in this major change indicated that these changes were meant to produce inclusive classrooms with increased female participation in the more challenging mathematics subjects. Also

implied, but not explicitly stated, were changes to pedagogy and assessment practices known to be more supportive of females (Parker & Thomson, 1993). The implementation of these changes included some professional development opportunities for teachers, but did not provide those curriculum materials considered essential by Eccles (1989) to ensure active involvement of teachers. Eccles (1989) made the point that to produce positive outcomes for females “requires an active commitment to non-sexist, non-racist instruction and guidance” (p. 55). Clearly in the Western Australian situation, equity objectives were implied but never fully operationalised, with the implementation activities failing to provide sufficient opportunities for teachers to make the active commitment referred to by Eccles. The new Western Australian syllabus did at least facilitate greater access to calculus than the former system, particularly for females. However, the improvements were due almost entirely to a change in the structure of senior secondary graduation requirements which occurred at the same time as the curriculum change, and not to any detectable change in the nature of assessment or pedagogical practices (Parker, et al., 1993; Tims (Goodell) & Parker, 1994):

Overall, it was clear that the intent and expectation regarding adoption of new mathematics teaching strategies had been lost. ... In assuming that gender issues would be addressed through changes in content and teaching methodology, those responsible for the curriculum renewal did not take into account either the complexities of changing teaching styles, or the complexities of providing a gender-inclusive curriculum.

(Parker, 1993, p. 12)

Another project, this time at junior secondary level, was analysed by Clarke, Morony and Schmitt (1994). The Junior Secondary Mathematics Resource Schools Project aimed to improve mathematics education for all students. It was a curriculum initiative also aimed at improving retention and successful participation in school mathematics by those students traditionally marginalised by school mathematics. Teachers in the project saw differences between their current practice and their desired practice (what they thought they should be doing) in the areas of valuing student ideas, questioning techniques and using a variety of tools to solve problems. Further, they thought that certain aspects such as individual work, teacher demonstration and working from text books were being overemphasised. The program was designed to allow each trial school to interpret the project’s goals with respect to its own particular needs. Being a site-specific curriculum development project, it allowed for site-specific equity goals to be addressed, teachers’ professional development needs to be acknowledged, and specific pedagogical practices to be encouraged and supported. The project

was able to increase the successful participation of marginalised groups, even during the short time it had been in operation before this report by Clarke et al was written. This project highlighted the value of acting locally to address specific local problems, and enabling teachers, who are a critical link in the reform chain (Fullan, 1993a), to formulate and implement solutions that are right for them and their students.

On a more comprehensive national level, the publication of *A National Statement on Mathematics for Australian Schools* (Australian Education Council, 1991) was the first stage towards the development of the outcomes-based curriculum document *The Australian Mathematics Profiles* (Australian Education Council, 1994). The development of these documents was a collaborative effort among the departments of education in all Australian states and territories, with representatives from universities, schools, professional bodies and industry groups. The *Profiles*, developed with social justice goals in mind, provided a set of inter-related outcome statements for the compulsory years of school in Australia. Progress through the eight levels of the curriculum is determined by attainment of an explicit outcome. Students must meet all the criteria of a particular outcome before they can be said to have achieved the outcome. Outcome statements make explicit the expectations for the student by the curriculum, and success in mathematics is determined by the attainment of these outcomes, not, as with traditional mathematics, by passing a course or reaching the end of a year. From the beginning, the writers of the *Profiles* had a strong commitment towards ensuring that student work collected during the trialling phase was from as wide a range of students as possible. Parts of the *Profiles* document included suggestions as to how the outcomes might be addressed by teachers in the classroom. The outcomes were also written in such a way as to attempt to encompass the diversity of Australian children and Australian culture, which today includes many Asian, South American and Middle Eastern aspects as well as British, European and Aboriginal. Interestingly, when one Australian state rewrote the *Profiles* for use in their schools, many of the references to non-European culture were removed (Willis, 1995b). This highlights one of the barriers facing equity reformers: others who aren't convinced of the need for curriculum to be inclusive of the experiences of all cultural and social groups in schools can thwart efforts to make it so.

In Western Australia, the *Profiles*, rewritten slightly, became *The Student Outcome Statements (SOS)* (Education Department of Western Australia, 1994). A trial of the *SOS* was conducted in Western Australian schools in 1994 and 1995,

and reported on in 1996 (Education Department of Western Australia, 1996). At the same time, the National Professional Development Program (NPDP), a federally funded program, funded a number of collaborative projects to provide professional development for teachers in a range of subject areas throughout Australia. One such funded group was the Mathematical Association of Western Australia (MAWA) with partners from three major universities in Western Australia. Many of these projects had not reported their outcomes at the time of writing this thesis.

The MAWA professional development project was school based. Each school's mathematics staff decided how they wanted to use the *SOS*, and professional development was provided to each school on a needs basis. Most schools decided to implement one strand of the *SOS*, and professional development consisted of consultations with the university representative assigned to that school.

Frid and Winnett (1996) reported the outcomes of one teacher's attempts to implement the "Working Mathematically" strand into their mathematics program. They found that the flexibility allowed by this new way of thinking about teaching and learning, namely outcomes-based as opposed to inputs-based, and the way in which the *SOS* fostered cross-curricula links and teacher decision making on assessment matters, were crucial to the classroom teacher's ability to connect mathematics to students' lived experience. Frid and Winnett (1996) demonstrated that a number of crucial changes had to be made to the traditional mathematics classroom before negotiating meaning and the development of student voice could occur. These changes included changing the traditional patterns of teacher/student discourse, so that students were involved in taking responsibility for their own learning; asked many questions; were not afraid to speak up about mistakes; and were able to use mistakes as a way to enhance their understanding and make their learning more meaningful. Another change which promoted a more connected classroom was the use of open-ended tasks connected to student experience. The teacher selected tasks based on some event that arose from the everyday lives of the students. Keeping a mathematics journal facilitated identification of suitable tasks and contexts. The journal was also an important feature of the class activities, and was used in a variety of ways: recording the results of their class activities, writing about the day's activities for homework and for self- and peer-assessment writing tasks. The final essential feature of this connected class identified by Frid and Winnett was the positive attitudes students in this class developed towards mathematics. The development of these attitudes,

recorded by students in a short written survey given at the end of the second year of trialling *SOS*, was linked to the confidence students felt in their mathematics classes and was an important indicator of students gaining a voice in the mathematics classroom. In Baxter-Magolda's (1992) terms, it was the confirmation of student voice which enabled students to become constructors of their own knowledge.

The *SOS* were also found to promote a classroom atmosphere of community, in which sharing of mathematical ideas was common, and open-ended problems and investigations were tackled enthusiastically. This type of approach appears to hold great promise for meeting the goals of reform within Australia, or elsewhere. The *SOS* trial demonstrated that it is possible to provide a flexible curriculum which is both intellectually demanding and firmly focused on promoting equity in the mathematics classroom (Education Department of Western Australia, 1996).

British projects

In the United Kingdom, an initial sharp increase in interest in female education in science and mathematics occurred in 1976, when the then Prime Minister questioned why so many girls were dropping out of science before the end of school (Smart, 1996). Industry was also pushing for more skilled labour, and the women's movement was highlighting imbalances in the educational opportunities for males and females. Teachers were fighting to make gender a central issue in education in the UK, and the stages of their fight were analysed by Weiner (1994). Reflecting the sequence presented in Chapter One of this thesis, Weiner characterised its first stage as a raising of awareness by the problematising of gender as an issue through research designed to find the facts. The second stage was the demanding of such change strategies as the creation of equal-opportunity working parties, revision of texts, appointment of senior female staff, changing the timetable to allow girls to enter non-traditional options and changing school organisational practices. The third stage was the emergence of different teacher perspectives, which she categorised "girl-friendly" and "anti-sexist". While the three stages initially gave rise to three different perspectives on gender and education, as concluded by Weiner, these three perspectives gradually merged through a need to develop more coherent strategies, and the perceived need to unify concerns about race, gender and class. Classroom and school-based strategies to support students from minority groups were developed. This process

of unification lasted over ten years and eventually led to many initiatives aimed at reducing the gender imbalance in mathematics and science.

The status of equity goals in British education have become unclear since the introduction of the National Curriculum in Britain, mandated by the government in 1988 and legislated through the Education Reform Act (ERA). This new curriculum heralded a completely new phase in British schools, one where “there were active moves to take away the gains girls had made in mathematics” (Smart, 1996, p. 215). This national curriculum, along with national testing, was gradually implemented over the next few years. The testing was for all students at age levels, seven, eleven, fourteen and sixteen years (Gipps, 1994). Initially the tests consisted of open-ended tasks and were fitted into the normal school week. Smart (1996) described how girls performed better than boys on these open-ended tasks in the pilot mathematics tests, a result which she found contrasted sharply with the other subjects tested in this age group. Subsequently the tests were short, one-hour paper-and-pencil tests, and the contribution of coursework to the final grade was cut down. Since then, there has been such continual change to the national curriculum that it is now quite different to the first drafts. Specifically, components of practical applications and communication skills have been eliminated. Smart observed that, although in the 1980’s girls were perhaps gaining a voice in the mathematics classroom, new government policies have reversed this trend and have allowed middle- and upper-class white males to again reassert their dominance. The introduction of a national curriculum has essentially diverted all energies away from other curriculum development in Britain. There was considerable resistance to many aspects of these changes, not the least of which the mandated testing of seven-, eleven-, fourteen and sixteen-year-olds (Black, 1993). Teachers even boycotted some of the mandated testing programs, refusing to administer them (Black, 1993; Smart, 1996). This situation in Britain illustrated the highly political nature of education and how the efforts of so many people over so many years can be negated in a very short space of time by government policies that are inherently simplistic in their view of accountability as a central tenet above educational advancement.

There have been, however, in the late 1980’s and early 1990’s, a few projects that have stimulated some curriculum development in Britain. One of these was the *Common Threads* exhibition described by Harris (1995). *Common Threads* was an exhibition of textile work produced by women from all over the world. It displayed and valued the work of women textile workers, linking it to mathematics. The exhibition was originally developed from the *Maths in Work*

project (Harris, 1991), which had been designed to investigate the mathematics skills used by new school leavers employed in their first jobs. For this project, young people new to the work force were given a questionnaire about the mathematics they used in their workplace. The results of the questionnaire were then used to monitor the effectiveness of a new secondary-school leavers course, as well as provide a source of realistic learning materials for schools. The use of textiles as context in mathematics is also described by Verhage (1990) and referred to later in this chapter. The *Common Threads* exhibition first toured Britain for two years and then twenty other countries over a period of four years. It stimulated curriculum development in school mathematics, cross-curricular work from elementary to tertiary levels, vocational work in formal and informal settings, ethno-mathematics research, and programs in women's development. Harris (1995) described the success of the project in terms of the way in which it helped to break down barriers and challenge stereotypes about mathematics and women commonly held in society.

USA projects

In the USA, The National Science Foundation has funded twelve mathematics curriculum reform projects since 1990 (National Science Foundation, 1994). These projects have all had the common goal of enhancing mathematics learning for all students, but were not specifically focused on equity goals. They were part of the Instructional Materials Development Program, which also supported 20 assessment-related projects.

The *Interactive Math Program* is one such project that began in 1990 in the San Francisco area. This high-school curriculum is built around substantial, complex problems where

students are challenged to actively explore open-ended situations, experiment with examples, look for and articulate patterns, and make and test conjectures in a way that closely resembles the work of mathematicians, scientists, and workers in industry.

(National Science Foundation, 1994).

Another NSF-funded project was the *Connected Mathematics Project* (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1996) at Michigan State University. This project was aimed at producing a series of modules of work for middle-school students that would emphasise the connections between each topic and between mathematics content and the real world. Each module had a unique context that was carried throughout the module. Although not specifically designed with only equity goals in mind, the connected nature of the curriculum

and its relation to real-world applications make it much more equitable than traditional curricula. This curriculum project has only just been publicly released, and no formal evaluation or description is available.

A similar project to the CMP was Mathematics in Context (National Center for Research in Mathematical Sciences Education & Freudenthal Institute, 1997), based on the work of the Dutch mathematics educator Jan de Lange and the approaches of Realistic Mathematics Education (de Lange, 1987). These curriculum materials have been demonstrated at recent NCTM national conferences. At the time of writing this thesis, a comprehensive evaluation of these materials was in progress, but the results were not yet available.

Frankenstein (1995) described how she attempted to raise awareness in her American students of how class inequities in society lead to the creation and perpetuation of inequities in schools. She challenged the hegemony of mathematics as a tool that “imparts an image of neutrality and naturalness to particular societal arrangements that obscure the class structure of our society” (p.167). She taught a course called Public Service Mathematics through which she tried make her students aware of how mathematics is used in society to benefit some and not others. She was attempting to get her students to understand and challenge the hegemony of mathematics through curriculum reform. Her perspective was a mixture of the Inclusive and Socially Critical perspectives because, although she was advocating curriculum as the main tool of reform, embedded in the reformed curriculum were considerations of how to challenge the hegemony of mathematics. Her focus on social problems helped students understand the inequities that exist in society today. Integrating social action into the curriculum is a very powerful method for connecting students with mathematics, and is a technique also advocated by researchers in multicultural education (Banks, 1995; Ladson-Billings, 1995).

The NCTM published standards for curriculum in their *Curriculum and Evaluation Standards for School Mathematics* (1989). This agenda aimed at creating a mathematics curriculum suitable for all students, the main vehicle of which was the teaching of mathematics through real-world problems (Apple, 1992). This document and the two that followed on teaching and assessment standards (National Council of Teachers of Mathematics, 1991; National Council of Teachers of Mathematics, 1995) formed the basis for many other reforms, including the NSF projects discussed previously. However, as previously mentioned, some aspects essential to creating the equitable classroom were not dealt with in the NCTM documents (American Association of University Women,

1992). Therefore, merely adhering to the reforms suggested by the NCTM will not automatically ensure that equity will be attained.

Others

Two other projects, one from Holland and the other a science initiative from Canada, need to be mentioned because both illustrate important aspects of creating an equitable mathematics classroom, namely the importance of context, and the link between pedagogy and achievement.

Verhage (1990) discussed her involvement in a new curriculum in Holland where an attempt was made to use contexts that were more girl friendly. The topic of symmetry was selected because of the wide variety of everyday contexts that could be applied to it. Strip patterns were studied through embroidery, cross stitch, paper cutting, wallpaper, tiling patterns and others. Verhage and her colleagues found plenty of mathematics in many traditional females contexts. Verhage concluded that using these female-friendly contexts contributed not only to female, but also to male emancipation by helping boys to become more familiar with topics from the female cultural domain. Designing this inclusive curriculum involved more than merely equalising textual frequencies of “his” and “her”. She concluded that context is of the utmost importance when designing mathematics curriculum.

Davis and Steiger (1993) discussed a three-year Canadian project, the hypothesis of which was that feminist pedagogy can produce more active, confident and committed women students of post-secondary physics. An integrated set of feminist teaching strategies was developed in accordance with research on the educational patterns and learning styles of women. The research design involved four semesters of experimentation in which the attitudes and achievement of students in two sections of college physics, involving the use of an integrated set of feminist pedagogical strategies, were compared with those of students in parallel control classes. A semester-by-semester analysis of both quantitative and qualitative data consistently showed significant differences in student attitudes and behaviours, both between females and males and between the experimental and control groups of students. Although this project focused on physics, rather than mathematics, it should be included here as an example of what can be done when a carefully designed and integrated set of teaching strategies are employed.

Summary

An analysis of the outcomes of the curriculum reforms presented in this section have added a number of important features to the CEMC. First is the importance of providing students with a learning environment that enables them to become constructors of their own knowledge. Traditional patterns of student/teacher discourse have to change so that students take more responsibility for their own learning, ask questions, are not afraid to speak up about their mistakes, and use mistakes to enhance learning (Frid & Winnett, 1996). The importance of placing mathematics in a context that is known and has personal meaning and connection is emphasized, and this can be facilitated through students keeping a personal mathematics journal. The final classroom aspect raised in this section was the importance of including some form of social action as part of the mathematics course. Again, using a context that is known to the students in the class can facilitate this.

At a more global level is the need for equity goals to be clearly identified in the reform documents. In the Australian *Profiles* example, curriculum documents contained explicit reference to the importance of using inclusive language, pedagogy and assessment practices. Trials by Frid and Winnett (1996) demonstrated that these goals could be put into practice. In contrast to this was the Western Australian senior secondary example, in which the equity goals were not made explicit and were not realised (Parker, 1992). The British situation highlights the sometimes political nature of educational change, and the importance of support at the policy level for change to occur and be long lasting.

SYNTHESIS OF CHARACTERISTICS OF THE IDEAL CONNECTED, EQUITABLE, MATHEMATICS CLASSROOM (CEMC)

In summary, a CEMC is one where:

1. All students have access to academically challenging curricula.
2. Students are encouraged to develop confidence in their mathematics ability and positive attitudes towards mathematics.
3. Basic skills are developed which will enable students to be mathematically literate in the world outside school.
4. The learning environment encourages students to develop their own voice and construct their own knowledge.
5. Teachers have high expectations for all of their students.

6. Teachers connect mathematics with the real world through the use of appropriate contexts for problems, the provision of career information, and a focus on social issues which affect all students (such as ecology and health).
7. Teachers are able to recognise and act on inequities in their classroom.
8. Teachers use a variety of teaching and assessment practices.
9. The curriculum challenges stereotypes and values the contributions of women and minority groups.
10. The curriculum includes real-world problems set in a variety of contexts that value and take into account the range of student backgrounds and experiences.
11. The curriculum includes a focus on issues of social justice and ecology which enables students to challenge social conditions. There may be some element of social action by students.
12. The curriculum explicitly states equity goals.

Many of these characteristics were present in the goals of the Ohio SSI; therefore it was appropriate to use them as a basis for an analysis of the impact of the Ohio SSI on mathematics classrooms. In the next chapter, the rationale, design, and methodology of the remainder of the study, based on the evaluation of the Ohio SSI, are outlined.

CHAPTER FOUR

EXAMINING EQUITY IN THE CONTEXT OF REFORM

INTRODUCTION

The problems and proposed solutions associated with gender inequities in mathematics education have been discussed in the previous three chapters, culminating in a synthesis of a set of characteristics which would be present in an ideal Connected Equitable Mathematics Classroom. As mentioned previously, the Ohio Statewide Systemic Initiative (SSI) *Project Discovery* had been founded with equity goals as a strong focus and thus provided an appropriate specific context for the study reported in this thesis. As part of the evaluation of the effectiveness of the SSI, it was therefore appropriate to see to what extent mathematics classrooms in Ohio were more equitable than they might otherwise have been without the SSI intervention.

The purpose of this chapter is to describe how the Ohio SSI was evaluated. The study undertaken to evaluate this initiative was known as *The Landscape Study*, and all data used in this thesis were collected as part of *The Landscape Study*, although the reverse is not true: all data collected in *The Landscape Study* were not used in this thesis. As each phase of the data collection and analysis is described in this chapter, it will be made clear as to how those data have been used in this thesis. My role in each part of the design and data collection for *The Landscape Study* will also be made clear.

The remainder of this chapter will present the background and design of *The Landscape Study* along with a justification of its design. Next, the data sources and data collection methods of the study are described including the validity and reliability checks which were incorporated into the design. Last, a description of each instrument is provided along with its method of analysis and a justification of its use.

BACKGROUND TO *THE LANDSCAPE STUDY*

In late 1994, in order to evaluate the impact *Project Discovery* was having on science and mathematics education in Ohio, *The Landscape Study* was initiated. Only schools that had participated in the reform were included in the

study; however, there were many teachers at these schools who had not directly participated in the professional development activities of *Project Discovery*. Planning began when the research team (comprised of *Project Discovery's* Co-principal Investigator Professor Jane Butler Kahle, Professor Kenneth Tobin from Florida State University, Dr. Iris Weiss of Horizon Research, *Project Discovery's* Project Director Dr. Steve Rogg, Joanne [Tims] Goodell from Curtin University of Technology, and Mark Brooks-Hedstrom, Dr. Nate Carnes, Dr. Arta Damnjanovic and Dr. Dana Riley all from Miami University) met to discuss the aims of the research and to design those instruments that would be used in the project. The senior members of this team had considerable experience and expertise in conducting research of this nature. The research team met a number of times before and during the data collection period in early 1995. Decisions about the design of the study, the content of the quantitative instruments, the data sources to be used and the general data collection procedures were made collaboratively at these group meetings. I was present at all of these meetings except for a preliminary meeting in December 1994.

In order to gain a broad understanding of the many factors influencing the success of the SSI, many data sources both qualitative and quantitative, were considered essential. The importance of this is widely recognised by researchers. Miles and Huberman (1994) for example pointed out the strengths of linking qualitative and quantitative data in this way. Quantitative data are useful in supplying background data, making sure all aspects of a project are considered and all participants are included. Qualitative data provide the detail to quantitative analysis by validating, clarifying and illustrating quantitative findings. Miles and Huberman (1994) considered the use of both qualitative and quantitative data essential to the quality of a project.

Tobin (1995) also stressed the importance of considering multiple data sources. He discussed the issues associated with using qualitative and quantitative data, what is appropriate in different situations, and the futility of proclaiming the superiority of one data form over another. He strongly argued for a common sense approach to selecting the data sources for a particular project. Using the analogy of grain size, he suggested that painting a large landscape requires methods that paint a large picture. To see patterns in data using statistics is a useful technique. Using interviews to examine specific issues in one particular situation is another useful method. Being mindful of the total picture of the research enables the researcher to select the appropriate data sources and tools of analysis.

OVERVIEW OF THE STRUCTURE OF *THE LANDSCAPE STUDY*

The first major quantitative component of *The Landscape Study* was teacher-based: a questionnaire given to mathematics and science teachers. At the time of the commencement of *The Landscape Study*, approximately 820 mathematics teachers from 350 schools across the state of Ohio had participated in the professional development activities of *Project Discovery*. A random sample of 126 schools were chosen from this pool of 350. The second quantitative component was student-based: an achievement test and student questionnaire given to students in some mathematics and science classes in a subset of the original 126 selected schools. The third component was classroom-based: site visits to a number of carefully-selected sites to fill in the detail of the broad brush picture obtained from the quantitative data. One teacher at each site was chosen to be the "focus" teacher. These teachers had completed a *Discovery* institute. A "match" teacher was chosen to match the focus teacher on years of experience and teaching assignment. During the site visits, researchers observed and interviewed the focus teacher, and interviewed students and administrators. Students from the match teacher's classes completed the questionnaire and achievement test. After the visit, a site-visit report was written, focusing on issues important at that site.

My role in the data collection for *The Landscape Study* in 1995 was that of project manager. This meant that I was responsible for the day-to-day running of the project. My role covered a range of responsibilities: I assisted in the design of instruments; devised distribution and collection procedures for the quantitative data; conceptualised (with others) the data base of information to be kept about the project; disseminated information about the project to researchers and other *Discovery* staff; coordinated follow-up phone calls and letters during and after data collection; designed (with others) interview protocols for the site visit interviews; organised training sessions for the research team to learn the software package NUD•IST; and conducted my own site visits and wrote reports about them. In 1996 when the Landscape Study was repeated, I was a collaborating researcher, and also responsible for managing Level B design and data collection. I also conducted four site visits and wrote reports about them. A more complete description of all data sources utilised in the study reported here is given in following descriptions of each element of *The Landscape Study*.

The Landscape Study was a three-level design. The levels will henceforth be referred to as Levels A, B and C, with the data sources used in the study

reported here described below in Tables 4.1 and 4.2. Only data from mathematics teachers in Level A and C, mathematics students in Level B and C and principals in Level C have been used in this thesis. Principals in Level A schools and parents in Level B schools also completed questionnaires; however these data are not used in this thesis because they did not relate to my research questions. I conducted all of the data analyses reported here.

Table 4.1

Data Source and Analysis Type from *The Landscape Study* 1995 Mathematics Sample

Level	Sample	Data Source(s)	My Analysis
A	560 mathematics teachers from 126 randomly selected schools	Landscape Teacher Questionnaire (LTQ)	Factor analysis on frequency and importance scale data
B	592 students in mathematics classes from 8 carefully selected schools	Landscape Student Questionnaire (LSQ) Mathematics Discovery Inquiry Test (MDIT)	Factor analysis on LSQ and MDIT attitudinal data Three way ANOVAs for sex, race and group differences in factors and MDIT achievement data
C	4 site visits at subset of B	Three days at each site, observing, and interviewing focus teacher, students and principal.	Cross-site analysis using NUD•IST software and Rossman framework.
	4 focus teachers of mathematics	Interviews approximately 90 minutes each	
	4 principals	Interviews approximately 30 minutes each	
	12 students	Interviews approximately 10 minutes each	
	4 site-visit reports	Each report approximately 20 pages typed double spacing	

Table 4.2

Data Source and Analysis Type from *The Landscape Study* 1996 Mathematics Sample

Level	Sample	Data Source(s)	Analysis
C	4 site visits at subset of B (only 1 overlap of '95C)	One or three days at each site, observing, and interviewing focus teacher, students and principal.	Cross-site analysis using NUD•IST software and Rossman framework.
	4 focus teachers of mathematics	Interviews approximately 90 minutes each	
	4 principals	Interviews approximately 30 minutes each	
	12 students	Interviews approximately 10 minutes each	
	4 site-visit reports	Each report approximately 20 pages typed double spacing	

DATA COLLECTION

Quantitative Data Collection 1995

Data collection procedures for Level A

The first stage of data collection in *The Landscape Study* involved obtaining permission to conduct research in the schools selected for Level A. Only schools where at least one teacher had participated in *Discovery* Institutes were eligible for selection. From a total of over 350 eligible schools, 200 were randomly selected for initial contact. A data base (which became known as *Landscape Schools*) of information about all schools chosen in the sample was established and maintained by the *Project Discovery* technical coordinator throughout the whole project. Records of all contacts with schools were kept in the data base. Permission to administer questionnaires to all science and mathematics teachers of grades six through nine in the selected schools was sought from over 140 superintendents in selected districts (some districts had more than one school selected in the random sample). In early January 1995, a letter (see Appendix A1) requesting permission to conduct the research as well as

a reply-paid return card and a copy of the LTQ were mailed to the superintendents. The return card had a check box to indicate permission granted or not, and space to nominate a contact person at the school. As return cards came in, the information was entered into *Landscape Schools*. Approximately four weeks after the letter was sent, phone calls were made to those superintendents who had not replied, to try to enlist their support. After these phone calls were completed, permission had been granted for 155 schools to participate.

The second phase was to establish contact with those schools for which we had permission to conduct our research. If the person nominated by the superintendent was the principal, another letter (see Appendix A2) and reply-paid return card was sent to that principal requesting the name of a contact person. If the person nominated by the superintendent was not the principal (i.e. we had a contact person), the next phase was continued.

The next phase was to establish contact with the contact person and obtain the necessary information to facilitate the distribution, collection and follow-up of the LTQ. A letter (See Appendix A3) requesting the names of all the science and mathematics teachers at the school teaching in any of grades six through nine was sent to the nominated contact person. Enclosed with this letter was a pre-printed reply form with space for the requested information to be entered, and a reply-paid addressed return envelope. Again, as the information was received, it was entered into *Landscape Schools*. After four weeks, phone calls were made to contact persons who had not replied to encourage them to supply the requested information. After these phone calls were completed, 134 schools had supplied their teacher information.

The next phase was the distribution and collection of the LTQ. The contact person at each school was mailed a packet containing all the envelopes (containing the questionnaires) for each teacher, instructions (see Appendix A4) and a check list to keep track of the distribution and collection. A personalised cover letter (see Appendix A5) and address label were produced for each teacher, so that the questionnaire could be addressed to each individual teachers and then returned in a sealed envelope if the teacher so desired. Before the school packets were mailed, record was made of the identifying code number of the questionnaire sent to each teacher. The contact person was responsible for distributing and collecting the questionnaires. A large reply-paid return envelope was also supplied for the return of completed LTQs. By sealing their envelopes before returning them, teachers were able to feel assured that the contact person would not read their responses. Once all (or most) teachers had returned their

LTQ to the contact person, the school packets were mailed back to the *Discovery* office. Record was made of all returned LTQs. Follow-up letters and replacement LTQs were sent to teachers who had not returned them. Again, contact persons were asked to distribute and collect the LTQs. After approximately four weeks, follow up phone calls were made to contact persons reminding them to send their school packets in before the end of the school year. After all possible packets were returned, 126 schools were left in the final sample. A thank-you letter and *Discovery* tote bag were sent to all contact persons at the end of the data collection process.

Reliability and validity concerns for Level A

The research design employed in this study was a three-level design, with level A being the broadest, focusing on the total picture. A random sample of those schools from across the state which had participated in the reform project was chosen to participate in Level A. A random sample was chosen so that it would be representative of all the schools that had participated in the SSI up to that time. The aim of the teacher questionnaire was to gather information about how the SSI had impacted in a broad sense on the teaching of mathematics and science across the state. Because there were no baseline data available about the participants' teaching practices before they completed the institutes, comparisons were made between teachers who had participated in the SSI (who will henceforth be referred to as SSI Teachers) and those who had not been part of the SSI (who will henceforth be referred to as Non-SSI Teachers). The biggest threat to the validity of this design was the self-selective nature of the SSI Teachers. Participation in the SSI was entirely voluntary, and required a large degree of commitment from participants: six weeks of class contact in a location which most often required them to be away from home, and it was held during their summer vacation—although there was compensation for participation. It could be argued that only dedicated teachers who were wanting to change would opt to participate in such a program. While this may have been true for some participants, because the pedagogical techniques the teachers were learning in the SSI institutes were so new and different to those they had been taught as pre-service teachers, there is no evidence to suggest that their pre-*Discovery* teaching methods were any different to those of their colleagues. This issue was addressed by the external evaluators Horizon Research Inc. in a study (Supovitz, 1996) which selected a sample from the population of Non-SSI teachers who were about to participate in the next round of summer institutes. Students in SSI classes were

compared to students in classes of teachers who had not yet participated but had volunteered to participate in the next round of institutes. By choosing persons who had volunteered, but had yet to actually participate in the SSI, and comparing this group to a group which had participated, any differences observed between these two groups could not be attributed to a volunteer effect. Supovitz found that students in SSI teachers' classes significantly outperformed their Non-SSI counterparts (volunteers yet to participate) across all racial and gender groups.

Other aspects of the study which added to its validity were the large sample of SSI teachers who completed the questionnaire, and the very high return rate of questionnaires. Of the 820 mathematics teachers across the state who had participated in *Project Discovery* up to 1995, 110 were sent questionnaires and 91 returned them.

The reliability of the data collection process (in the positivist sense) was a high priority for *The Landscape Study*. The entire data collection process for the LTQ was designed to ensure that there was as high a return rate as possible for all the questionnaires. The research team decided that there were a number of important features of the data collection process that would enhance the return rate: ensuring we had permission from the district superintendent to conduct the study, making contact with the principal of the school, and establishing one person as a contact person who would distribute, collect and return to us the completed questionnaires.

Every effort was made to ensure that the project could reliably be replicated, as it was planned to replicate it over a number of years. As project manager during the first six months of *The Landscape Study*, my role was pivotal in this process. Detailed records were kept of all procedures (which were replicated in 1996 and 1997). Because most of the communication between the research team and the participants at this level was through the mail, great care was taken to ensure that cover letters and directions for completing the questionnaire were as clear as possible. Copies of all of these letters are given in Appendix A. All procedures were documented and records kept of all communication between the research team and the participants. Because of the large number of people working on this project, these records were used throughout the project to help me (the project manager) keep the entire research group aware of what was happening in the project.

The reliability of the quantitative data analysis was ensured through the choice of techniques that were well documented and well known in the research literature—factor analysis, analysis of variance and effect sizes. For the

qualitative data, the reliability of the analysis was enhanced through the use of computer software to help manage the large amount of data, and the use of many quotes from the interview transcripts to enable the reader to understand the interpretations made about the data.

Data collection procedures for Level B

Schools for Level B site visits were carefully chosen so as to try to gain a broad picture of how the reform had been implemented across the state. In 1995, the main criterion used in the selection process for both urban and rural sites was that there had to be at least a 30% minority enrolment. The research directors felt that unless there were sufficient minority students in the sample for the student data collection, it would have been impossible to determine if the SSI had impacted on minority students. In terms of the study reported here, this criterion did not impinge on the validity of the sample.

The process of choosing the sites occurred in a research group meeting. All schools in *The Landscape Study* with more than 30% minority enrolment were identified. Other factors such as ensuring a mix of urban, rural and suburban schools, and geographic diversity, were considered when making the final selection. In 1996, one school was retained and three new schools were included. The main criterion for new schools in 1996 was that the school had to be in a district that had received funding from the NSF for a new Urban or Rural Systemic Initiative.

Data collection procedures for the LSQ and MDIT were quite different to those for the LTQ. Because all of the schools where the LSQ and MDIT were to be administered were either mathematics or science site-visit schools, the site visitors were able to distribute the forms. After the site visit, focus teachers and match teachers administered these instruments to two of their respective classes and then mailed the response forms back to the *Project Discovery* office in supplied reply-paid envelopes. The LSQ was not numbered, but students were asked to supply the first letters of their first and last names, together with their birth date as an identifying code. To ensure that the MDIT and LSQ were linked, the answer forms were stapled together before being sent out to the schools. Each teacher also had an identifying number from their LTQ and this number was coded as part of the student identifying code so that every student could be linked to their teacher.

During the complete data collection process, I was responsible for making sure that each stage was carried out correctly. I checked and double checked

everything before it was sent out. I worked with and supervised the clerical assistants and technical coordinator during every phase.

Reliability and validity concerns for Level B

Level B was narrower in focus than Level A: the intention of collecting questionnaire data from students was essentially to triangulate the information given by teachers about their teaching practices. Great care was taken with instructions as to how to administer the instruments, as this was to be done by a large number of teachers. Copies of the directions to teachers are given in Appendix B. The small group of schools chosen to be part of Level B were carefully selected from the random sample of schools in Level A, so that a range of teaching situations would be represented from all geographic areas across the state. As mentioned previously, one criterion that was applied to the selection of these schools, however, was that there had to be at least thirty percent minority students in the total school population, although in some schools the actual percentage of minorities was as high as ninety percent. The reason for setting this percentage-minority criterion was because of the SSI's focus on equity. The evaluation needed to determine how the reform had impacted on minority groups.

The comparison groups for the LSQ and the MDIT were SSI and Non-SSI groups, that is they were students in classes taught by either SSI or Non-SSI teachers. The biggest threat to the validity of this design was that the classes were matched on teacher characteristics. At one school it turned out that the SSI students were seventh grade and the Non-SSI students were eighth grade. Although this made within-school comparison problematic, when aggregated across all schools there were sufficient numbers of seventh- and eighth-grade students of SSI and Non-SSI teachers to form large enough comparison groups for statistical purposes.

Quantitative Data Collection 1996

I was involved with the replication of *The Landscape Study* in 1996, but this time I was not overall project manager. I was, however, still responsible for the Level B data collection. Data collection procedures at Level A in 1996 were nearly identical to those of 1995. The same schools that had participated in 1995 were contacted again in 1996. Data collection procedures at Level B were changed considerably in order to have a much larger student sample. To accomplish this, all SSI teachers of seventh- and eighth-grade mathematics at every Level B school were asked to administer the LSQ and MDIT to all of their

classes. Where possible, match classes at the same school also completed the LSQ and MDIT. Through this procedure, the sample size ended up being over 2000 students. This huge volume of data generated by the quantitative instruments in 1996 meant that it was not possible for me to include any of the 1996 quantitative data in my analysis, mainly because data entry and checking were not complete until March 1997 (a much longer delay than for the 1995 data), and I needed to have all of my analyses completed well before that. Subsequent preliminary analyses of the 1996 data (Kahle & Rogg, 1997), when compared to the same analyses of the 1995 data (Kahle & Rogg, 1996), show similar general trends in 1996 to those from 1995. Because of this, and the fact that the SSI had continued its work over the 1995/96 academic year, it is quite reasonable to include the site-visit data from 1996.

Qualitative Components

The qualitative data were collected during the site visits to seven schools, conducted in May 1995 and May 1996. Table 4.3 lists a pseudonym for each site, the researcher who visited that site and the year the visit took place.

Table 4.3
Site Visit Researcher Summary

Site name	Researcher name	Year
Naylor Middle School	Researcher A	1995
Kingsford Middle School	Researcher B	1995
Greenway Middle School	Researcher C	1995
Draper Middle School	Joanne (Tims) Goodell	1995, 1996
Troy Middle School	Joanne (Tims) Goodell	1996
Lakeview Junior High School	Joanne (Tims) Goodell	1996
Obern Junior High School	Joanne (Tims) Goodell	1996

Before visiting the site, lengthy meetings between all site visitors and the research team took place. During these meetings, the overarching principles of the whole study were discussed as well as some very loose interview protocols. During the site visit, the researcher spent the majority of time in the focus teacher's classes. He or she also conducted interviews with the focus teacher, the principal, and some students from the focus class. The overall focus of the site visits was emphasised as being on equity and reform issues, raised either through the

questionnaires or through observations and interviews at the site. The focus class was chosen randomly by the focus teacher as part of the process of completing the LTQ. (This process will be fully described in the section on the LTQ which is later in this chapter.) After the site visit, each researcher produced a site-visit report which gave details of the visit. The reports highlighted issues that had arisen during the interviews or observations that were important factors in facilitating or inhibiting equity and reform objectives.

Site visits

In preparation for the site visit, the site visitors were given as much background information about the site and the focus teacher as possible, including the teacher and principal questionnaire responses. Although specific interview protocols were provided, the use of these protocols was optional because the purpose of the site visit was to further investigate the issues raised in the questionnaires, and to find out what made that particular site unique. Facilitators of and barriers to implementing equity and inquiry principles were to remain the main focus at all times, and researchers were encouraged to keep an open mind during the interviews and pursue topics that were identified by teachers as important. As a starting point to each interview, the researcher was to hand over a copy of the interviewee's completed questionnaire and ask them to comment on each section. In some cases the researcher had indicated on the copy of the questionnaire specific questions they would like the interviewee to talk about. These items were usually ones where the person had indicated a large difference between frequency and importance, or where the response was particularly negative. During these interviews, other issues often came to the fore, and these were pursued further as appropriate. Additionally, there was certain demographic information required for the site-visit report, and researchers had a list of these requirements prior to their visits.

The site visits were conducted towards the end of the school year, sometimes in the last week of classes. This may have adversely affected the atmosphere of the school and the general behaviour of the students as they had finished most of their academic course work for the year and were anticipating their upcoming long vacations.

After each site visit, the researcher produced a site-visit report, and these are referenced where appropriate throughout this analysis. The original transcribed interviews and field notes are also referenced as needed. Pseudonyms

have been used throughout this thesis for all schools, teachers, principals, students and parents. Please see Appendix P for a complete list of pseudonyms.

A detailed classroom observation protocol was developed from the LTQ to help provide further information about the reformed teaching practices evident in the focus classroom, although very few site visitors used this protocol. A copy of it is provided in Appendix C.

When conducting large-scale research of this nature, some compromises are inevitable in terms of the desired methodology. One such compromise was the shortness and the timing of the site visits. Three-day sit visits necessitated the researcher being away from the SSI office for one whole week, and then there still was considerable time needed to prepare the data for analysis, and write site-visit reports. However, the number of sites visited did compensate for these shortcomings to some extent.

Reliability and validity concerns

Multi-level qualitative research designs have at their heart ethical concerns about the practical wisdom needed to facilitate such research processes. Guba and Lincoln (1989, p. 136) discussed the “craft of evaluation”, and pointed out that determining what to include and what to leave out of a case study is largely up to the individual evaluator, is something that is learned by practice, and is not determined by a set of rules. Practical wisdom comes from engaging in the framing of many case studies. A good case study, according to Guba and Lincoln, is one which “demonstrates integrity, originality, passion, commitment, and balance” (p. 136).

Because the purpose of the site visits was to provide detailed contextual information to clarify and illustrate the quantitative findings, it was important to pay some heed to the reliability and validity (in the positivist sense) of the qualitative data. This was enhanced by each researcher using the LTQ or LPrQ (the principal’s questionnaire) as the starting point for interviews. Interviewees were given a copy of their responses to these instruments and asked to comment on each question if they wished, or on particular questions that the researcher had highlighted. This ensured comparability between sites in terms of the range of issues likely to be covered. Of course, each site was quite unique, and researchers pursued on those issues that were of most importance at each particular site.

During the many research group meetings, a number of points relating to analysis of interpretive data in a multi-level design were discussed and enacted. Data analysis was constantly taking place at the same time as data collection.

Frequent meetings between researchers involved in the project, both formal and informal, enabled this to occur. Properly conducted member checks were encouraged and most researchers used the agreed upon procedures.

Emergent findings were consistently presented to “disinterested peers”. (A disinterested peer is one who has no vested interest in the study, but is able to understand the study and offer suggestions as to the authenticity of interpretations.) This was enabled through informal contact between researchers involved in the project and other *Discovery* teachers and staff not involved with *The Landscape Study*, as well as through presentations of initial *Landscape Study* results to *Discovery* regional directors at their monthly meetings.

The search for discrepant cases and the reasons why these cases were discrepant appears to offer a good avenue to understanding the forces driving the situation being studied. Without a full understanding of why these cases are different, analysis would not be complete. Before the site visits, this aspect was continually stressed in meetings and communications between members of the research team. Site visitors were fully readied to look for reasons as to why the reform had not been implemented as completely as possible.

The importance of establishing an audit trail with respect to authenticity of the study was continually reinforced. Guba and Lincoln (1989) discuss at length the concepts of an audit trail. They liken the process to that of a financial audit, where the auditor seeks to attest to the quality and appropriateness of the accounting process. In an “Inquiry audit” the auditor seeks to confirm that the data are authentic, and that interpretations made from those data can be confirmed. Thus, an audit trail establishes a justification for any changes and shifts in the inquiry process so that an outside reviewer of the inquiry can understand the context and relevant factors that led to these changes. In *The Landscape Study* site-visit reports, researchers used a great many quotes from the interviews conducted during the site visit to illustrate their conclusions. This technique of letting the teacher, principal or student speak for themselves allows the reader to follow the researcher’s line of reasoning and come to his or her own conclusions, which may or may not be the same as that of the researcher. In using data collected by other researchers for this thesis, the high quality of the audit trail established by the researcher who visited the site enabled this secondary analysis to take place, and, in nearly all respects, reach similar conclusions to the original researcher. Interpretive discrepancies did arise, however, between those researchers who had little or no teaching experience and those such as myself, with extensive experience teaching mathematics in the classroom. My own

differing interpretations to those of the original site visitor could also be attributed to a different perspective on social justice due to my Australian upbringing. Each particular country offers its own slant on issues of funding for education, social welfare, and the different cultural and ethnic issues. I had also been studying gender equity issues for longer than any of the other researchers and so had a broader view of equity than some of the site visitors. In order to gain a more internally consistent picture of what was happening across all of the sites, I decided to use all of the original interview transcripts and re-code these with my own codes derived from the definition of the ideal CEMC and the application of the Rossman (1993) framework. This will be discussed in full later in this chapter.

In relation to external validity for the qualitative data, the parallel construct in this study is transferability and the major technique for ensuring transferability is “thick” description. In this study, thick description is provided in the form of detailed descriptions of the context, culture, place and time of the site visits, thereby enabling the readers to determine for themselves how transferable the results of this study are to other similar situations.

In relation to internal validity, the parallel construct suggested by Guba and Lincoln (1989) is credibility: what is found is a credible interpretation of the situation being studied. Some techniques utilised in this study to enhance credibility were intensive observation at the site, peer debriefing with others not involved with the site visits but with knowledge of the school system and the SSI, full transcription of all audio-taped interviews, and the production of interpretive site-visit reports by each researcher.

In relation to the reliability of the qualitative data collected at the site visit schools, the concept of reliability in its positivist form has limited application. Guba and Lincoln (1989) suggest that a parallel to reliability is dependability, which is based on being able to track the processes followed by the evaluator in making decisions and interpretations. It is important that

... the data can be tracked to their sources, and that the logic used to assemble the interpretations into structurally coherent and corroborating wholes is both explicit and implicit in the narrative...

(Guba and Lincoln, 1989, p.243)

The main technique used in this study to assist in establishing dependability was the use, throughout Chapters Six and Seven, of extended quotes from the teachers, students and principals interviewed in the study. This enables readers to follow the researchers logic in constructing interpretations. The thick description of the context and culture of each site also assists readers in this regard.

DATA ENTRY AND CHECKING

Data input for the quantitative data was facilitated by the use of the software File Maker Pro. Clerical assistants entered the responses into carefully designed data-entry screens that were made to look almost exactly like each page of the questionnaires. The data-entry screens were designed by a graduate student working for *Project Discovery* at the time. Once all the data were entered, random checks were conducted on approximately 30 LTQ's, and the error rate was found to be extremely low, at less than 1% of keystrokes. Once the data were checked, SAS data sets were compiled by two graduate students working for *Project Discovery* at the time. Comprehensive records of all data sets, their location and contents were maintained by technical staff. I was able to access these data sets, which were stored on the University's main-frame computer, whenever I needed to perform quantitative analyses.

Data input for the qualitative data, which mainly consisted of transcribing audio taped interviews with teachers, students and principals, was done either by clerical assistants working for *Project Discovery*, or by the researcher. Once the transcripts were typed, I checked all of them for inconsistencies and supervised editing where required. I then prepared the documents for entry into the software package QSR NUD•IST, which was used to assist with the analysis. The decision to use this software is discussed fully later in this chapter, in the section dealing with the qualitative analysis. I ensured that every document contained the necessary codes and formatting required by the software, in order to make searching and indexing text easier and more meaningful. The most important of these requirements was using an appropriate length of text unit. Any coding that is applied to text refers to one or more whole text units. I decided to use the length of one standard line, approximately 75 characters of typed text, because that was the easiest and most appropriate for the kind of analysis I was planning to do (Qualitative Solutions and Research Pty Ltd, 1995). To make this possible, documents must be saved as "text only with line breaks".

DATA DESCRIPTION, ANALYSIS AND TYPE

Copies of all instruments used to gather data for the study reported here are provided in Appendix D, except for the Mathematics Discovery Inquiry Test (MDIT). Because *The Landscape Study* is being replicated over the period 1997 to 1999, the MDIT is not able to be publicly released until the end of this period.

Landscape Teacher Questionnaire

LTQ description

The LTQ (see Appendix D1) was developed by the research team to reflect those principles of inquiry and equity that had been the focus of *Project Discovery* since its inception. It also reflected many aspects of the Connected Equitable Mathematics Classroom (CEMC), which is not surprising considering that the CEMC definition had been synthesised from the same body of equity literature which guided the initial *Project Discovery* proposal.

There were seven sections in the questionnaire, each one concerning a different aspect of teaching and learning. The first four sections were entitled “How I teach”, “What my students do”, “My school principal’s involvement” and “Parental involvement”. These four sections were similar in structure in that participants were asked to respond twice for each statement on two Likert scales. The first response concerned the frequency of teaching practices, what actually happened in their classrooms, and consisted of five choices. Those choices were Almost Never (AN), Seldom (Se), Sometimes (So), Often (O) and Very Often (VO). The second response indicated how important each practice was to the respondent. There were only four choices available in this category: Very Unimportant (VU), Unimportant (U), Important (I), and Very Important (VI).

The fifth section was entitled “My views about mathematics”. For this section, two responses were also required. The first response was on a four point Likert scale with choices of Strongly Disagree (SD), Disagree (D), Agree (A), and Strongly Agree (SA). The second response asked about the importance of each particular view being reflected in the classroom of the respondent, and used a similar response scale to that used for importance responses in the first four sections.

The sixth section was entitled “Changes in my school’s mathematics program”, and was a mix of multiple-choice and short-answer format. The seventh section was entitled “My ideas for improving learning outcomes”, and was a mixture of multiple-choice, ranking and short-answer format.

As mentioned previously, the LTQ reflected many aspects of the CEMC. It is therefore appropriate to match questions in the LTQ to the characteristics of the CEMC which were presented in point form at the end of Chapter Three. In the CEMC, point four of the synthesis states “The learning environment encourages students to develop their own voice and construct their own knowledge.” In the Ohio SSI, a major focus was on constructivist principles which emphasise

actively engaging students in the learning process so that they may construct their own meanings. In the LTQ (see Appendix D1), there were ten items in three sub-scales which addressed this issue: from the “How I Teach” sub-scale, items 1, 4, 6 and 10; from the “What My Students Do” scale, items 2, 3, 6, 7, and 8; and from the “My School Principal’s Involvement” sub-scale, item 3.

Two features of the CEMC which are closely related to each other are “All students have access to academically challenging curricula” (point one), and “Teachers have high expectations for all of their students” (point five). In the LTQ, this aspect was addressed through four items in two sub-scales: from the “How I Teach” sub-scale, items 2 and 7; and from the “What My Students Do” sub-scale, items 4, 5.

An important feature of the CEMC is discussed in point six: “Teachers connect mathematics with the real world...”. In the LTQ, there are five items in two sub-scales related to this. From the “How I Teach” sub-scale, items 9, 11 and 12; and from the “What My Students Do” sub-scale, items 1 and 11.

Another important feature of the CEMC is discussed in point eight: “Teachers use a variety of teaching and assessment practices”. In the LTQ, there are five items in four sub-scales related to this. From the “How I Teach” sub-scale, item 13; from the “What My Students Do” sub-scale, item 9; from the “My School Principal’s Involvement” sub-scale, item 4; and from the “Parental Involvement” sub-scale, items 2 and 13.

The final goal of the CEMC not related to curriculum development and not yet discussed is the one stated in point two: “Students are encouraged to develop confidence in their mathematics ability and positive attitudes towards mathematics.” There was one item in the LTQ which was somewhat related this, and that was item 5 in the how I teach scale: “...I allow my students to work at their own pace.” When teachers insist on students working a rate too fast to allow them to fully understand concepts, this tends to undermine students’ confidence and attitudes towards mathematics.

Looking at the LTQ instrument in total, there are only two items in the first two sub-scales, “How I Teach” and “What My Students Do”, that are not specifically related to features of the CEMC. The first is associated more with teaching and learning science concepts through experimental work, and the second concerns arranging field trips to zoos or aquariums, neither of which are particularly applicable to a mathematics classroom. Such a close alignment of the goals of the Ohio SSI as articulated through this instrument (which was designed to measure the effectiveness of the project in transmitting these goals to practising

teachers) with the goals of the CEMC as distilled from the wide range of literature presented in Chapter Three, was accepted by the project director and members of the research team. This validates the use of the Landscape data in the analysis presented in the following chapter. The equitable and reformed teaching practices being advocated by the SSI were essentially the same as the characteristics of the CEMC as presented in Chapter Three. The other items in the LTQ sub-scales concern principal and parental involvement in the school, and as such are not within the control of the classroom teacher (at whom the goals of the CEMC are directed). These scales were designed to uncover possible reasons as to why the goals of the SSI were or were not being transmitted or implemented effectively. The purpose of defining the characteristics of a CEMC was to enable meaning to be made out of the qualitative data collected at the site visits. Facilitators and barriers to achieving equity in the classroom could not be determined until it was clear just what an equitable mathematics classroom might look like.

As previously mentioned, the Ohio SSI deliberately did not focus on curriculum development, and as such there were few references to matters relating to curriculum development in the LTQ.

At the beginning of the LTQ, a sample item was included with a demonstration of how to respond to the item by circling the best response. The instrument was revised several times, and was trialed with two groups of practising science and mathematics teachers. These teachers provided useful feedback on how to improve the wording and readability of the instrument. These changes were subsequently incorporated into the final version.

The questionnaire was designed to find out about teachers' teaching practices. Streaming (or tracking as it is known as in the USA) is fairly widely practised in mathematics, with teachers typically employing different teaching techniques with high-ability (e.g. eighth-grade algebra) classes than they do with low-ability (e.g. eighth-grade general mathematics) classes. Several members of the research team believed that teachers would be likely to respond in differing ways to the same question depending upon which group of their students they were thinking about at that time. To ensure that teachers would respond consistently throughout the whole questionnaire, respondents were asked to choose a particular class that they taught and answer the whole questionnaire with respect to that class. To facilitate a random choice of class by each teacher, a selection protocol was devised. Every questionnaire distributed had a different set of random numbers in the selection protocol printed on the first page, and this

ensured that every class was chosen randomly. The teacher was also asked to provide some demographic information about the selected class.

LTQ analysis

For the LTQ, I conducted all the analysis reported in this thesis. Only the first five sections of the instrument were used in this analysis, because the remaining two sub-scales contained information that was not directly relevant to my research questions, and the format of these sections was entirely different (not Likert-type responses). I decided to use factor analysis on the LTQ because of its widespread use in educational research as a reliable statistical procedure. It is often used to reduce a large set of variables, in this case the teachers' responses to each question, to a smaller set called factors which are more basic (Ferguson & Takane, 1989). The factors are used to explain an underlying principle connecting all of the variables together. In this case, the factors were the teacher's teaching behaviours, their views about mathematics, the principal's support and the parental support they experienced at their school.

In order to ascertain the underlying factor structure for these items, a principal-components rotated-varimax method of factor analysis was employed twice: once each for the "frequency" and again for the "importance" responses in the questionnaire. Principal-components factor analysis is the most commonly used method, with the rotation of those factors using varimax rotation allowing meaning to be attached to the factors (Ferguson & Takane, 1989). Cattell's Scree test was applied to determine the optimal number of factors for each analysis. For the "frequency" responses, the Scree test identified four or six factors as the best solution, and both were examined. For the "importance" responses, the Scree test identified three or five factors as the best solution, and both were investigated. Following the factor analysis, the internal consistencies of the factors were investigated using Coefficient Alpha.

Effect sizes were used to investigate differences in the reporting of these factors by SSI and Non-SSI teachers. The effect size is a standardised measure of the difference between two means and provides a measure of the magnitude of the differences (Robinson & Levin, 1997). A number of researchers (Keeves & Kotte, 1996; Rennie & Parker, 1996) have used effect sizes when reporting differences between mean scores on attitude scales because effect size is not affected by the size of the sample in the way that a t-test would be. On the other hand, a t-test estimates the likelihood of an observed difference occurring. With large sample sizes even a very small difference is reported as statistically significant, which is

of little use when trying to determine the practical implications of a difference between means.

When using effect sizes with respect to differences in achievement, Keeves (1992) found that an effect size of 0.30 can be interpreted as being equivalent to the amount learned in one year of schooling. In terms of educational significance, Keeves (1992) also considered an effect size less than 0.2 as trivial, one lying between 0.2 and 0.5 as small, one lying between 0.5 and 0.8 as moderate, and those in excess of 0.8 as large. These benchmarks were used in the interpretation of analyses conducted in this study.

Landscape Student Questionnaire (LSQ) and Mathematics Discovery Inquiry Test (MDIT)

LSQ description

The LSQ (see Appendix D2) was designed by the research team to complement the LTQ in gathering information about the impact of *Project Discovery* on equity and reformed teaching practices. Statements in the LTQ that students were considered to be informed enough about to give a reasonable response were included in the LSQ. However, issues to do with such things as teachers' professional development and provision of resources were not included. Since socio-cultural factors such as peer influences were considered to be important factors associated with learning, a section entitled "My friends..." was included. Some items were modeled after items on the Mathematics Learning Environment Survey (Taylor, Fraser, & White, 1994), the concept of involuntary minorities (Ogbu, 1978) and the "Home Involvement in Science Learning" scale of the 1988 NAEP test (Mullis & Jenkins, 1988).

All of the statements took the same format. Five different stems were provided, and responses about the frequency of this behaviour or event were to be indicated on a five-point Likert scale with responses of Almost Never (AN), Seldom (Se), Sometimes (So), Often (O) and Very Often (VO). The five stems were "In this math class, my teacher ...", "In this math class I ...", "My principal...", "My friends ...", and "At least one adult in my home...". Because the LSQ was given with the MDIT, and the MDIT was only designed and trialed with seventh- and eighth-grade students, the LSQ was only administered to seventh- and eighth-grade students.

MDIT description

The achievement test for mathematics was constructed in 1994 by a team of teachers, university mathematics educators, and members of *Project Discovery's* academic leadership teams. (Leadership teams consisted of teachers who had participated in the institutes and who had been selected by their district to be teacher leaders.) As mentioned previously, this test is still being used and will not be available for public release until the *Landscape Study* is completed. Items for the MDIT were selected from 1990 and 1992 National Assessment of Educational Progress (NAEP) public-release items. Most items were multiple-choice format, with most having three or four distracters. There were also some items that required a written explanation of why the student chose that particular answer, and one problem where the answer had to be provided as a number. These tests were designed to measure students' abilities in problem solving and conceptual thinking, and were given to seventh- and eighth-grade students in selected classes of the selected schools.

There were also some attitudinal items at the beginning of the MDIT designed to assess the student's views about mathematics and report frequencies of certain classroom practices. There were nine statements about particular teaching and assessment behaviours which students had to respond to concerning the frequency of occurrence of these behaviours. The four choices were "Almost every day", "Once or twice a week", "Once or twice a month" and "Never or hardly ever". There were eight statements about their attitudes towards mathematics which students had to respond to by assessing their degree of agreement with the statements. The five choices were "Strongly agree", "Agree", "Undecided", "Disagree", and "Strongly Disagree".

The MDIT was field tested and revised in 1994. Using the Cronbach Alpha Test of Internal Consistency, reliability was established at $r=0.86$.

LSQ and MDIT attitudinal analysis

I conducted all of the analysis on the LSQ and MDIT attitudinal data, although a preliminary analysis of these data was conducted by a graduate student working for *Project Discovery* —this preliminary analysis was reported in Tims Goodell, Kelly, Damnjanovic and Kahle (1997). Due to concerns about the robustness of the factors initially obtained using a cutoff of 0.5 to decide whether or not to include an item from a factor, I used a slightly lower cutoff than the preliminary study in the analysis reported in the present study. This led to more items being included in each of the factors.

As detailed previously, the LSQ consisted of five stem statements concerning the frequency of the event or behaviour occurring to which students were required to respond. The MDIT attitude items included nine statements about certain teaching and assessment behaviours which students had to respond to concerning the frequency of occurrence of these behaviours. There were eight statements about their attitudes towards mathematics to which students had to respond by assessing their degree of agreement to the statements.

Principal components and rotated varimax factor analysis was used to determine the factor structure associated with reformed teaching practices and socio-cultural influences on achievement for the LSQ items and attitude items on the first part of the MDIT. For the LSQ items, Cattell's Scree Test showed that a four-factor solution was the most appropriate. For the MDIT items, Cattell's Scree Tests showed that a two-factor solution was most appropriate. Following the factor analysis, the internal consistencies of the factors were investigated using Coefficient Alpha. For those factors identified by the factor analysis, three-way ANOVAs were used to investigate differences in the reporting of those factors by students of different gender, race or SSI groups. In the context of this thesis, gender and SSI group were clearly important variables. Race was included as a variable in the analyses presented here because of the importance of race as a variable in selecting the sample to be tested, and because there had been interactions between race and gender found in previous analysis of *Landscape* science data (Damjanovic, 1996). As previously mentioned, the site visit schools, and hence the students to whom the LSQ and MDIT would be given, were chosen only if there were at least 30% non-White students enrolled.

MDIT achievement analysis

The achievement of students on the MDIT in classes taught by SSI teachers was compared to that of students taught by Non-SSI teachers. SSI and Non-SSI teachers were matched on several common characteristics including teaching assignment, classroom experience, and participation level in extracurricular activities. Across all of the schools, it was assumed that the distribution of students in the SSI and Non-SSI classes was random. Three-way ANOVAs were used to investigate whether differences in achievement could be attributed to the students' gender, race or SSI group, or an interaction of these three variables.

Qualitative Data Analysis and Type

Computer software for qualitative data analysis—QSR NUD•IST

There was a huge volume of qualitative data collected during the mathematics site visits—70 documents in total, comprising interviews, observations and some site-visit reports. Because of the difficulty in managing such a large volume of data, a qualitative data analysis computer software package was sought that would make the analysis more manageable and meaningful. Miles and Weitzman (1994) provided an overview of the types of qualitative data analysis software packages available at the time, and also gave advice on how to choose the most appropriate software based on the type of data to be collected and the analysis planned. They listed five main categories of software, three of which were specifically designed for qualitative analysis: code-and-retrieve programs which help divide the text into chunks, attach codes to the chunks, and find and display all instances of a particular code; theory builders which have all the code-and-retrieve features plus they allow connections between categories; and conceptual network builders which have similar functions to the theory builders but use visual graphic displays. The analysis planned for this thesis, the cross-site analysis, was outlined in Chapter One. This analysis required not only the code-and-retrieve functions but also the theory-building functions. Based on their table of program characteristics (Miles & Weitzman, 1994, pg. 316) NUD•IST was the only package available for the Macintosh computer that had all of the required features.

To use the program effectively, each interview or set of observation notes needed to be entered into the computer as a separate document. Each document could then be displayed on the computer screen and codes attached to chunks of text. Codes could be predetermined or invented as needed during the coding process. The research team developed a simple set of codes that would be used as a starting point by each researcher. Researchers could subsequently invent as many more codes as necessary for their particular site. I used this initial set of codes with my first site-visit data analysis in 1995.

Cross-site analysis

A number of previous studies have demonstrated that cross-site analysis, which combines all data sources from a number of sites, provides a valuable tool for understanding the complexities of educational reform (Anderson, 1995; Huberman & Miles, 1983; Rossman, 1993). A cross-site analysis was chosen so

as to develop a more complete understanding of the many issues encountered in the implementation of the SSI across the state. It was decided to use the methodology of cross-site analysis based on ideas put forward by Miles and Huberman (1984), formalised by Rossman (1993), and continued by Miles and Huberman (1994). Rossman identified eight phases in the process of cross-site analysis. Table 4.4 shown above, adapted from Rossman (1993), summarises the eight phases of cross-site analysis and how each phase was accomplished in this study.

The first three phases of the Rossman cross-site analysis were all accomplished during the planning and implementation of the site visits. Phase 4 was accomplished during repeatedly reading all of the interview transcripts, field notes and site-visit reports during the process of transcribing, editing and entering the documents into NUD•IST. The fifth and sixth phases of the cross-site analysis were completed during the coding of the transcripts using the definition of the Connected Equitable Mathematics Classroom (CEMC) presented in Chapter Three. One branch of the coding tree referred to the features of the CEMC. All the original transcripts of interviews and researchers field notes were then entered into the NUD•IST software. Using the coding system developed from the features of the CEMC, these documents were then coded. Once coding was completed, reports were generated for each site with reference to the CEMC features. For example, all text coded with a feature of the CEMC that was associated with Naylor Middle School would be collected together in the node report for Naylor. These site-based CEMC-feature reports enabled a comparison to be made between the picture of equity obtained from the original transcripts with the descriptions provided by the reports of the site visit researchers. Node reports were also generated for each feature of the CEMC. For example, the node “valuing students’ responses” would contain references to all text that was coded as an example of “valuing students’ responses”. The node report would contain text from all documents that contained this reference. This enabled the comparison part of Phase 6 to be easily accomplished.

Phase 7 of the Rossman (1993) framework was the most difficult, but made somewhat easier by the use of the NUD•IST software and the conceptual framework for synthesising case studies located within the practice of systemic reform as described by Rossman (1993). The four dimensions of this framework are

Table 4.4

Rossman's Phases of Cross-Site Analysis, as Applied to This Study

	Name of phase	Task	Application to this study
Phase 1	Beginning	Locate the areas of interest that will provide the focus of the cross-site analysis.	Equity and reform in Ohio SSI mathematics classrooms.
Phase 2	Bounding the scope	Place initial boundaries on the scope of the synthesis	Site visits to focus on topics raised in the LTQ. Individual researchers to identify issues that facilitate or prevent implementation of reform.
Phase 3	Inventorying the cases	Describe the focus, goals, scope, complexity, organisation and audience.	Individual researchers prepare site-visit reports.
Phase 4	Reading the cases	Become immersed in the cases - read repeatedly and reflect on the texts.	Read and prepare original interview transcripts for entry into NUD•IST software.
Phase 5	Developing an interpretation of the cases	Focus on each case in turn to identify the key metaphors that illustrate the central meanings of the cases.	Identify elements of equity present at each site based on the definition of connected equitable classroom described in Chapter 3, and code documents in NUD•IST using one node for each example of equity.
Phase 6	Juxtaposing the cases	Identify how one case is like and not like another. Compare themes, metaphors and explanatory stories across cases.	Print out each site's equity observations as coded in NUD•IST. Summarise features of each site and write Chapter 6
Phase 7	Synthesising the cases	Combine the interpretations while preserving the contradictions in each case.	Code documents using one node for each dimension of reform. Identify facilitators and barriers to reform. Print out node reports and synthesise issues.
Phase 8	Writing the synthesis	Provide a more complex understanding of the subject than does any single case.	Write Chapter 7.

Adapted from Rossman (1993)

- Technical: Professional knowledge and skills, and the means by which they are acquired.
- Political: Matters of authority, power and influence, including the negotiation and resolution of conflicts.
- Cultural: Values, beliefs and school norms—both in terms of a general ethos and competing perspectives that contend with each other.
- Moral: Matters of justice and fairness.

Each dimension was given a node in the NUD•IST tree, with sub-nodes being developed as each document was analysed. Because many of these issues were a matter of judgment on the part of the researcher, direct reference to the issue was sometimes not found in a transcript. Interpretations and judgments were influenced by the researcher's own perspectives. The vast differences in backgrounds and work situations of the four researchers who visited the sites made the task of cross-site analysis quite challenging because there was sometimes little consistency in the focus of the teacher interviews or the issues that were focused on in the classroom observations and site-visit reports. However, these differences added richness to the data as well, enabling a broad picture of many issues to be constructed. Using the original transcripts of interviews and field notes made the lack of consistency between site-visit data a little less problematic. This could have threatened the validity of the study if only qualitative data were being used. However, the range of data used, together with the contextualisation of the site-visit data provided in the rich site descriptions in Chapter Six, has minimised this risk.

SUMMARY

The wide range of qualitative and quantitative data, and the range of types of analysis, enabled a broad picture of the impact of the Ohio SSI on middle-school mathematics classrooms to be constructed. In Chapter Five, the quantitative results for the LTQ, LSQ and MDIT analysis are presented. Chapter Six gives details of each of the sites visited and the equity observations made at each of those sites. This is followed in Chapter Seven with the results of the cross-site analysis. In the final chapter, Chapter Eight, the implications and challenges for future research are discussed.

CHAPTER FIVE

STATEWIDE QUANTITATIVE RESULTS

INTRODUCTION

The purpose of this chapter is to present and synthesise the results of the quantitative analyses of the Landscape Teacher Questionnaire (LTQ), Landscape Student Questionnaire (LSQ) and Mathematics Discovery Inquiry Test (MDIT). The methodologies used for each of these analyses were described in detail in Chapter Four.

First, the results of the factor analyses of the LTQ are presented, followed by a discussion of a number of individual items from the LTQ that are directly related to equity. Next the LSQ and MDIT attitudinal-item factor analysis is presented. Next the results of the three-way ANOVAs performed on the achievement data from the MDIT are presented. The chapter concludes with a summary which discusses and synthesises all of the quantitative results.

TEACHER DATA: LANDSCAPE TEACHER QUESTIONNAIRE (LTQ)

The purpose of the analysis of items from the LTQ was two-fold. The first aim was to determine the extent to which reformed teaching and assessment methods were practised in mathematics classrooms in Ohio. These practices had been advocated by the SSI since its inception, and many of these were identified as features of the ideal Connected Equitable Mathematics Classroom (CEMC) constructed in the first phase of this study. The second aim was to compare the responses of SSI and Non-SSI teachers in order to begin to identify those factors which facilitated or inhibited the achievement of equity and the implementation of the features of the CEMC.

It was decided to conduct two separate factor analyses on the LTQ data: one for the “frequency” responses and one for the “importance” responses. Only data from the first five sections of the LTQ were analysed: those which were concerned with teaching and assessment practices advocated by the SSI; parent and principal support for those practices; and the respondents views about the

nature of mathematics. The last two sections contained information that was not directly relevant to the aims of this study. For the first four sections, each item required two responses: one on a five-point scale about the frequency and the other on a four-point scale which indicated their view about the importance of that particular event or behaviour occurring in their class. In the fifth section, respondents were asked to agree or disagree on a four-point scale and rate the importance of that view being reflected in their classes on a four-point scale.

Frequency Scales Analyses

To find the optimum number of factors, a principal components factor analysis was carried out. Using Cattell's scree test on the eigenvalues of the 63 variables, four factors appeared to be optimum for the "frequency" scales and five for the "importance" scales. (Appendix E Figure E1 and E2 show the scree plots of these analyses.)

Further evidence for choosing a four-factor solution for the "frequency" scales came from examining both four- and six-factor solutions. In the six-factor solution, two factors had very few unique variables loading onto the last two factors. Thus it was concluded that those two factors were not stable enough to consider in the analysis. The factor loadings for the four-factor solution, shown in Appendix F Table F1, indicated that nearly all variables loaded onto one of the four factors. Traditionally, only loadings greater than 0.3 are shown (Rennie & Parker, 1996) because loadings of less than 0.3 explain less than 10% of the variance in a factor. Stevens (1992) demonstrated that loadings of 0.32 are significant at the 1% level for samples of about 270. In the analysis presented in this chapter, all samples are over 270, so it is reasonable to choose a value of 0.30 for the cut-off in reporting loadings and including those variables in the factors. Only two out of the 63 items did not load onto any of the four factors in the "frequency" scales.

For the "frequency" scales, the first factor concerns classroom teaching practices, and includes most of the items from the sections "How I teach" and "What my students do", and is named CLASSTCH (see Appendix G Table G1). The second factor contains items from the section "My school principal's involvement" and is named PRINSUPP (see Appendix G Table G2). The third factor, containing items from the section "Parental involvement", is concerned with support from the home and is named HOME (see Appendix G Table G3). The fourth factor contains items from the section "My views about mathematics", and is named NATMATH (see Appendix G Table G4).

The reliabilities of these factors were calculated using a correlation analysis and the Cronbach Coefficient Alpha. Values are shown below in Table 5.1.

Table 5.1
Cronbach Coefficient Alpha for LTQ Frequency Factors

Factor Name	Number of Items	Reliability
CLASSTCH	24	.886
PRINSUPP	17	.876
HOME	13	.873
NATMATH	7	.873

To determine if there were any differences in the way SSI and Non-SSI teachers responded to these factors, effect sizes were calculated. The effect size was calculated by subtracting the Non-SSI teachers' mean score for the factor from the SSI teachers' mean score and dividing this difference by the pooled within-group standard deviation. A positive result indicated SSI teachers' mean was higher than Non-SSI teachers, and as discussed in Chapter Four, an effect size greater than 0.2 was considered to be educationally significant. The means and significant effect sizes for all of the LTQ factors are shown graphically in Figure 5.1 below, and in tabular form in Appendix H Table H1.

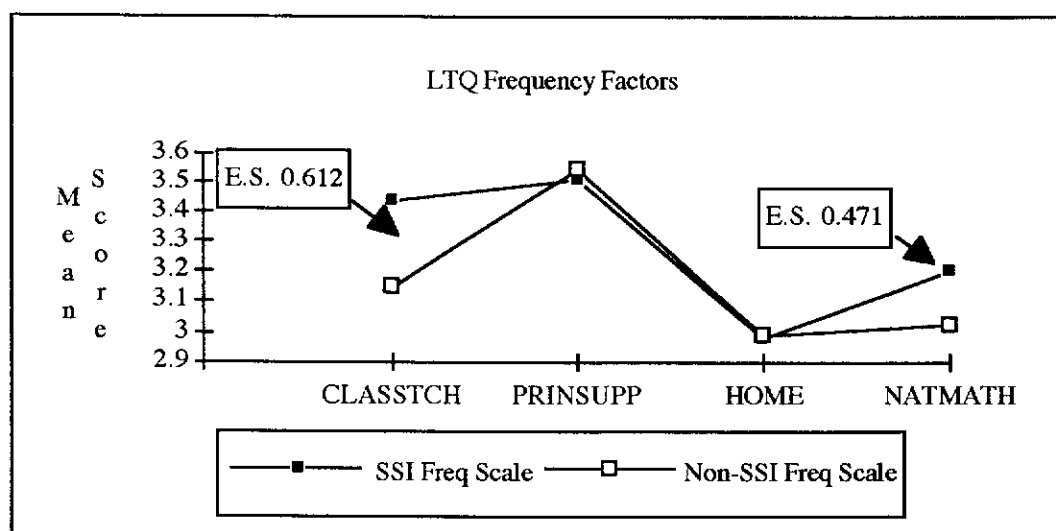


Figure 5.1 Means and effect sizes for LTQ frequency scale factors.

As can be seen from Figure 5.1, although SSI teachers responded very differently to Non-SSI teachers in terms of their classroom teaching practices and their views about the nature of mathematics, the responses of both groups on the

principal- and parent-support scales were very similar. For the purpose of this analysis, reformed teaching practices will be those teaching practices described on the LTQ in the “How I teach” sub-scale and “What my students do” sub scale. In general, SSI teachers reported using reformed teaching and assessment practices more frequently than their Non-SSI counterparts. The SSI teachers also agreed more with statements that purported mathematics to be subjective, open to debate, constantly being refined by new discoveries and having many issues unresolved. As indicated earlier, these views were espoused by institute leaders in the SSI program. The analysis of the LTQ items indicated that SSI teachers were more in agreement with these statements than their Non-SSI counterparts.

Importance Scales

The items from the “importance” scale did not form factors as readily interpretable as those from the “frequency” scale. This could have been because the respondents tended to use the Important or Very Important response a great deal creating a ceiling effect. The items from the “How I teach” and “What my students do” sections were split between the second and third factors, although the other three factors formed as readily from the relevant sections of the LTQ as they had for the “frequency” scales. The factor loadings for the “importance” response factors are given in Appendix I, Table I1. The names of the five factors identified by this factor analysis, along with the number of items comprising the scale and the alpha reliabilities, are given below in Table 5.2. The first factor concerns the importance of principal support and is called IMPPRIN. The second factor is concerned with the importance of students being actively involved in the classroom and is called IMPACTVT. The third factor is concerned with the importance of teachers and students communicating with each other in the classroom and is called IMPCOMM. The fourth factor is concerned with the importance of parental support and is called IMPPAREN. The last factor is concerned with the importance of the teachers’ views about the nature of mathematics being reflected in their teaching practices and is called IMPVIEW. Appendix J Tables J1 - J5 show the content of every item in each factor.

The reliability of these factors was calculated using a correlation analysis and the Cronbach Coefficient Alpha. Values are shown below in Table 5.2.

Table 5.2
Cronbach Coefficient Alpha for LTQ Importance Factors

Factor Name	Number of Items	Reliability
IMPPRIN	17	.902
IMPACTVT	12	.855
IMPCOMM	12	.821
IMPPAREN	11	.859
IMPVIEW	8	.866

Regarding the “importance” sub-scale factors, effect sizes were calculated to determine if there was any differences in the way SSI and Non-SSI teachers responded to each “importance” factor. Table K1 in Appendix K shows the mean, standard deviation, sample size and effect size for the “importance” scale factors. In Figure 5.2 below, the means and significant effect sizes for each of the five “importance” scale factors for SSI and Non-SSI teachers are shown graphically.

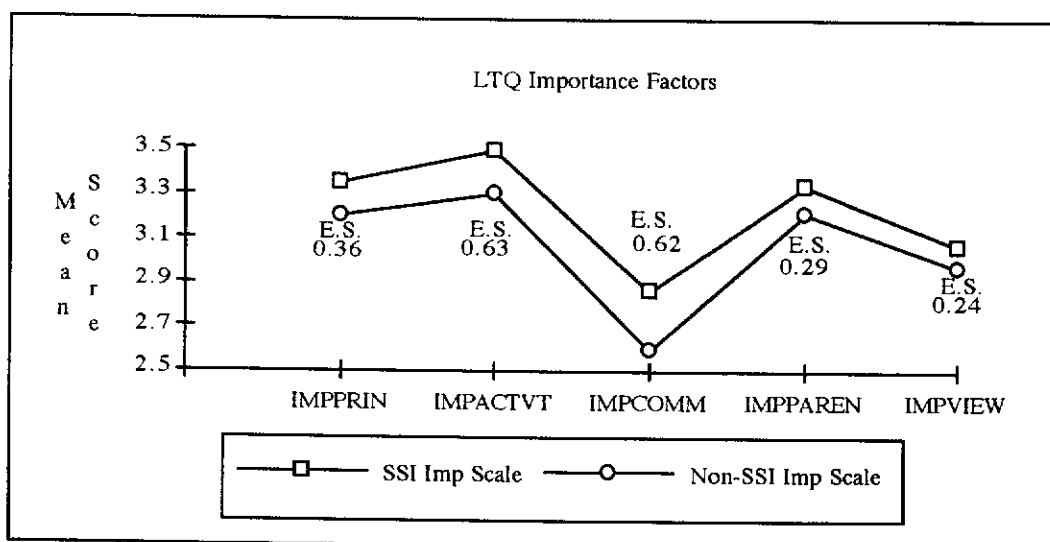


Figure 5.2 Means and effect sizes for LTQ importance scale factors.

Given that effect sizes of greater than 0.2 are considered educationally significant, the results of this analysis show that SSI teachers attached a significantly greater level of importance to all factors than did their Non-SSI counterparts.

Comparing the “Frequency” and “Importance” Responses

As previously stated, the factor analyses identified four factors for the “frequency” responses, and five factors for the “importance” responses. The main differences between these two factor structures occurred in those scales that were concerned with the reformed teaching practices advocated by the SSI: whereas for the “frequency” responses all variables formed one factor, for the “importance” responses two factors were identified. Nevertheless, there were significant differences between SSI and Non-SSI teachers’ responses on all factors that were concerned with reformed teaching practices on both the “frequency” and “importance” responses. The conclusion to be drawn from this comparison is that, at least in terms of the participants’ own perceptions, the reformed teaching practices advocated by the SSI were more evident in SSI classrooms than Non-SSI classrooms.

For principal- and parent-support factors, there was no difference in the way SSI and Non-SSI teachers responded about the frequency of these events; however, there were significant differences in the way the two groups of teachers responded about the importance of principal and parental support. SSI teachers reported more than did their Non-SSI counterparts, that it was important to have the support of principal and parents. Even though SSI teachers reported that they were not getting more support from principals and parents than their Non-SSI counterparts, they thought that it was important to get such support.

Overall these analyses indicated that SSI teachers implemented reformed teaching practices, and valued these practices, along with principal and parental support, more than their Non-SSI counterparts.

Factors Affecting the Achievement of Equity in the Classroom

Although the LTQ was designed to investigate factors associated with reform, many of the items in the LTQ were also concerned with equity objectives. In order to gain a state-wide perspective on the achievement of these equity objectives, sub-scales of items related to those objectives were created following from the description of the Connected Equitable Mathematics Classroom distilled from the literature and presented in Chapter 3 of this thesis. For each sub scale, the “frequency” and “importance” responses of SSI and Non-SSI teachers are compared using effect sizes as described in Chapter Four.

Actively engaging students

There were a number of items in the LTQ that referred to actively engaging students in the learning process. In almost every instance, SSI teachers reported that they engaged in these practices more frequently and that they regarded these practices as more important than their Non-SSI counterparts. Table 5.3 shows the effect sizes for each of the items from the LTQ related to actively engaging students in the learning process. Figure 5.3 displays the mean scores for the “frequency” responses.

Interestingly, although SSI teachers reported that they encouraged questions from their students more frequently than Non-SSI teachers, both groups thought this practice to be equally important. The most frequent responses for both groups were “Very Often” and “Very Important”, with the mean scores on both scales for all groups being close to the maximum of 5 for “frequency” responses or 4 for “importance” responses. SSI teachers also perceived that their principal accepted the noisier classroom that reformed practices would produce, and that it was more important for the principal to do so.

Table 5.3

Effect Sizes for SSI and Non-SSI Teachers on Items Related to Actively Engaging Students

Item	Item	Freq.	Imp
	In this class, I ...		
T1	arrange seating to facilitate student discussion.	0.72	0.63
T4	encourage questions from my students.	0.28	0.04
T6	encourage my students to explain concepts to one another.	0.51	0.65
T10	provide time for my students to discuss subject-specific ideas among themselves.	0.35	0.30
	In this class, my students ...	Freq.	Imp
S2	argue or debate with one another about the interpretation of data.	0.46	0.47
S3	repeat experiments to confirm results.	0.06	0.27
S6	design activities to test out their own ideas.	0.30	0.38
S7	consult one another as sources for learning.	0.41	0.32
S8	talk with one another to promote learning.	0.53	0.43
	My school's principal...		
P3	accepts noise associated with my active classroom.	0.38	0.62

NB: Significant effect sizes are shown in boldface.

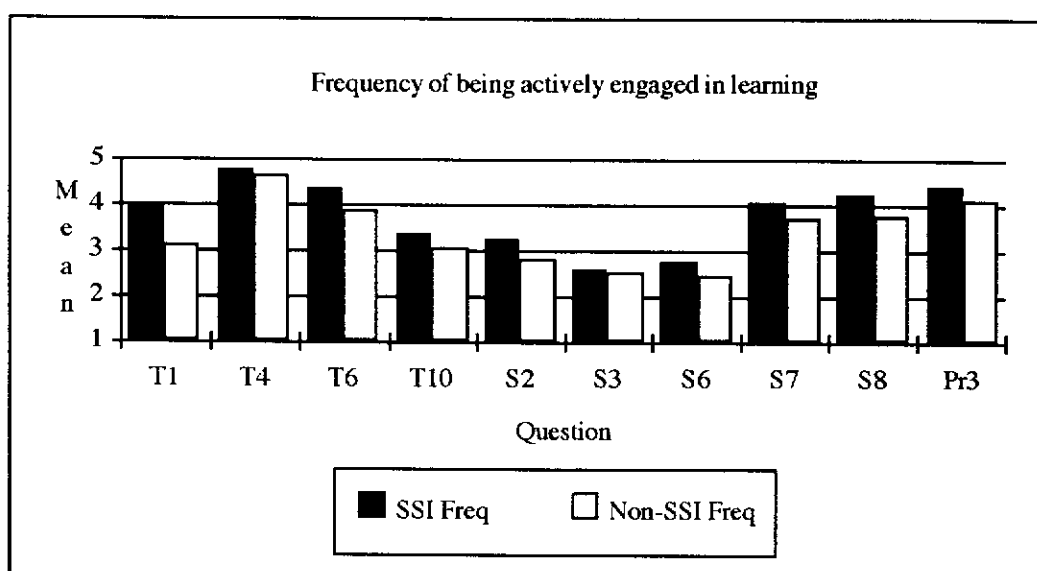


Figure 5.3 Mean scores on LTQ frequency items related to students being actively engaged.

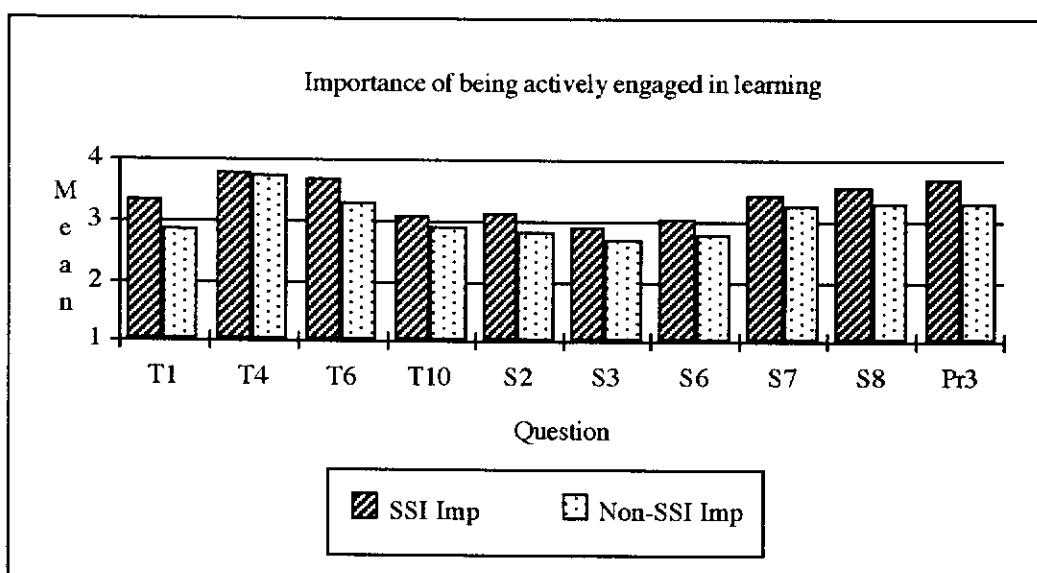


Figure 5.4 Mean scores on LTQ importance items related to students being actively engaged.

Extending students' thinking

Another feature of the CEMC is extending students' thinking by using open-ended questions that encourage students to search for alternative explanations. There were some items relating to these features in the LTQ. There was a small difference between SSI and Non-SSI teachers in the way they used

and valued open-ended questions, although most teachers reported that they used open-ended questions often, and that it was important to do so. There were much larger differences in the way the two groups responded about their frequency of encouraging students to consider alternative explanations, with most SSI teachers responding “Very Often” or “Often”, while most Non-SSI teachers responded “Often” or “Sometimes”. If these responses are compared to the responses about what students actually did in the classroom, an interesting difference is noted. Both SSI and Non-SSI teachers reported that their students only “Sometimes” considered alternative explanations, but that they “Very Often” or “Often” encouraged them to do so, thus showing that there was a difference between what teachers perceived themselves as encouraging students to do, and what students were actually perceived to do.

Table 5.4

Effect Sizes for SSI and Non-SSI Teachers on Items Related to Extending Students' Thinking

Item	Stem	Freq.	Imp
	In this class, I ...		
T2	use open-ended questions.	0.27	0.29
T7	encourage my students to consider alternative explanations.	0.61	0.49
	In this class, my students...		
S4	use multiple sources of information to learn.	0.20	0.19
S5	consider alternative explanations to accepted theories.	0.10	0.19

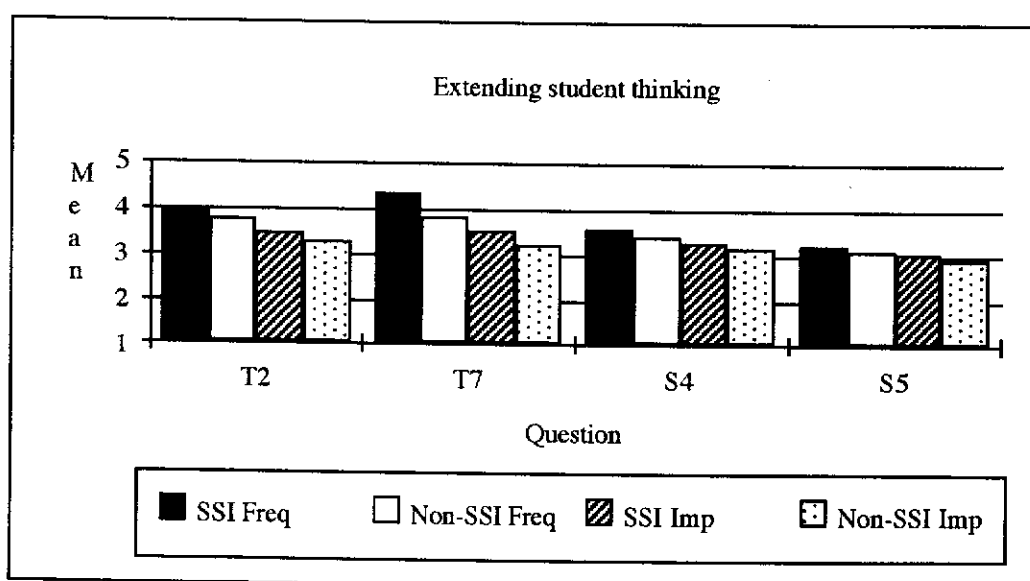


Figure 5.5 Mean scores on LTQ items related to extending student thinking.

Use real world contexts, connect to student experiences

One of the most important features of the CEMC concerns connecting students to the mathematics being learned either through using real-world contexts for problems, talking about how mathematics is used by mathematicians, or using contexts that students can relate to in some way. There were five questions in the LTQ that were concerned with these aspects. On only two of these items—arranging field trips to museums and discussing experiments from the history of mathematics—did the SSI teachers report more frequent occurrence than their Non-SSI counterparts. SSI teachers attached a greater level of importance to these things happening in their classes than did their Non-SSI counterparts, both on the previously mentioned two items, and also for discussing the work of mathematics and using data to justify responses to questions.

In terms of the actual responses, the frequency of arranging field trips to museums was very low for both groups of teachers. Most teachers responded “Almost Never” and thought that this was “Unimportant” (but not “Very Unimportant”). This issue was frequently mentioned during the interviews conducted during the site visits because of the discrepancy between “frequency” and “importance” responses. Lack of money to arrange such field work was the reason the SSI teachers quoted as accounting for the low frequency.

In contrast to the low frequency of museum visiting, high levels of frequency and importance of learning about real-world applications of mathematics were reported for both SSI and Non-SSI teachers. Most teachers reported that their students did this “Often” or “Very Often”, and that was “Very Important”. These responses indicate that all teachers, whether or not they have participated in the SSI, have adopted some of the messages of the NCTM (1989; 1991) reforms. Using real-world applications was a central element of the changes advocated by the NCTM, and these aspects are discussed in Chapter Three of this thesis.

Table 5.5 gives the effect sizes for comparing SSI and Non-SSI teachers’ responses, and Figure 5.6 shows graphically the mean scores for SSI and Non-SSI teachers on each of the items from the LTQ relating to the use of real-world contexts.

Table 5.5
Items Related to Connecting to Student Experiences

Item	Stem	Freq.	Imp
	In this class, I ...		
T9	discuss the work of mathematicians/scientists ¹ .	0.12	0.23
T11	arrange field trips to museums.	0.28	0.33
T12	discuss experiments from the history of mathematics/science.	0.28	0.36
	In this class, my students...		
S1	use data to justify responses to questions.	0.08	0.26
S11	learn about real world applications of mathematics/science.	0.13	0.17

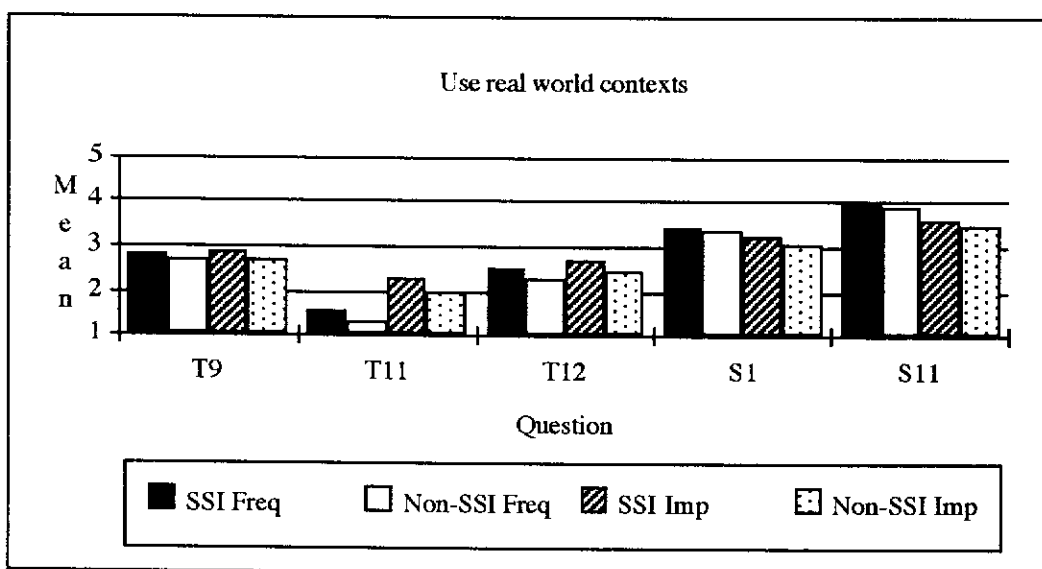


Figure 5.6 Mean scores on LTQ items related to using real world contexts.

Use a variety of teaching and assessment practices

The last feature of the CEMC that was dealt with in the LTQ was the use of a variety of teaching and assessment practices. Table 5.6 shows the effect sizes for comparing SSI and Non-SSI teachers' responses and Figure 5.7 shows graphically the mean scores for SSI and Non-SSI teachers on each of the items from the LTQ relating to using a variety of teaching and assessment practices.

¹The Landscape Study collected data from both mathematics and science teachers, so the instrument had to be worded in this way to simplify the distribution process. However, the study reported in this thesis uses only data collected from mathematics teachers.

The large effect size for item T13 showed that SSI teachers reported using non-traditional assessments far more frequently than their Non-SSI counterparts, and they reported valuing this much more highly, although the mean scores for SSI teachers showed that most teachers indicated that they used non-traditional assessment only “Sometimes”.

SSI teachers also reported using educational technology more frequently and thought it was more important to do so than their Non-SSI counterparts, although the effect sizes here were small. The mean scores on this item indicated that both groups of teachers did so only “Sometimes”, but thought that it was “Important” to do so, indicating that the SSI teachers embraced change more frequently than did their Non-SSI counterparts.

The principal support item showed much bigger effect sizes on both the “frequency” and “importance” scales, as well as generating very high frequency and importance ratings. SSI teachers reported significantly greater principal support for their innovative instructional practices than did Non-SSI teachers.

The last two items in this section come from the parent sub scale of the LTQ, and concern support for reformed teaching and assessment practices. There was a moderate effect size for frequency of parent support for different types of homework but a much larger effect on the importance of parent support for different types of homework. There was no difference between SSI and Non-SSI teachers in terms of the way they perceived the level of parental support for innovative teaching practices and only a moderate effect size for the perceived importance of parent support.

Table 5.6
Items Related to Use a Variety of Teaching and Assessment Practices

Item	Item	Freq.	Imp
	In this class, I ...		
T13	use non-traditional/authentic assessments.	0.67	0.62
	In this class, my students ...		
S9	use educational technology in the classroom.	0.27	0.32
	My school’s principal ...		
Pr4	supports my innovative instructional practices.	0.50	0.64
	The parents of my students ...		
Pa2	support different types of homework such as journals and activities/experiments.	0.35	0.53
Pa13	support innovative methods of instruction.	0.14	0.31

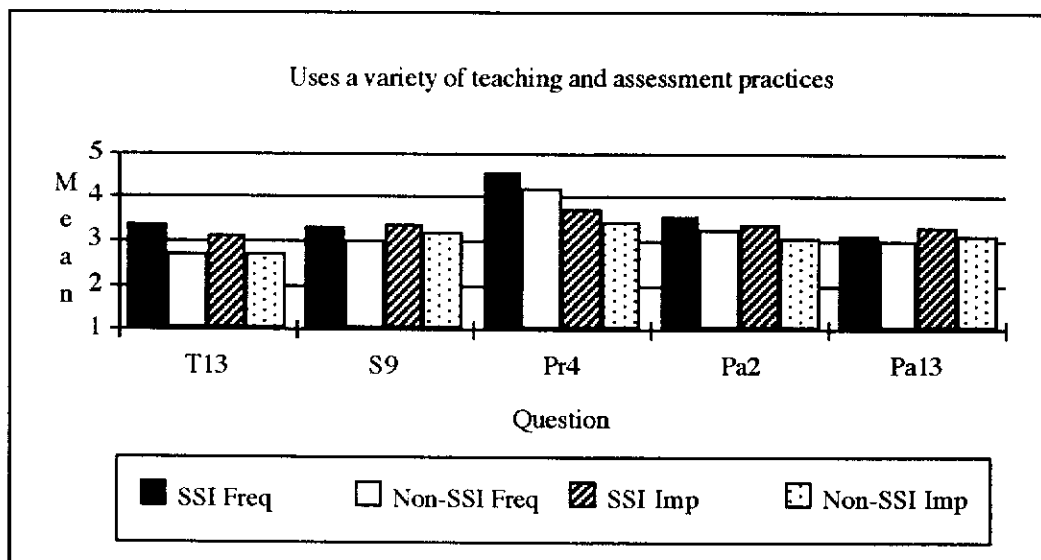


Figure 5.7 Mean scores on LTQ items related to using a variety of teaching and assessment practices.

Summary of factors affecting the achievement of equity in the classroom

The data presented in this section clearly show that SSI teachers reported that they engaged more frequently than their Non-SSI counterparts in most of the teaching and assessment behaviours investigated in this questionnaire which contribute to the achievement of equity in the mathematics classroom. That is not to say that all SSI teachers have adopted all of the behaviours necessary to achieve equity in the classroom. The quantitative instruments did not attempt to deal with certain behaviours involving changing students by valuing and encouraging student voice, negotiating meaning between teacher and student, building student confidence, or setting high standards. Nor did the LTQ deal with curriculum related issues such as the use of language and stereotypes, or using social problems as contexts which in turn stimulate social action. Many of these issues were dealt with during the site visits, and will be discussed in Chapter Six.

STUDENT DATA: LANDSCAPE STUDENT QUESTIONNAIRE AND MATHEMATICS DISCOVERY INQUIRY TEST ATTITUDINAL ITEMS

The student questionnaire and attitudinal data from the MDIT were analysed using principal component rotated varimax factor analysis for similar reasons as to those previously stated in reference to the LTQ analysis.

To determine the optimum number of factors, scree plots for the items from the LSQ and MDIT items were constructed and are presented in Appendix L

Figures L1 and L2. These show the optimum number of factors to be four and two respectively. Tables M1 in Appendix M shows the loading of each item in the LSQ and MDIT.

The first factor in the LSQ analysis was named PEER (See Appendix N Table N1), and concerned the influence of peers on mathematics learning. The second factor was named CLASSTCH (See Appendix N Table N2) and included items that described the reformed teaching practices advocated by the SSI. The third factor was named HOME (See Appendix N Table N3) and was about the influence of support for learning mathematics from adults in the home. The fourth factor identified by the LSQ analysis concerned negative peer influences and was named NEGPEER (See Appendix N Table N4). In the MDIT analysis, the first factor was named ATTITUDE (See Appendix N Table N5) because it contained items that were about the student's attitude towards mathematics. The second factor in the MDIT analysis concerned using technology, manipulatives, and group work when solving problems, and was named HANDPROB (See Appendix N Table N6).

Three independent variables were tested in a three-way ANOVA to determine if there were any significant differences or interactions among the three variables for students reporting of the established classroom factors. The variables used were Gender, either female or male; Stud_eth, either African American or White; and Group, either SSI or Non-SSI. See Appendix O Table O1 for a summary of F-values for all of the ANOVAs. For those effects that were significant, the LSMEANS post-hoc tests were employed to determine the direction of the difference. These effects are summarised in Table 5.7.

The ANOVAs showed that there were main effects for only two factors, and there were no interaction effects for any factor. There were significant main effects in the NEG PEER factor for Gender and Stud_eth. Post-hoc tests showed that male students reported significantly more negative peer influence than did female students, and White students reported significantly more negative peer influences than did African American students. There were also significant main effects in the ATTITUDE factor for Gender and Stud_eth. In this case, post-hoc tests showed that males reported more positive attitudes towards mathematics than females, and African American students reported more positive attitudes than White students.

Table 5.7

LSQ and MDIT Reliabilities and ANOVA/LSMEANS Summary

Factor	Coefficient Alpha	Effects/Differences
PEER	.74	No effects.
CLASSTCH	.71	No effects.
HOME	.76	No effects.
NEG PEER	.66	Gender and Stud_eth effects. Males and Whites report more negative peer influences
ATTITUDE	.76	Gender and Stud_eth effects. Males and AAs report more positive attitudes towards mathematics
HANDPROB	.51	No effects.

A comparison of these results with those of the LTQ analysis will be presented later in this chapter in a concluding summary section.

MDIT ACHIEVEMENT

For the mathematics achievement test, the three-way ANOVA indicated main effects for sex, race and group differences but no interaction effects. Sample means and effect sizes are given in Table O2 in Appendix O. A summary of significant results is given in Table O3, Appendix O.

Sub-group performance

Examining each individual subgroup and using Keeves' (1992) approximation that an effect size of 0.3 is roughly equivalent to what students might be reasonably expected to learn in one school year, it was revealed that African American females in SSI were the equivalent of approximately two school years ahead in achievement over their Non-SSI counterparts. White females were the equivalent of one school year ahead of their Non-SSI counterparts, while males, and African Americans and Whites were considerably less different in SSI than in Non-SSI classes.

Table 5.8
 Three-way ANOVA for MDIT Achievement Scores

Source	df	SS	MS	F
Group (A)	1	5234.7	5234.7	11.69***
Sex of Student (B)	1	1893.69	1893.69	4.23*
Race of Student (C)	1	10914.16	10914.16	24.38***
A X B Interaction	1	734.53	734.53	1.05
A X C Interaction	1	470.17	470.17	1.05
B X C Interaction	1	526.73	526.73	1.18
A X B X C Interaction	1	9.133	9.133	0.02
Within Groups	584	261475	447	
Total	591	280963		

Note. N = 592

* $p < .05$, ** $p < .01$, *** $p < .001$

LSMEANS post hoc tests showed that males outperformed females ($F(1,591) = 4.21, p = 0.04$), White students outperformed African American students ($F(1,591) = 24.46, p = .0001$) and students in SSI groups outperformed students in Non-SSI groups ($F(1,591) = 12.24, p = .0005$).

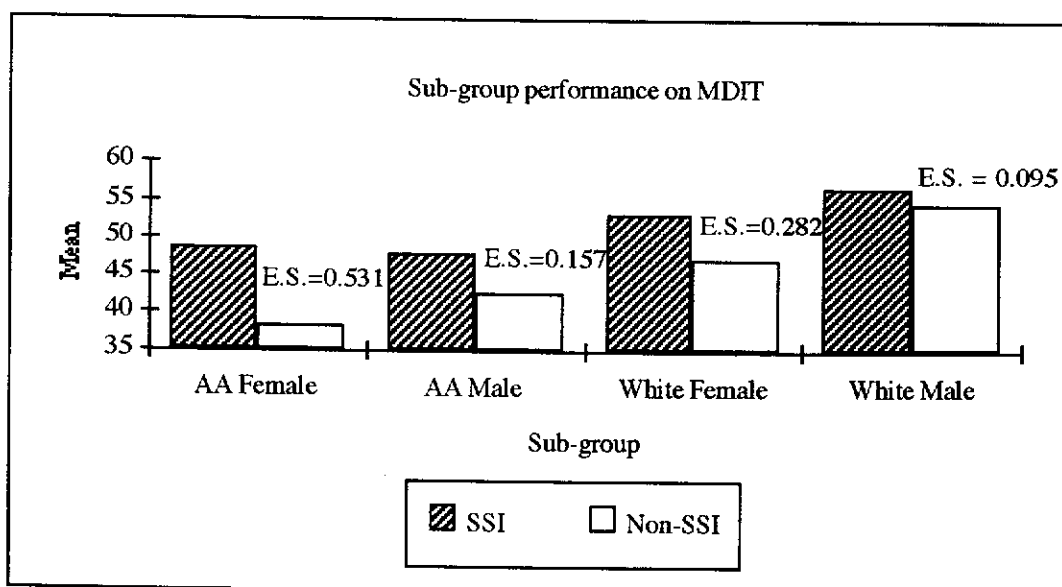


Figure 5.8 Means and effect sizes for sub-group performance on MDIT.

The results of these analyses show that higher achievement for females is associated with being in an SSI class, most particularly for African American females. The significant main effect for Group (SSI vs. Non-SSI) can be mainly attributed to the performance of females, both White and African American, performing significantly better in the SSI groups. Although there is still a significant difference in achievement in favour of males overall, it could be argued that females in SSI classes are closing the achievement gap, although there is still some way to go.

SUMMARY

The quantitative data analysis presented in this chapter shows that SSI and Non-SSI teachers perceive themselves to be quite different from each other in many ways. SSI teachers report that they engage in reformed teaching and assessment practices more frequently, agree more with statements concerning the subjectivity of mathematics, and value all aspects investigated in the questionnaire more highly than their Non-SSI counterparts. Further, students in SSI classrooms achieved significantly higher results on the MDIT than their Non-SSI counterparts, and differences between male and female achievement was smallest in SSI classrooms, although overall males outperformed females, and White students outperformed African American students. Finally, there were no differences detected between SSI and Non-SSI students in their responses to the LSQ and MDIT attitudinal items. Taken together, the pattern of differences between SSI and Non-SSI teachers and students would indicate the likelihood that SSI teachers have made and sustained changes to their teaching practices. In Chapter Six, the specific context of seven sites is described, and an analysis of each of the classrooms visited at these sites is provided in terms of the degree to which it was a Connected Equitable Mathematics Classroom.

CHAPTER SIX

ANALYSIS OF THE SITES

INTRODUCTION

The purpose of this chapter is to present the first part of the findings of the qualitative data analysis, conducted using the cross-site analysis methodology of Rossman (1993). The analysis utilised Phases 5 and 6 of the Rossman framework, which are concerned with the interpretation of the essential elements of each case. It is emphasised here that, in order to identify these essential elements, the definition of the Connected Equitable Mathematics Classroom presented in Chapter Three was used to define codes which related to occurrences of those equitable behaviours, events, teaching and assessment practices, and curriculum materials which had been observed at each site. To summarise, a Connected Equitable Mathematics Classroom has the following characteristics.

1. All students have access to academically challenging curricula.
2. Students are encouraged to develop confidence in their mathematics ability and positive attitudes towards mathematics.
3. Basic skills are developed which will enable students to be mathematically literate in the world outside school.
4. The learning environment encourages students to develop their own voice and construct their own knowledge.
5. Teachers have high expectations for all of their students.
6. Teachers connect mathematics with the real world through the use of appropriate contexts for problems, the provision of career information, and a focus on social issues which affect all students (such as ecology and health).
7. Teachers are able to recognise and act on inequities in their classroom.
8. Teachers use a variety of teaching and assessment practices.
9. The curriculum challenges stereotypes and values the contributions of women and minority groups.
10. The curriculum includes real-world problems set in a variety of contexts that value and take into account the range of student backgrounds and experiences.

11. The curriculum includes a focus on issues of social justice and ecology which enables students to challenge social conditions. There may be some element of social action by students.
12. The curriculum explicitly states equity goals.

The analysis presented in this chapter used all of the raw interview transcripts, field notes and observational data, from the eight site visits to seven sites, as well as parts of the site-visit reports completed by the four different site visitors. As indicated earlier, each researcher brought their own set of lenses for viewing a situation, based on their background, education and experience. It was for this reason that the decision was made to use the raw data (original transcripts of interviews and field notes) and re-code it using my own codes, rather than rely on the interpretations reported in the site-visit reports. Having access to the original interview transcripts and observation notes enabled me to make my own interpretations of the data and to focus on those aspects which were concerned with the Connected Equitable Mathematics Classroom.

In order to contextualise how equity objectives had been enacted at each site, a description providing demographic and locality information was constructed for each site. Then, the features of the CEMC which had been coded in the data were synthesised into one of three foci: interactions with students, pedagogy, and the curriculum. These foci were chosen to correspond with the framework of Willis (1996) used in the literature review. A detailed description of each of these three aspects, as enacted at each site, was constructed. This chapter presents the results of these analyses, in preparation for Chapter Seven which is the culmination of the cross-site analysis, Rossman's Phases 7 and 8. It is then that the barriers to and facilitators of achieving equity in the classroom are discussed.

SITE DESCRIPTIONS

Draper Middle School 1995, 1996

I visited Draper Middle School¹ for three days in May 1995 and then again for three days in May 1996 (Tims [Goodell], 1995; Tims [Goodell], 1996a). I spent most of my time with the focus teacher, Ms Eckland, a white female with 20 years' classroom experience. She had participated in the SSI in its first year of operation, 1992. Draper Middle School is a small middle school located in a mid-

¹Please see Appendix P for a comparison of pseudonyms used in this document as compared to other reports on the Landscape Study.

west rural town once well known for its pottery industry. Although at the time of the first site visit, the town, with a population of around 28 000, had a prosperous appearance, like a lot of small mid-west towns it had recently lost some important large industries. According to the principal, this had led to many families being on welfare, with the school providing increasing numbers of students with free or reduced-cost lunches.

Draper Middle School changed from a junior high school to a middle school at the beginning of the 1994/5 school year, the first year I visited. The school community had contemplated this shift for about five years. As a result of this change to a middle school, students had been grouped into teams for language arts, social studies and science. There were two teams in each of seventh and eighth grade, with a total of 360 students in the school. Each team was taught by a language arts teacher, a social studies teacher and a science teacher. Students remained with their team for most of their subjects, although not mathematics. This had the effect of making the school seem smaller and more personal, with greater communication being fostered among those teachers on the same team. Each day the students had two periods of language arts, one of science and one of social studies in their team groups. The students were not tracked for these subjects; however the school received funding for fifty "*Chapter 1*"² students, which enabled them to track the lowest achievers into separate classes for mathematics (which they called *Chapter 1* classes). In 1996 when I visited for the second time, the *Chapter 1* funding had allowed the school to hire an extra support teacher whose main job was to assist in the *Chapter 1* classes.

Because mathematics was not part of the team process, there were three mathematics teachers. In eighth grade there was an algebra class, a general mathematics class and a number of *Chapter 1* classes. The school tried to ensure that students in mathematics classes were from the same team so that mathematics teachers could participate in team meetings.

There were eight forty-minute teaching periods each day with the normal teaching load being six periods per day. Each teacher had at least one planning period per day with his or her team, if he or she was part of a team. Other subjects offered included "today's teens", technology, art, health, choir, and physical education. At the end of each day there was a short period called "encore". For three out of five days each week students signed up for different activities during

²*Chapter 1* students was the term used by the school to refer to the students who were tracked into remedial classes for mathematics. The school received federal funding according to economic need.

encore, with all teachers offering a different activity. These included cake decorating, kite flying, photography and working on the school magazine. The remaining two afternoons were reserved for school choir and band rehearsal.

The school offered many special programs for physically-, developmentally- and behaviourally-handicapped students. It was the only middle school in the district having wheelchair access and an elevator. There was also a unit for hearing-impaired students.

Because Draper had a large grant from a cable television company, it was a special technology school with TV monitors in every classroom, as well as a television production studio. Students delivered school-wide announcements from the TV production studio every morning. There was also cable access to news agencies such as Reuters and AAP. Located in the library was one computer for each team. The cable company provided ready-made lessons structured around current affairs for all subject areas. Apart from the cable-company computers, Ms Eckland had seven Apple IIe computers in her classroom, which the students used mainly for drill and practice programs, and one Macintosh which she used for demonstrations and record keeping. The principal said in his interview that he would like to improve access to computers throughout the school, eventually having computers in every classroom. Towards this end, the school community was raising money to pay for a new computer laboratory.

Although the school building was quite old, it was nevertheless well maintained, being painted in bright colors, with no visible graffiti. Student work adorned every available space in the hallways. An honor roll occupied most of the wall space above the door into the administration area. Students regularly received honor certificates for a variety of reasons, with their achievements being displayed in this area for a short time. Walking through the hallways during class-change time, I noted students to be quite well behaved. Teachers waited for students at the door of their classroom, hurrying them inside once they arrived. Only once in three days did I hear a teacher raise his or her voice at a student. The principal often walked around the halls when students were changing classes. He had only been at the school for four years at the time of the first site visit in 1995, and he was well respected by students and teachers. Before his appointment, there had been a succession of four or five principals in a row, changing each year. When I asked the principal what he thought made the school what it was, he replied:

“The staff is really the key to the whole thing. I mean they really do a good job of working together and pulling together like they did on the move to the middle school. ... I tell them my job here is to make your job the best it can be and the

easiest it can be in the classroom to get done what you need to do, so they've made it real easy on me because they pretty much take care of it. ... if they have an idea or suggestion they come to me and if it's the best for the kids we do it."

Draper principal, 5/16/95

The overall impression conveyed by the atmosphere at Draper Middle School was that of a happy working environment. Teachers were committed to the goals of the middle school and there had been very few staff changes since the new principal was appointed. There were opportunities for students to participate in a wide range of extracurricular activities. Sport, however, was not particularly well patronised with only 50% of students involved. The principal felt that this was because parents were typically working until well after school hours and so could not pick up their children from school after sporting fixtures and training. Once the school buses had gone, there was no other way for most students to get home. The teachers and principal tried to provide an enriched environment for these students, many of whom, the principal noted, were from low-income single-parent families. Each year, the eighth-grade students were taken on a trip to Washington DC. Fund raising took place in both seventh and eighth grade to enable as many students as possible to participate. They also obtained some support from community groups. All students were eligible to go on this trip except those who had been very badly behaved throughout the year.

Although the school population was approximately 40% African American, the teachers and the principal were certain that race was rarely an issue in disagreements between students. Although the *Chapter 1* classes I observed had a much higher proportion than 40% of African American students, this was not mentioned by the focus teacher or the principal as a potential equity problem. There were far fewer than 40% African American teachers at the school, however, and the principal did indicate concern at this, and his desire to hire more African American teachers.

Interactions with students

When asked to verbalise her ideas about equity, Ms Eckland responded in a simplistic manner even though her classroom environment displayed many of the features of the CEMC. When asked "What is equity to you, and how does it operate in your classroom", Ms Eckland replied

Just treating everybody equally... And—I don't know—how does it operate in my classroom? I try to treat everybody equally (chuckles). I don't know. That's about all I think of it. I don't really think much of it at all. In fact, I don't even think about whether I'm treating people equally. I try to... I don't think of it as treating them equally, but I try to spread my comments around, and the people I call on around.

Rebecca Eckland, 5/17/95

Ms Eckland displayed many of the characteristics of connected teaching in mathematics advocated by Becker (1995), and demonstrated some of the Ladson-Billings (1995) lessons, such as valuing students responses, trusting her students, encouraging them to develop their own voice, building confidence and moving from the known to the unknown. These are described in the following paragraphs.

Ms Eckland valued student responses in her classroom interactions. She tried to include all students in class discussions, and sometimes called on students who didn't usually participate. One student commented on the way Ms Eckland did this.

Sometimes, she'll ask so and so "Do you know how to do this problem?" And if they don't understand she'll help them through it.

Draper student 1, 5/17/95

She never embarrassed a student if they did not know the answer to a question, even if they were not paying attention. Students were not afraid to ask or answer questions in her class. She encouraged questions from the students during many of the lessons I observed. Students I interviewed acknowledged this.

J And does she encourage people to ask questions?

S6 Yeah, she tells us don't feel, don't feel, dumb to ask a questions. Like if you don't understand or something, she says everybody don't understand sometimes, you know, she says just ask, don't feel like dumb or whatever. I know there's people that don't feel comfortable asking a question and ...

J She tries to make them feel comfortable?

S6 Yeah, comfortable and if you don't feel comfortable asking a questions, she tells them that you can come, you know to see me after class or after school or something. She has a thing after school, like I think on Wednesdays, you come up and she teaches you stuff if you don't understand.

Draper student 6, 5/23/96

She seemed to respect and trust her students and demonstrated this through giving them a copy of her teaching program every five weeks, and allowing them to work at their own pace.

I give them the syllabus at the beginning of the period and that takes them halfway through the grading period and then I give them the new one halfway through the grading period and that basically gives them—if they're absent—a source so if they're absent they know what the assignments were, know what was going on in class. And I started doing this because I was sick of all the papers that were being sent up from the office asking me to write down what the assignments were for somebody who was absent. They also know when their tests are so it gives them an idea of when things are due. If they have something that's going to take them out of school for a few days they can work ahead—they can keep track of what they've done, what they haven't done with it.

Rebecca Eckland, 5/17/95

Ms Eckland also tried to give students the chance to reflect on questions she posed before eliciting answers, or giving the answer herself if the students could not answer the question. She often played the role of facilitator of learning rather than provider of knowledge. She rarely gave the answer to a student's question without first asking the rest of the class and giving each person time to think of an answer, as this excerpt from the field notes taken during the visit shows.

"Let's do another one" someone says. Ms Eckland replies "I can't do another one until everyone has had a go at this one". Then they try to find a square pattern. Almost immediately some boys shout out "I've got it, yeah!" (showing off a lot). Another shouts out "Can we do another one?" Ms Eckland gives the same response "Everyone hasn't got it yet, so we can't".

Field notes, May 1996

If no one was able to find the answer, she would sometimes let the students continue working until a student did come up with the answer. In this way, and through using interactive questioning, she negotiated meaning with her students, and actively involved her students in the learning process. She also gave students time in class for "independent work". This consisted of working on an individualised program to improve basic skills. During independent work, group interactions were encouraged, and students were able to struggle over solutions for themselves. Students were allowed to choose their own groups unless discipline problems arose. Group work was also graded. Students described her grading program just as she did.

Sometimes we'll have a worksheet that we got to work on together and we'll, you know do different problems with it then. Then we'll put it all together on one worksheet and then we'll turn it in (to be graded).

Draper student 2, 5/17/95

She would often allow students to briefly see problem-solving questions in an examination paper prior to the examination. She wrote these problems on the overhead projector so that students could read them, although they were not allowed to copy them down. As a result, Ms Eckland felt that students would be more confident going into exam situations. This confidence-boosting activity was an example of Ms Eckland allowing students to confirm themselves as knowers, a practice advocated by Belenky et al (1986).

Her students also liked the clear way she presented things. She used the overhead projector instead of the chalkboard, enabling her to see the faces of her students as she wrote up a problem. Two of the students I interviewed commented

on the way she introduced a new concept by starting with what was already known and then moving to the unknown.

S1: Yes, she starts out with easy things we already know and then compares it to our lesson for the day its like when we did radical expressions she showed us first how to do it with numbers and we went back to exponents a little bit.

J: So it was things that you were already familiar with?

S1: Yes, and then she got more difficult and more difficult.

Draper student 1, 5/17/95

Yeah, I mean—its—she, yeah teaches it from stuff we know and then she just takes it into there with the harder stuff and so it doesn't seem like it's a lot different, but when you look back on what I did know in elementary school then it is a lot harder.

Draper student 2, 5/17/95

Pedagogy focus

Ms Eckland used a variety of assessment methods including writing exercises, group tests, reworking incorrect test problems to increase test marks, awarding points for homework turned in, and awarding points for sections of independent work completed. Ms Eckland valued all types of student effort and rewarded this through her assessment system. Students in the *Chapter 1* class earned half of their semester grade through independent work. They got bonus points if they were ahead of schedule and no points if they were behind. As Ms Eckland said, "It's complex and my formulas in my grade book are unbelievable, but it works." Students in the focus class liked her grading system.

I really like the homework system and the tests. ... I like taking tests because I like to see how I've improved from test to test and see what I need to work on. [pause] I don't really like to do test corrections, but sometimes they can really help you understand how to do a problem [pause] they're time consuming, that's what I really don't like, they're real time consuming, but they can really help you see how to do a problem so you can get it right on the next test.

Draper student 1, 5/17/95

Ms Eckland tried to vary her teaching methods so that all students would at some point experience a method they preferred. She provided many different types of learning opportunities in every class I observed. She acknowledged that all students could learn, and that everyone had a different learning style and she felt that she always provided stimulating material that her students had not encountered before.

In her questionnaire, Ms Eckland indicated that she often actively engaged students in the learning process, often extended students' thinking, and often used

a variety of teaching and assessment practices. Her reported frequencies were verified by the classroom observations and student interviews.

Ms Eckland also agreed or strongly agreed with all of the statements in the section “My views about mathematics” which represented mathematics as subjective, continually being tested and refined, and needing review. She was not as strong with her views of the importance of these practices being reflected in her classroom, however, and she indicated “Important” rather than “Very Important” as her response for all but the last question.

Curriculum focus

Although Ms Eckland said that she had complete control over her curriculum in terms of the length, sequencing and choice of topics, she taught a very traditional curriculum. From my examination of her teaching program and some assessment materials, it seemed that she did occasionally use real-world contexts for problems, and related topics to future topics in high school. There was little evidence that she tried to connect classroom mathematics to student experiences, and at times it seemed that she would almost deliberately introduce a new topic which was completely unrelated to what had just been done, with no attempt to justify to students the reason for this switch (Field notes, May 1996). In her questionnaire, Ms Eckland reported that she sometimes connected mathematics to student experiences. In the final section of the questionnaire Ms Eckland ranked “curriculum focused on problem solving” as the third most promising idea to improve student learning outcomes. She ranked sustained professional development first, and equipment and supplies to support inquiry second. These responses indicated that she was seeing her teaching from a Non-discriminatory perspective and was not considering the impact of the curriculum. Her focus was on getting the students through the middle school and preparing them for high school mathematics. She did not appear to acknowledge the importance of connecting mathematics to students’ experiences and presenting mathematics in a relevant and engaging context.

Summary

The classroom of Ms Eckland appeared to be very equitable in terms of the classroom climate and pedagogical elements of the definition of the Connected Equitable Classroom. She helped students improve basic skills, used learning and assessment activities to foster confidence, had an atmosphere which encouraged students to develop their own voice, used a wide range of teaching and assessment methods, and generally set high standards for most of her

students. In terms of the Willis model, it appeared that Ms Eckland taught in a way that reflected a Non-Discriminatory view of the mathematics curriculum. There was little evidence from my two site visits that she recognised the importance of curriculum. For Ms Eckland, the way to improve student achievement was through finding more inquiry-oriented ways of presenting the concepts so that students would have a deeper understanding and be able to construct their own knowledge.

Troy Middle School 1996

I visited Troy Middle School³ for three days in May 1996 (Tims [Goodell], 1996d). The school was located in a large urban public school district. The US census data for 1990 indicated that the population for that zip code area was around 44% White and 55% Black⁴, with 1% other races. There were approximately 60 000 persons in the zip-code area. Almost half the adult population in that zip code area did not have a high school diploma. The unemployment rates for White males and females were 12% and 9% respectively. For Black males and females, the rates were 20% and 16% respectively. The median value of owner-occupied housing units in the area was \$34 800 in 1989, with the median year of housing structure construction being 1939. The area had a high poverty level: 25% of the total population lived below the recognised poverty level. There were twice as many Blacks below the poverty line as Whites.

The school is situated on a small plot of land with very little room, even for parking cars on site. The building, about 70 years old, was built originally as a high school, which accounted for the classrooms being somewhat bigger than other school rooms I had seen. The surrounding urban area consisted of medium to low density housing and light industry. Although the houses were quite well maintained, the streets were dirty and the roads in very poor repair. Overall, the area had a run-down, worn look, although not the worst area in the city by any means.

The school had approximately 900 students in Years 6, 7 and 8. These students were organised into two teams for each year group, except for sixth grade where there were three teams. Students studied the core curriculum of English, reading, mathematics, science and social studies in teams. There were

³Please see Appendix P for a comparison of pseudonyms used in this document as compared to other reports on the Landscape Study.

⁴Although elsewhere in this thesis I have referred to African American people, the US census uses the term Black.

also two special-education teachers who went into regular classes to help with inclusion students, and a full-time, computer-support teacher. Each student in the school was scheduled to use the computer lab once each week during the time either directly before or after the lunch period. In addition to the core curriculum there was foreign language (for those who achieved beyond a particular cut-off score), orientation to technology, music, health, and physical education. Although exploratory short courses had been tried with varying degrees of success, these were not offered any more. Apart from computer-support, special education and French, there were no other special programs in the school.

The school had subject departments and a department chair with the latter getting one period per day time release to coordinate the department. However this was being phased out in 1996/7 due to staffing cuts. In fact, eighteen pink slips (termination notices) were handed out during the week I visited, making for low staff morale.

The teaching day consisted of eight 41-minute periods with three minutes between each period. Student lunch was during periods four and five from 10:30 to 11:59, and was only 20 minutes duration. Teachers were required to teach five periods plus an extra half period during the student lunch period with their fourth- or fifth-period class. This was extra teaching time for that class. Students did not get any time out of class all day except for 20 minutes in the cafeteria to eat their lunch, which was supervised by the assistant principal and a few other staff members (always the same ones). Teaching staff had it written into their contract that they did not have to go into the cafeteria or supervise lunch.

The teacher I was observing, Barb Zoran, was chair of the Mathematics Department. She was a White female with 23 years teaching experience (mainly with special education classes). She taught periods one, two, three and five with the fifth-period class having 20 minutes extra at the start of the period because of the scheduling of their lunch break. Once a week, this class went to the computer lab for the extra part of the period. Other days they did extension work in Ms Zoran's classroom.

Interactions with students

Ms Zoran made every attempt to treat her students fairly in teaching and pastoral-care situations. She obviously cared for her students, and readily admitted this.

I care about my students. I'm interested in them and generally I care about what's happening to them and what's going on. So I do try to go, and I guess that's back from the special education days where the kids needed a pat on the

back and some extra encouragement. The kids that don't respond well ... you know, a lot of the kids respond well to that or are looking for that. A little boy that we met in the office yesterday ... who wanted to come to lunch with us, he'll come up and just hug, you know, "give me a hug, give me a hug."

Barb Zoran, 5/16/96

She valued the responses of her students and did not use sarcasm or try to belittle students at any time while I was in her classroom. Students verified that this was her typical behaviour, as indicated in the following passage from one of the student interviews.

I: If a student answers incorrectly what does she say to them?

S4: She'll say try again or [pause] that's about it, try again.

Troy student 4, 5/16/96

She seemed to respect her students, demonstrating this, for instance, through giving them responsibility to move to another seat if they felt they could not behave properly sitting in their usual place.

Yeah usually the options for me are, you have two choices. You can move yourself before you get into trouble. I can move you. And if, if you don't move yourself or you don't move when I ask you to move and it continues to be a problem, then we have to do an office referral. So most of the times the kids will move... at least they're still in the class, they're still learning math. Or if they'll come in and say "I'm having a real bad day can I sit by myself?" Yeah, I'd rather you tell me now, because if I have to do something about it then it could get into something more serious. And I found that that works pretty well

Barb Zoran, 5/16/96

While I visited Ms Zoran, her students, all of whom were in seventh grade, were working on a series of worksheets about finding a pathway through a network. Each lesson consisted of a teacher-directed introduction, a period of individual student work, and a teacher-directed summary. It was difficult to determine if the students were actively engaged, and they did not appear to be particularly interested in the topic. During the student interviews, I asked them about the kinds of things they usually did in class. They reported that they did activities with manipulatives approximately twice each month, and worked in groups most of the time. It seemed that Ms Zoran tried to involve the students mainly through the use of cooperative learning.

Ms Zoran had high expectations of her students in terms of the level of difficulty of some of the problem sheets she gave them for homework. Even I had a bit of trouble with one problem set. The level of difficulty seemed unrealistic compared to the level of the difficulty of the worksheet they were all working on. In spite of this, she expected all students to get an A grade, and gave them time and help to complete work and gain as many points as possible for the semester.

Basically everybody should get an A because she makes sure everybody got their stuff and make sure we got what to do and give us extra time if we don't got the stuff.

Troy student 1, 5/16/96

Pedagogy focus

Ms Zoran liked to introduce a new topic with an activity before spending time on building skills. The activity was designed to develop understanding and was often an idea she picked up in the SSI workshops. She had tried a number of inquiry activities with her students during the year. She felt that the new approach had resulted in much greater student understanding of concepts, with greater retention of ideas and enhanced ability to transfer knowledge to another situation, although she had not collected "hard evidence to prove" that her observations were correct. She described her experiments with inquiry methods to me in the interview.

I try to do it that way anyway and not say "this is the way" and let them discovery the way. Even though telling them would often be easier because we could finish things sooner but they remember better when they've struggled with it and finally figured it out. When we were working with perimeter and area of rectangles, I could have very easily told them it's two length plus two width or it's length times width, but we did a whole series of activities and they've had a chart that they were actually able to, I made them compare. What's the relationship between the area and the perimeter, the length and the width, and what's the relationship between the perimeter and the length of the width. And when they actually thought about it and could see, oh, this is just doubled or this is when you multiply them together, it made it so much better. Because then they can look at a problem on a test and they don't have to think, "oh, I don't know what to do here, what was that formula?", they remember.

Barb Zoran, 5/16/96

From an equity perspective, it was through these inquiry methods that the students were developing their voice in her classroom. Ms Zoran said she

...liked this way better...not being the oracle. I don't have to have all the answers. I don't know everything and I'm not afraid to say to the kids "I don't have a clue, what do you think, what can you figure out?" I try not to always have the answer.

Barb Zoran, 5/16/96

In her questionnaire, Ms Zoran reported that, although she often would actively engage students in the learning process, she only occasionally would employ a variety of teaching and assessment strategies, and she indicated that all of these processes were important. The classroom observations confirmed Ms Zoran's reports. In the final section of her questionnaire, Ms Zoran ranked "more time for instruction" and "equipment and supplies to support student inquiry" as the two most promising alternatives to improve the mathematics learning

outcomes of her students. She seemed to hold a non-discriminatory perspective and was not as concerned with the curriculum. She even mentioned that “using technology in daily lessons” and “single-sex classes” were better ideas than those listed on the questionnaire as strategies to improve student learning. Here too Ms Zoran was taking a non-discriminatory perspective in her classroom.

Ms Zoran used a few different teaching strategies, but perhaps because she trained as a special education teacher and had always used a lot of cooperative learning strategies in her classes, she appeared to favour cooperative group work over all other strategies. To facilitate this, her classroom was permanently set up with desks in groups of four.

Ms Zoran tried to fairly spread her questions and answers around to everyone in the class. All four of the students interviewed said that she typically puts questions to different people, not just the same people all the time. There was one boy who seemed to be trying very hard to answer a question in the first lesson I observed during my visit:

The boy she was interacting with when I first came in had his hand up the whole time trying to volunteer his answers, but she didn't ask him. The boy became exasperated, and eventually gave up trying to answer. She then said “OK now turn over the page”.

Field notes, 5/15/96

Reflecting on this incident, I recalled that in other lessons I observed this boy had often been disruptive and demanded a lot of her time in class. Although at first it seemed like she was ignoring the student, she could have been employing a method of disciplining the student in a non-confrontational way. Had she allowed the boy to answer the questions, chances are he would have tried to be a clown and make the class laugh, thus causing a disruption. Ms Zoran, being an experienced teacher, was well aware of this possibility and apparently avoided it.

For the assessment of the course, Ms Zoran had the students keep a detailed record of all of their daily class work, and she gave them points for each item included in the folder, which they handed in at the end of the grading period. All points earned throughout the semester were added to obtain the final mark on which the semester grade was based. She also gave written tests periodically, which also contributed points towards the grade.

In her questionnaire, Ms Zoran reported that she often extended students' thinking. The classroom observations did not verify this. There was little evidence that she routinely extended student thinking, nor was there much evidence of building basic skills. Although her students generally liked her, there was not a

great deal of mathematics happening in her classroom on the days I visited. It was possible that her expectations of students had been shaped by her many years of training and experience with learning-disabled and behaviourally-disabled students, and by the culture of the school and the school district. It should also be noted that the site visit occurred in the last few weeks of the school year when most of the course work was completed. This could have influenced the kind of lessons Ms Zoran planned during this time. These issues will be explored further in Chapter Seven.

In the section of the questionnaire probing her views about the nature of mathematics, Ms Zoran agreed with all statements, and thought that it was important that all of these views be reflected in her classroom.

Curriculum focus

Ms Zoran had very little control over the curriculum and, as previously noted, was more focused on her own teaching methods as a way to improve student learning outcomes. The school district required all teachers in the district to keep together in content and sequence so as not to unduly disadvantage students needing to change schools, which apparently happened quite frequently.

Ms Zoran did make some attempt to connect mathematics to the experiences of her students. When starting the lesson on networks, for which I was present, she took the First-Period class students to a window and had a lengthy discussion about how the diagram on the worksheet related to the actual roads they could see out of the window. However, for no apparent reason, she chose not to repeat this activity with the remaining classes. I asked students about their recollections of how Ms Zoran was able to connect mathematics to real-life applications:

- I: And does she ever bring in real world applications when she's doing problems, like she'll say when you are working at McDonald's you might have to do something?
- S3: Yeah, she explains it so we can understand it better, she has named places, names, things and people.
- I: Does she use other people's name in the class and stuff like that sometimes in the problem?
- S3: Yeah sometimes. Yeah very often.

Troy student 3, 5/16/96

Summary

In summary, Ms Zoran was a caring teacher whose classroom was equitable in many ways. She used inquiry methods which she felt enhanced

students' understanding, and tried to actively involve students through the use of cooperative group learning in most lessons. She tried to relate mathematics to the real world by using contexts she thought students would be familiar with, and she used a variety of assessment methods. Her views about improving the learning outcomes of her students indicated that she held a Non-Discriminatory perspective view of mathematics, and was not aware of the power of changing the curriculum to improve learning outcomes.

Lakeview Junior High School 1996

I visited Lakeview Junior High School⁵ for one day in May 1996 (Tims [Goodell], 1996b). The community of Lakeview is situated in a very rural area of the state near the Appalachian mountains. The school was chosen for a site visit because the county in which the school is located was part of the Appalachian Rural Systemic Initiative. Most community members considered themselves to be Appalachian (assistant principal interview, 5/9/96). The population of 14 288 (US Census, 1989) was considered entirely non-urban. Of those, 143 persons were Black, 25 were American Indian, 4 Asian, and the remainder White. Housing had a median value of \$44 000 in 1989, with the median year of housing construction being 1965. Although almost half of the students received free or reduced lunch, as explained by the assistant principal, this did not really represent the true number eligible:

To be honest with you, at this age it [the number taking free or reduced lunch] would be higher, but many of the students either won't apply, or won't eat and pay for their lunch.

Lakeview assistant principal, 5/9/96

Of those persons above 25 years of age, 60% had a high school diploma. However, in 1989, 27% of the population lived below the poverty level and the unemployment rate was 11.2% (US Census, 1989).

The school had sixth, seventh and eighth grades, with a total enrolment of approximately 450 students. The building was built originally as an elementary school, but, after the district reorganised some years prior to the site visit in 1996, it became one of two junior high schools in the district. It is situated in the middle of town, with the high school being immediately adjacent.

The focus teacher Suzanne Shortland had been teaching for four years at the time of the site visit. She was a White female in her early forties. She had

⁵Please see Appendix P for a comparison of pseudonyms used in this document as compared to other reports on the Landscape Study.

tried to make her classroom attractive by putting up mathematics-related posters and charts. She was quite apprehensive about the site visit and appeared to have gone to some effort to ensure that the activities she had prepared for her students to do that day were stimulating and engaging.

The rooms were quite small, being designed for young children; however, the hallways were wide and the gymnasium was large. The grounds appeared quite spacious, and there were paved basketball courts as well as grassed areas for students to use during lunch recess. The furniture in the classrooms was completely inadequate for the current school population. Fourteen-year-old boys were sitting at desks designed for seven-year-olds. They looked very uncomfortable. The desks were fixed to the chairs and were very heavy and difficult to move into groups, although Ms Shortland frequently had the students move them to make group work possible. When I mentioned this to the superintendent, she assured me that replacing the desks was very high on the list of priorities, after installing new computer laboratories.

There were no teams at this school. Students did not remain with one group of students for most of the day as they did at most of the other schools visited during *The Landscape Study*. The school operated with subject departments, although there were no department chairs, and the three mathematics teachers at the school communicated very little among themselves. Ms Shortland would have liked to change this.

We don't do anything in our math department, the only contact we have is I talk to the teacher next door that's it. We never have department meetings, we never talk to the teachers in the other building. We did an inservice, Laurie and I did an inservice at the beginning of the year for the third, fourth, and fifth grade teachers. Other than that, that's the only discussion there's been about math.

Suzanne Shortland, 5/9/96

The school had a nine-period day, including lunch. Teachers at this school had to teach seven periods per day. During lunch period, they were expected to supervise in the cafeteria. The distribution of teaching load appeared inequitable: Ms Shortland had all five seventh-grade math classes and two eighth-grade classes. She took the eighth-grade classes so that the eighth-grade math teacher could go to the high school and take an *Algebra* class in order that an *Advanced Placement Calculus* class could be offered. Other teachers at the school usually taught six periods in one grade level, making up their seventh period each day with a study-hall supervision.

The impression obtained while walking around this school was one of a well ordered, happy community. Students were very polite and friendly, asking to

have their picture taken with me and talking to me after class in the hall. I didn't have much time to talk to many teachers other than Ms Shortland, but the assistant principal and superintendent were both very positive about the general school culture, describing it as a decent hard working community of teachers and students.

Student focus

Ms Shortland's classroom had some of the characteristics of the Connected Equitable Mathematics Classroom. She actively involved her students through group discussions and collecting real data. For example, she took them to shoot baskets so that they could work out the percentage of scoring and non-scoring shots. In her questionnaire responses, she indicated that she often actively involved students, and that it was very important to do so. My classroom observations and information from student interviews confirmed this to be the case.

She valued the responses of all students, and asked all class members to answer questions. She encouraged students to ask questions and to try again if they were wrong. When students were working in groups, Ms Shortland would walk around the room offering to help those who needed it.

Pedagogy focus

Ms Shortland was confident that all of her students could learn by inquiry. She regarded her role as finding the right way to introduce and guide the students so that they could make their own "discovery" of the concept. In her questionnaire responses, she reported that she sometimes extended students thinking, and that it was important to do so. She had noticed throughout the year that the inquiry methods were helping students learn not only the concept that was the particular focus of a lesson, but other concepts as well. Asked what it was that made inquiry a better way for her to teach, Ms Shortland replied

I think with the inquiry the kids end up actually in less time getting more premise than you expected. In looking for the answer they're discovering so much along the way, they're stumbling onto things that they really didn't think about. A good example, we were, well when we were doing the pattern blocks, the cuisinaire rods with fractions I had a little boy come up to me and say that he thought that the answer was $2/12$ ths, but somebody else said it was $1/6$ th in his group. And he said I can prove that my answer's right and he said that his answer's right and they went {a surprised sound} they are the same thing. So we were just trying to name fractions and he's in the process of finding out what equivalent fractions really are. On paper if I'd of told him to reduce $2/6$ to $1/3$, if I'd told him to do whatever the process was he would have done it but he wouldn't have understood, and just the look on his face when it first occurred to him that that's what equivalent fractions are, is just amazing. That wasn't my lesson for the day but he got that out of it and I dare say that he won't forget that. That'll be

something that he understands now and the next time he, when we do something else with equivalent fractions, will be something he understands.

Suzanne Shortland, 5/9/96

One thing Ms Shortland did not seem to incorporate into her teaching was an emphasis on basic skill building. Her quest to make as many lessons as possible have an inquiry focus had led to a somewhat disjointed program which some students did not like. I asked the students how this class was different to math classes they had previously experienced:

J: Is this class different ?

S1: Yeah it's a lot different. Actually I think I liked like last year in sixth grade better because we ...see in this class we do like, one day we might do percents and then the next day we might come in and do area and perimeter and all that. [She] kind of skips around. She's not very organised.

Lakeview student 1, 5/9/96

Ms Shortland used a variety of assessment methods, and was also prepared to negotiate grades with her students. One of her students could barely write, so she assessed him using different methods to the way she assessed the rest of the class. She still used tests with the majority of her students, but also assessed group work, projects and homework. Everything that the students did in class was assessed in some way. There were some obvious disadvantages to this system. First was the amount of work it created for her. Second, students were not sure how their grade was arrived at, which meant that they were unable to concentrate their efforts on a particular topic or type of assessment. An advantage of this system was that all efforts were rewarded, which helped enhance student motivation.

Curriculum focus

Ms Shortland tried to relate what was being done in the classroom to practical situations she thought her students would be familiar with. The basketball activity was one such example. The students I interviewed all talked about this activity as one that they enjoyed. Ms Shortland realised the importance of using contexts that students were familiar with.

When I actually do lecture or just teach what is traditionally... I try to at least use things that they know, baseball or t.v. program or something that's ... part of their world.

Suzanne Shortland, 5/9/96

The other project students talked about was the "cat" project, which involved determining which cat was the average cat, given descriptions of a large group of cats with different characteristics. The real-world context was something

that the students liked and could connect with, and they had remembered this project from the beginning of the year.

In her questionnaire, Ms Shortland reported that she seldom discussed the history of mathematics and almost never discussed the work of mathematicians. She regarded the historical aspect as important, but the discussing of work of mathematicians as unimportant. She did expect students to use data to justify their responses and to learn about real-world applications of mathematics. When I visited her, she had taken part in the SSI only the previous summer. Ms Shortland expressed her anxiety at not being able to instantly change her teaching methods, programme and curriculum. She would have liked to have made more progress than she perceived she had by the end of the school year. In the final section of her questionnaire, Ms Shortland ranked “professional development sustained over time” as the number one idea that held the most promise of improving the mathematics learning outcomes of her students. Her second choice was “a curriculum that focused on problem-solving”, and third was “teaching materials to appeal to a diverse range of students”. It seemed that Ms Shortland was looking to curriculum reform as a way to help her improve the learning outcomes of her students. Her difficulty in finding appropriate materials manifested itself in the perception of some students that the work they did in Ms Shortland’s class was disjointed. Her final comment in the open-ended question at the end of the questionnaire was “Teachers should be required to teach to the Ohio Model and not the text.” This comment also points to her belief that better curriculum materials improve learning.

Summary

Ms Shortland had tried to make many changes to her teaching practice during the year I visited, the first year after her participation in the SSI. She was using a variety of teaching and assessment methods, and actively involved students in the learning process through group projects, inquiry lessons and outdoor activities. She used real-world contexts and was aware of the importance of finding suitable curriculum materials for diverse learners.

Obern Junior High School 1996

I visited Obern Junior High School⁶ for one day in May 1996 (Tims [Goodell], 1996c). The school was located in the city of Obern, approximately 15

⁶Please see Appendix P for a comparison of pseudonyms used in this document as compared to other reports on the Landscape Study.

miles west of a large urban area. The zip code area in which it was located was defined by the US Census as mostly urban. The racial mix of the area in 1989 was approximately 42% Black, 57% White, and 1% other races. English was the main language of the population, with a few Spanish-, German- and Russian-speaking people. Of those over 18 years, approximately 18% did not have a high-school diploma.

The unemployment rates for White males and females in 1989 were 3.7% and 5.7% respectively. For Black males and females the rate each was 6.7%. The median household income for 1989 was \$30 632. The percentages of the White and Black populations living below the poverty line in 1989 were 7% and 6.8% respectively.

The focus teacher, Patricia Dante, was a White female in her mid thirties, recently returned from maternity leave. She had been teaching at this school for approximately four years, and had taught at an elementary school in the district for a few years prior to that.

The school was set on a large plot of land well back off the main road. There were spacious grounds and parking areas. The building, about 20 years old, seemed very well maintained. The hallways were wide, with the gym very large and well equipped. The building was supposed to be air conditioned. The main office certainly was, but the classrooms did not appear to be. It was quite warm the day I visited and Ms Dante had three fans (which she purchased herself) operating in her classroom all day. The classroom furniture was adequate and set up in a double U shape—one inner and one outer U. The walls all through the school were adorned with student work. Ms Dante had some examples of recent student work stapled up on the wall outside her classroom.

Of the 735 students enrolled at Obern, 85% were African American. Compared to town demographics in 1989, which showed a population only 45% African American, there seemed to have been a shift toward a much higher proportion of African American students. This trend was confirmed by the principal (who had been at the school as the assistant principal a number of years prior to this visit), who could remember a time when the demographics of the school population were almost completely opposite, that is predominantly White with a small proportion African American. According to the principal, some teachers who had been at the school for a long time and had experienced this change, were not completely adjusted to this new situation (principal interview, 5/10/96).

The students were grouped into five “families”. There were five teachers and approximately 120 students in most families, with some inclusion students in each. There was one special family that had students in both seventh and eighth grades and offered an extension program involving other languages besides English. Although teachers identified with subject departments, it was not clear as to how departmental planning took place because there was no common planning time for departments. However, the principal did mention that more intra-departmental communication had been happening and that he was encouraging it to continue.

The school had a well-developed special-education program. Students who were classified either as learning disabled, developmentally disabled or severely behaviourally handicapped were catered for. Some of these students were included in regular classes, in which case the special education teacher was available to assist teachers with these inclusion students. The special-education teachers also taught one or two withdrawal classes each.

Teachers were responsible for teaching their particular subject area to all the students in one family. This meant that most teachers taught five sections per day of either seventh or eighth grade. Students studied English, language arts, science, mathematics and social studies as well as some “exploratory” non-academic subjects. The exploratory subjects were taught by teachers not involved in the family structure.

The standard of discipline within classes seemed to vary widely. As I walked around the school building there seemed to be a lot of noise coming from some classes. However, it should be noted that on the day I visited the school students were allowed to wear “free dress”, leading to behaviour the principal noted as more restless than usual. A pep rally was held in the gym for an upcoming track meet. Students participated vigorously in the cheering and were hard to control in the large group. Students were rowdy in the halls and cafeteria, being constantly reproached by teachers to behave properly.

Interactions with students

The lesson Ms Dante had prepared for all her classes the day I visited was one which involved very little mathematics. The students instantly knew the aim of the assigned worksheet without any explanation. Although it was close to the end of the year and most of the curriculum content would have been completed, I found it hard to see the worth of this activity. It appeared to me to be “busy work”, something that would keep the students quiet and occupied. During my

visit, Ms Dante had very few teaching interactions with her students, and this made it impossible for me to determine how she normally interacts with her students in a lesson, except from what the students told me in the interviews. The general impression I got from the students was that she was strict with her classes. She did not tolerate bad behaviour, and was quick to refer students for further discipline if required. This approach certainly led to her classes being much quieter than most other classes I observed as I walked around the building. It also meant that there was a lack of connection between her and her students. I asked students if this class was different to other mathematics classes.

S2: Yes it's different. It's like, well, we get more help and it's under control, won't nothing happen in this class. There's no trouble in here 'cause we know that Ms Dante is going to get us, so we don't act up.

I: In other classes?

S2: In other classes it's kind of wild, in a lot of my other classes.

Obern student 2, 5/10/96

The students also reported that she did encourage students to use their own methods for solving problems, and that she encouraged all students to participate in lessons, without forcing them. She encouraged questions from all students.

Ms Dante said that she set high standards for her students and moved through the course at a fast pace.

I do expect the kids to produce. I have very, very high standards for the kids and I keep moving. I don't wait till everybody grasp the concept. If I've got 75% of them that have gotten the concept, I move on. There is always going to be some who don't get the concept and I'd rather move on and have those kids try and keep up, then have those who can excel become bored and not do anything.

Patricia Dante, 5/10/96

She seemed to be just waiting for the students to step out of line. It was as though she assumed that the students would without hesitation take advantage of any lapse in her authority over them.

Trust and the use of inquiry methods

As mentioned previously, the population at Obern had over the past ten years changed from a predominantly White population to predominantly Black. Some teachers who had been at the school for many years found this change difficult to adjust to (principal interview, 5/10/96). The principal had even heard of instances of teachers making in class such counterproductive comments as "you black kids over here you are too loud". It seemed as though Ms Dante did not trust her students enough to engage in inquiry activities. Whether that was

related to the fact that she was White while most of her students were Black is open to speculation.

I'd like to do more hands-on. I would like to do more student-centered activities. These kids don't handle freedom and responsibility very well. They can't, they're not{pause} I'm not going to say they can't. A lot of the times they choose not to do what they are suppose to do. They've never had to accept the responsibility and that makes it really difficult.

Patricia Dante , 5/10/96

Ms Dante was aware of potential safety problems within the school, although she said that she was not concerned for her own personal safety at school.

Drugs are a problem. Gangs are a problem. I have no doubt in my mind that some of our kids carry weapons in the building, I have no doubt about that. I don't fear for my personal safety. I don't think any of the kids are that stupid, hostile—yes, stupid—no. These kids have more street sense than people that I know that are fifty or sixty years old. It's hard to believe that they deal [drugs] at thirteen or fourteen years of age.

Patricia Dante, 5/10/96

Pedagogy focus

During my short visit to Ms Dante's class, it was evident that her students were rarely actively engaged in the learning process. Students themselves reported working in groups very infrequently. Examining some of her prior teaching programs and lesson plans, it appeared that most of her lessons consisted of individual work from prepared worksheets. Lessons used a traditional teacher-directed format. In her questionnaire, Ms Dante reported that she actively engaged students very often, and that it was very important to do so. This was not borne out by my observations or interviews with students. It was difficult to see how she could use open-ended questions very often with the style of teaching that her lessons plans and her students' reports suggested.

Ms Dante did say that she had tried to implement some alternative assessments and use problem-solving and open-ended questions, but that she had not persevered with these approaches because of a perception that her students were unable to handle any type of freedom in the classroom. She felt uncertain of her control in the classroom, and, since reformed teaching and assessment practices require the teacher to relinquish some control, Ms Dante was either unable or unwilling to employ these approaches. I examined a large number of her handouts, worksheets and teaching programs, and none of them gave any evidence that she had implemented reformed teaching or assessment practices. As mentioned previously, this was at odds with how Ms Dante responded to the first

two sections of her questionnaire. However, in her responses to the last section, “My ideas for improving learning outcomes”, Ms Dante rated items that mentioned equipment, supplies or materials in her top four. She also rated second “curriculum that focuses on problem solving”. This could be interpreted as a belief that change should come from outside her own practice. In other words, if only she had the right materials, equipment, supplies or curriculum, student learning would improve. Her responses to the section “My views about mathematics” also indicated that Ms Dante had not really embraced some of the ideas about the nature of mathematics which had been presented to her in the institutes. Although she agreed with all of the statements in this section, she thought it unimportant that these same ideas be reflected in her class. She did state that she thought the school program had improved from four years prior because of changes in the teaching practices of herself and her colleagues. She attributed these changes to education—presumably to her involvement with the SSI, although she did not actually state this. Further, although she reported that she had changed, it is impossible to determine whether she was continuing to do so. Her classroom appeared to me as a poor example of a CEMC.

Summary

In summary, Ms Dante appeared to have adopted few of the suggested reforms from the SSI. She felt constrained by the general behaviour of the students from being able to use inquiry learning. My observations and student comments during interviews suggested that her teaching methods were highly teacher-directed with little room for student exploration, a view that was at odds with what Ms Dante herself reported in the questionnaire and the interview.

Greenway Middle School 1995

Researcher B visited Greenway Middle School⁷ for three days in May 1995. Information about the site and demographics of the school were reported in the site-visit report (*Project Discovery*, 1995a). According to the site-visit report, the buildings of Greenway Middle School were quite new and well maintained. Although the walls and lockers were graffiti free, the girls’ rest room was just the opposite: every available space was written on.

In the centre of the building was a spacious solar atrium that flooded the building with light and provided a tranquil spot for classes of students to use.

⁷Please see Appendix P for a comparison of pseudonyms used in this document as compared to other reports on the Landscape Study.

Located in one of the biggest urban areas in the state, Greenway has a large minority population. In 1995, there were 900 students in grades six, seven and eight. There were many special programs offered along with bilingual, magnet and regular streams. Each core group had between 90 and 140 students and four core teachers who taught all the students in that group. The usual daily teaching load consisted of five 45-minute classes and a short homeroom period. Teachers also had to participate in weekly core planning meetings .

Control and discipline

There were three full-time security officers employed at Greenway Middle School to patrol the halls during class. Students were not allowed into the building before 7:45 am for an 8:00 am start, and they were escorted onto buses within minutes of the final bell. One security officer commented “These places are just like jails—all these schools.” Lunch time was short and strictly supervised. There was no other break time for the students. Every teacher interviewed and spoken to affirmed that enforcing discipline was a main objective for the school administration. Security officers reported that although rarely it occurred at the school, gang violence was prevalent once students returned to their “home turf”. Security officers believed that gangs had accepted that school was neutral territory. It seemed as though students were constantly being given the message by the school administration that they would be strictly managed and not allowed to get out of control.

Student interactions

The focus teacher Harriet Nando was previously a high school teacher and had been at the school for nearly eight years. Ms Nando had low expectations of her students. She characterised her students as “the bottom of the bottom of the bottom”. She described a selection process that filtered out the brightest students to participate in the many special programs at the school or another school. As for the remaining students, those whose parents could afford to move to another district usually did so. According to Ms Nando, they wanted their children to be in a more motivated environment. The final section of the teacher questionnaire asked what ideas would improve learning outcomes for students. Ms Nando did not complete the ranking or importance sections, but wrote at the bottom “For me student attitude is what must change”. She also made reference to the student population in another comment she wrote on her questionnaire. She rated her school’s program compared to what it was four years ago as “A little better”. Her comment about what changed to make it better was “My teaching has changed. It

may not result in (higher) test scores since class population changes so much.” This comment indicates that she probably had a Remedial Perspective view on the problems experienced by her students. Throughout the interview transcripts were other indicators of her opinion about the importance of improving student attitudes as a first step to improving learning outcomes. She said she felt powerless to help them improve their learning outcomes until she saw some improvement in their attitudes. She was convinced that her students had acquired a disparaging attitude toward the value of education from their parents, as she described in the following interview segment.

I question how much value my students really do see in education. Most of their parents are minimally educated, whether it be high school or not high school yet. And it's something that is not important at home. They don't see the example at home and they don't see an importance. Most of the parents that I talk to, the first thing they say to me when they hear that I'm the math teacher is they say, “I never did well in math. That's why my child doesn't do well in math,” which gets under my skin and it annoys me. I don't think this is just my students. I think that this is a national thing. I've never ever heard a parent say I'm illiterate; that's why my child does poorly in English but they're almost proud of the fact that they're poor in math.

Harriet Nando, 5/10/95

Ms Nando did try to involve all of her students by having them write up on the overhead projector their answers to problems done in class. She would call on different students in the class throughout the lesson; however, some students did not like this approach because of fear of embarrassment if they did not know the answer. This scenario was described by a female African American student.

I: Do you sometimes go to the board and do things at the board in math?

SI: We go up to the - what's the name?

I: Overhead.

SI: Yeah up there. I don't want to go up there. I think I'll probably mess up cause if I don't know it. She call me but I say I don't want to cause it's hard. I don't want to do it up there in front of everybody.

Greenway student 1,5/10/95

The brightest student in her class, another African American female, was also interviewed. When asked if she would teach the same way if she were the teacher she replied

I'd teach the same way. It's simple, we don't do much. We copy notes, she helps us over the problems, we do the homework. The past few weeks we haven't had any [homework] because they're testing but that's basically it.

Greenway student 2,5/10/95

It seemed as though Ms Nando had low expectations of her students' capabilities. This student obviously did not feel challenged by the work she was doing in Ms Nando's class.

Pedagogy focus

Despite the strict control and apparent school-wide lack of trust of students, Ms Nando had implemented a hands-on approach in her classes. In her questionnaire, she reported that she sometimes actively engaged the students, and that it was important to do so. The observations and student interviews substantiated her claim of actively involving students.

I enjoy teaching, using some of this more. I find it more enjoyable to me and I get a big kick out of it. Yesterday you were sitting and the kids were measuring circumferences and diameters and they weren't given any prior explanation of why I was asking them to do this other than just to do it, and it excited me that two boys came up with the idea that there was a relationship between this and their first thought was that the diameter was always half of the circumference. But then when they worked a couple of problems they found that it wasn't the case. That excited me but out of 100 students because there were a lot absent yesterday that was the only time that happened and this is what I mean by smaller rewards.

Harriet Nando, 5/9/95

The researcher made detailed field notes about the lessons she had observed. These notes indicated that Ms Nando involved students in lessons through interactive questioning and class discussions. She used a similar format for most lessons observed: some introductory discussion, then an activity in small groups or individually, followed by a summarising of what had been done so far, concluding with practice examples for consolidation. The researcher noted that the tone of the class was focused on getting the work done. As one student in their interview put it: "If you get your work done, you get [the grade] you deserve."

Students liked the clear way that she explained concepts and her readiness to help whenever needed. Her students performed slightly better than students in other classes at Greenway in the 1995 Ohio Proficiency test. Of Ms Nando's 143 students, 29 passed (20%). Of the remaining 273 eighth-grade students who sat the test from Greenway, only 23 passed (12%).

In her questionnaire, Ms Nando reported that she sometimes used authentic assessments, and she indicated it was important to do so. Her assessment instruments included tests and oral examinations.

Last year when we did a unit where they were doing surface area and volume what I did was I would have after they had spent a long time on this I made up a different problem and one at a time, when they felt they were ready they came up and explained the problem to me and that to my way of thinking I was satisfied. It gave me a chance to hear if they had the vocabulary and the things like that.

Haven't had an opportunity to do that this year but I did a lot of not written type testing but individual come explain this problem to me or what would you do to solve it or that kind of thing.

Harriet Nando, 5/9/95

Curriculum focus

Ms Nando had very little control over the curriculum. The school district required all teachers in the district to keep together in content and sequence so as not to disadvantage students who had to change schools.

Ms Nando tried to relate the topic to something the students were familiar with, and would sometimes use a real-world context. For example, when starting a topic on scale drawing, Ms Nando asked the students "How did they make the kids look so small in '*Honey I shrunk the kids*'? They made the desk huge." The students were then given a homework assignment to measure their bedroom at home and make a scale drawing using 1 ft = 1/2 inch. Ms Nando commented later "I try to get as much information from them and I try to apply it to stuff that they can see around the room or can relate to." Ms Nando was attempting to connect mathematics to the experiences of her students.

Summary

Ms Nando appeared to have low expectations of her students and did not provide them with very challenging work. She did attempt to use inquiry teaching methods and a variety of assessment methods with her classes, but felt constrained in her attempts by what she perceived to be a lack of student motivation and poor attitudes towards mathematics and education generally. She tried to connect the classroom mathematics with contexts with which she thought students would be familiar.

Naylor Middle School 1995

Researcher B visited Naylor Junior High School⁸ for three days in May 1995. Demographic and site information quoted in this section was documented and described in the site-visit report (*Project Discovery*, 1995c). The focus teacher, Kathy Straub, had 24 years of teaching experience, 17 of which had been at Naylor. She was a White female in her late forties. According to the site-visit report, Naylor Junior High School was located on the outskirts of one of the state's major cities. In 1995, the school enrolled 390 students in grades seven and

⁸Please see Appendix P for a comparison of pseudonyms used in this document as compared to other reports on the Landscape Study.

eight and operated on a family system. There was one seventh-grade family, one eighth-grade family and one split seventh- and eighth-grade family. There were 22 teachers across the three families. Students would stay with the same group of students and teachers all day, although they moved from room to room. Each family had the same group of teachers for their core subjects. Each lesson was forty minutes, with an extra twenty minutes per day in one class, the purpose of which was not stated.

The area, once a coal-mining Appalachian community, had recently experienced a large influx of new residents from a nearby urban area. This influx had changed the population of the school and appeared to have impacted on the culture (Naylor principal interview, May 1995). Two types of new residents had moved to the area. The first were wealthy families, possibly fleeing a downturn in inner-city areas. The second occupied new low-income housing projects, and, according to teachers at the school, had brought drugs and destructive attitudes to the school. Community cohesiveness seemed low, and this had led to lack of community support for the school district. There had been drastic cuts to the district funding over the previous few years. Many teachers and administrators had left or lost their jobs, and there had been no significant pay rises for the past eight years. The district was relying on state loans to survive. Despite these negative aspects, there had been, after seven attempts, a recent one percent increase in the tax levy. Both Ms Straub and the principal commented that this had helped lift morale at the school. Morale had been further boosted by a strategic planning process that the district was involved with. Representatives from all sectors of the district had been investigating the needs of the district for the next five-year period. Seven strategies for change were identified and plans were made for their implementation. According to the principal, staff were sensing a clear direction and achievable goals.

Student interactions

The students interviewed had very positive views of Ms Straub and the way she interacted with them, as indicated in the following interview segment.

I: What kind of teacher is Ms Straub?

S3: She is a good teacher, my favorite teacher

I: When you mean good, what makes someone a good teacher?

S3: I don't know, it is easy to learn in her class. I always get good grades in her class, and I really don't have to try real hard to do it. I'm not saying it is an easy class. I mean it is hard. But just the way that she explains it, it's a lot easier.

Naylor student 3, 5/15/95

The way she treated this particular class was not the norm at Naylor, as related by one student during the interview.

D: How do you think she is different than other teachers?

S3: I don't know, it is like our class is a pretty bad class, you know, we have a really bad class, like a lot of trouble makers and stuff. She always gives us like a chance, so everybody is good in her class. She always sticks up for us with other teachers.

D: So, you guys kind of have some respect for her?

S3: Yeah, everybody has respect for her

Naylor student 3, 5/15/95

Ms Straub concentrated on helping students understand the method they were using to solve a problem. As one student said, "Other teachers just worry about the answer. [She worries about] getting the steps plus the answer". Ms Straub felt that because students had a better understanding of concepts, they were more confident in their approach. Before proficiency tests, Ms Straub spent time "going over things so that we would know how to do everything" (Student 2, 5/15/96). She built the confidence of her students before a test by providing them with plenty of problems for revision. These revision problems were kept in a journal so that, by the end of the year, there were revision problems for every section of the course.

Ms Straub was careful not to give students answers without first giving them a chance to think through questions and to try to find answers on their own.

One female asks what a parallelogram is. She simply responds, "I don't know." It appears that the students are quite used to answers similar to this. A male student on the other side of the room asks a definition question, and ends up going over to find a dictionary to look it up. At a nearby group, the students ask her what a parallelogram is. She continues to ask them questions about the definitions they provide to her—typically questions that put "holes" into their definitions. She ends up saying to them, "Perhaps you should do a little more research and I'll come back later." The female of the group goes over to the side of the room and gets a copy of the math book to look up a definition. The students discuss the definition together—you hear them both say, "no, that is a rhombus." Later as they walk by my desk, the male student declares, "Hey Mrs. Straub, I know what a rhombus is now!"

Naylor observations, 5/16/95

By allowing students to struggle with a concept before being given the answer, Ms Straub was giving them the opportunity to develop their own voice (Baxter-Magolda, 1992).

Pedagogy focus

Ms Straub reported that her time with the SSI had made a big difference to the way she taught. Asked how her teaching had changed since she completed the SSI institute she replied

Now, its "let's work with a partner and let's see if we can come up with the solutions together" or "lets work with a group, or lets get down on our hands and knees and find out the area of this room and the perimeter". You know, draw or make something that shows area, make something for me that shows perimeter. They actually have to show an understanding as opposed to just being able to do. I think that was the difference. Before maybe there wasn't an extreme understanding, just being able to do the problems.

Kathy Straub, 5/15/95

Students enjoyed the hands-on and outdoor activities in Ms Straub's class. They also enjoyed not always working out of the text book. When asked "What is it like to be a student in Ms Straub's class?", two students replied

I like it, it is real fun, I mean, everybody I talk to they like Ms Straub and stuff because of the activities that we are doing, like we are doing out there right now (measuring, outside). And they are not always not working out of the book. So far I like her better than most of my math teachers.

Naylor student 1, 5/15/95

I don't know, we do a lot of fun things like the tangram, we go outside sometimes and measure poles and stuff like that. Like yesterday we were measuring things like sidewalks and stuff. We always do fun things like that.

Naylor student 2, 5/15/95

Ms Straub used a variety of teaching techniques including individual work, working with partners and group work. Students found her classes interesting and stimulating and looked forward to coming to class. Just prior to the site visit, one group of students had given her a thank-you card expressing their feelings and thanking her for being "our favourite teacher". In my experience, this sort of reaction only occurs if a teacher is truly outstanding in the eyes of the students.

In her questionnaire, Ms Straub reported that she often or very often actively involved her students and that it was very important to do so. She also reported extending students' thinking very often and using a variety of assessment methods very often and that it was very important to do so. Student interview data and classroom observations supported these claims.

Curriculum focus

Ms Straub said during her interview that she had complete control over the order in which she taught the curriculum, although the county mandated what was to be in the curriculum. She also said that this was a relatively new curriculum

and it had been developed by people who had been associated with the SSI in various ways, although the development of this curriculum had not been part of SSI. Ms Straub felt that the objectives of this new curriculum were in line with her new style of teaching “Discovery” mathematics. However, every day she gave students three problems that were typical of what they might encounter in the proficiency test. Even though Ms Straub had adopted many of the strategies advocated by the SSI, she continued to focus part of every lesson on preparing her students for the proficiency test.

Perspectives on learning

In the final section of her questionnaire, Ms Straub reported her school’s mathematics program being much improved over what it had been four years previously. The changes she saw had been to teaching practices, and she attributed these changes to her participation in the SSI and the proficiency tests. She rated the proficiency test second on her list of ideas to improve teaching, compared to most other teachers who ranked it last or nearly last. Her perspective was a Non-Discriminatory one which saw changes to teaching practices as the way to improve student outcomes.

Ms Straub did not complete the section on “My views about mathematics”. She replied to four of the eight statements, agreeing with all of them. The issue of not completing that section was not mentioned even when the researcher returned her questionnaire and invited her to comment on it.

Summary

Ms Straub had adopted many of the reformed teaching and assessment practices advocated by the SSI. The students interviewed enjoyed her classes and some said that she helped them improve their grades. She provided activities to help students build confidence and motivation. There was no indication in the raw data or site-visit report as to whether Ms Straub used real-world contexts or tried to connect mathematics to the experiences of her students.

Kingsford Middle School 1995

Researcher C visited Kingsford Middle School⁹ for three days in May 1995 (Project Discovery, 1995b). According to the site-visit report, Kingsford Middle School is situated in a lower socio-economic area of a middle-sized city

⁹Please see Appendix P for a comparison of pseudonyms used in this document as compared to other reports on the Landscape Study.

with a population of 70 000 people. The site-visit report and interview transcripts contain very few references to the culture of the school, its organisation, teaching load, special programs or facilities. The US Census data for 1990 indicated that of the 18 800 people living in the school's zip code area, 11 300 were White and 7 500 Black. English was the main language, spoken by 17 000 people. There were 240 Spanish speakers and 80 German speakers, with some other languages spoken as well. Approximately 60% of the population of persons over 25 years had completed high school, with less than 10% completing less than ninth grade.

The school had students in grades six, seven and eight. Most of them were eligible for free or reduced-cost school lunch as part of a federally-funded financial assistance program for children from low-income families. Many children came from single-parent families. The neighbourhood had a reputation for being unsafe, and, although teachers and students did not necessarily agree that it was dangerous during the day, they thought it could possibly be so at night.

Approximately five years before the visit in 1995, the school had changed its policy on tracking (streaming) to eliminate this practice. Students had been grouped heterogeneously for all subjects. The principal said that this change was introduced to improve the motivation of the lowest-ability students, which was hoped would, in turn, improve the behaviour of these students. It was not made clear in the interview transcripts whether or not this strategy had worked, but the school was contemplating changes to the current policy for the following year, indicating that there may have been some dissatisfaction with the current situation.

The focus teacher, Diane Young, had participated in the SSI in one of its first institutes in 1992. She had been teaching for 18 years, but there was no indication, in either the transcripts or the site-visit report, of how long she had been at Kingsford.

Student interaction

Ms Young tried to ensure that all students experienced success in her class.

I: Do you feel like you're good at math?

S3: Oh, [laughs] I'm okay. I'm not really that good, but Ms Young is helping me find some easier ways to get the problems done.

Kingsford student 3, 5/25/95

I: Do you feel like that you have figured things out on your own very much in that class?

S1: Yeah, some things but then again Ms Young helps you with the other things that you might not understand. She'll help you understand, she'll explain and show you how to do the problem.

Kingsford student 1, 5/25/95

One student reported that Ms Young had high expectations of the amount of work students should do, both during class and at home.

[She gives us]...a lot of work. She just gives us work and work and don't never give us a break, and we always have homework."

Kingsford student 2, 5/25/95

Pedagogy focus

Ms Young had, according to one of the students interviewed, been using hands-on group work activities approximately once every two weeks.

I: Have you ever in class used like blocks or manipulatives, or other kinds of toys to play with?

S1: Yeah.

I: Describe one of those sorts of things.

S1: She let us use that ... telegrams?

I: Tangrams?

S1: Tangrams! I call it telegrams all the time. She had us put together ... she gave us a sheet and she had us put together seven different shapes with certain amount of pieces. That was pretty fun. She had us in groups doing that. Then she had us measuring area and space of cans. That was pretty cool 'cuz she let us ... she let us make our own labels and put around them and stuff.. It was fun.

I: And when was that?

S1: This was about ... before Christmas break, about three or four months ago. She had the whole class in about groups of three to four, and they made a product and they were going to ... and they got up in the class and they were selling ... they were talking about it and trying to get you to [buy] it. And they told you how much it was. And everybody was trying ... they voted on whose they liked the best. Everybody, they ... she set them up in the front of the room, the winners out of all the classes, then everybody picked the winner of those. It was pretty fun.

Kingsford student 1, 5/25/95

Ms Young had used a variety of assessment types since her involvement with the SSI, including group tests. She had been using group work with her students, and was careful to group students to ensure that each group reflected a range of abilities.

We do a lot of peer grouping. If someone is having problems and I know that someone else can help them, they'll work together.

Diane Young, 5/25/95

Students enjoyed the range of activities, and understood the purpose of group work to be learning how to work together as a team.

We help each other in the groups, and she tries to get everybody to do that, and that's one of the main reasons she does that—to get everybody to communicate and be able work as a team.

Kingsford student 1, 5/25/95

In her questionnaire, Ms Young indicated that she actively involved her students and extended their thinking often. The small amount of detail given to these aspects in the site-visit report, or the principal, teacher or student interviews made it difficult to determine if this was a shared perception or not. The site researcher was not convinced from examining Ms Young's teaching programs and classroom materials that she engaged the students in discovery learning. However, his views may have been influenced by talking to the principal prior to visiting Ms Young. The principal did not respect Ms Young as a teacher, and made it quite clear to the researcher that he would not mind if Ms Young found a job in another school. The principal's main complaint was that Ms Young did not control her classes as much as he would like her to, and that she did not spend enough time going over certain concepts that he thought were important. He had been a mathematics teacher himself, although not for some time. Feedback from the students, however, was much more positive. Two of the three students interviewed enjoyed Ms Young classes and said that she was a "good" teacher. Using the achievement data from the MDIT as a measure of teacher effectiveness is of no use for this school because Ms Young's class was seventh grade, and the comparison Non-SSI class was eighth grade.

Curriculum focus

Ms Young tried to prepare her students for high school mathematics by discussing with them about the kind of work they can expect to do. She related what she taught in the classroom to the real world whenever possible "any time that it is, which is most of the time, she tells us" (Kingsford student 3, 5/25/95). She felt this was especially important since it seemed that the majority of her students would not be continuing with higher mathematics.

Usually, towards the end of the year I try to do some lessons that are practical applications and that life skills, and that are kind of an outreach of things that we've done earlier in the year. So, we've been doing a unit on money. We talked about, earlier in the year obviously we worked with percents, and we talked about decimal points, and putting decimal points in money. So the unit we're doing now deals with finding the sales price, and writing checks, and balancing the check book, and things that a lot of these kids won't be going into higher math but they'll need to know.

Diane Young, 5/25/95

In her questionnaire, Ms Young indicated that she only sometimes related mathematics to the real world through discussing the work of mathematicians.

Perspectives on teaching and learning

Ms Young's most highly-rated ideas for improving learning outcomes all focused on equipment, supplies and materials, indicating that she held a Non-discriminatory perspective on curriculum practices. The section in her LTQ responses on her views about mathematics is very interesting. She either agreed or strongly agreed with all of the statements, but thought that it was unimportant to reflect these views in her class. Although she did not see mathematics as a fixed body of knowledge or as a static field, she seemed to accept her students holding these conceptions—a likely scenario if they had never been encouraged to consider alternatives. Her focus on materials and supplies indicated that she did not consider her teaching style as having much of an effect on students. In her view, if she only had the right equipment, supplies or assessment materials, she would be able to teach effectively. Transmitting her views about mathematics was not important to her.

Summary

There were conflicting views of the success of Ms Young in implementing the reformed teaching practices advocated by the SSI. The principal did not respect Ms Young as a teacher and would have preferred her to find another job. The site researcher also formed a negative view of Ms Young's teaching ability as reported in the site-visit report. The students were much more positive about Ms Young as a teacher, and Ms Young herself thought that she was making progress with many of the reforms she was trying to implement. Without a further site visit, it is difficult to make any valid conclusions about the classroom of Ms Young.

OVERVIEW OF ESSENTIAL ELEMENTS OF CEMC AT EACH SITE

A summary table of the essential elements of the Connected Equitable Mathematics Classroom observed at each site is given in Table 6.1 to assist the reader to place in context the quotes used throughout the cross-site analysis in Chapter Seven.

Table 6.1
Essential Elements of the CEMC Observed at Each Site

School and Teacher Alias	Perspective	Essential elements of CEMC observed at each site
Draper Ms Eckland	Non-Discriminatory	Strong focus on students enabling them to have a voice and develop confidence and good attitudes. Used a variety of teaching and assessment methods. Unaware of curriculum issues.
Troy Ms Zoran	Non-Discriminatory	Very caring approach, however low expectations in class work, possibly because of special ed. experience. New to <i>Discovery</i> , prior experience of co-operative learning. Seemed to use mostly co-operative learning. No power over curriculum.
Lakeview Ms Shortland	Inclusive	Very new to inquiry and co-operative learning. Very few resources to support new pedagogy. Quite aware of importance of this. Trying to change everything at once has led to somewhat disjointed curriculum.
Obern Ms Dante	Remedial	Very little evidence of change. Great mistrust of students. Recent drastic change to demographics of school. Racially-based problems in the school.
Greenway Ms Nando	Remedial	Low expectations of students. Transient staff and student population. No control over curriculum. Some evidence of inquiry methods. Some evidence of variety of assessment methods.
Naylor Ms Straub	Non-Discriminatory	Students really enjoyed her class. Strong focus on enhancing understanding through inquiry methods.
Kingsford Ms Young	Unable to determine from limited observations.	Students enjoyed new style of teaching. Focus on enhancing student achievement through much practice, some inquiry methods. Principal very unfavourable comments which coloured researcher's perspective.

CROSS-SITE ANALYSIS OF EQUITY OBJECTIVES

When comparing and contrasting the ways in which equity objectives were enacted at each of the sites, it is necessary to reflect on the process of observing equity objectives in a classroom setting. Looking at the first set of characteristics of the CEMC, those that are focused on students in order that student voice is developed, there are some aspects that are easily observed and others that are far more difficult to observe. The processes that enhance the development of student voice include facilitating knowledge construction through actively engaging students in the learning process, negotiating meaning through

interactive questioning, building confidence, valuing student responses, and interacting with and respecting all students. The first two aspects, actively engaging students and using interactive questioning techniques, were easily identified from examining the transcripts: first, because these aspects were concrete observable actions; and second, because students and teachers could recall and talk about specific instances of teachers doing these things. Researchers were also able to observe and document specific occurrences of these events.

Building confidence, valuing student responses, and respecting students are much harder events to observe or assess, and involve a large degree of interpretation by the researcher. The relatively short time of the site visits—one or three days—limited the extent to which site researchers could gain a full picture of the typical manner in which students and teachers interacted, thus making it harder to identify these aspects. Also, some researchers did not consider these aspects important and therefore made no reference to them.

The second set of characteristics of the CEMC concern teaching and assessment processes. Again, the shortness of the visits made it difficult to gain more than a superficial understanding of these processes; however the triangulation of data collected through the questionnaire, teacher, student and principal interviews, and the classroom observations have enhanced the quality of these understandings. A difficulty with these aspects occurred when conflicting views were uncovered, as was the case at Kingsford and Obern.

In order to determine if a teacher values student responses, it is necessary to observe the teacher while she or he is teaching. It is also important to ask students how the teacher responds to them when questions are asked. None of the other researchers reported much about the questioning techniques of their focus teacher, but that does not mean that these teachers did not routinely value student responses. It could have been either that the researcher was not looking for that aspect or that that aspect did not occur in the particular lessons observed. Both Ms Zoran at Troy and Ms Eckland at Draper were particularly good at valuing student responses. They both encouraged questions at all times, and students reported being confident to ask for help whenever they needed it. Each of these teachers had been teaching for at least 18 years.

All teachers observed, except for Ms Dante at Obern, actively involved students in the learning process to varying degrees. Both teachers and students described a variety of activities that were regularly conducted in these classes. Using manipulatives to investigate polygons, prisms, and patterns; estimating and measuring the size of objects; and conducting experiments to gather data were

some of the activities mentioned. Most often these activities were done in groups, with students enthusiastically in favour of this hands-on approach. The goal of increasing student understanding of particular concepts through active engagement in the learning process was common to all teachers interviewed. Even Ms Dante, who rarely did such activities because she thought her students might get out of control in a small-group setting, admitted that she would like to be able to do more hands-on activities and use manipulatives more often. She was not able to trust her students and therefore did not engage in these activities.

The final set of characteristics of the CEMC concern the curriculum. In Ohio, responding to a mandated proficiency test in ninth grade, curricula across the state were aligned to the Ohio Model Curriculum (Ohio Department of Education, Not dated). Teachers in some districts had a small degree of control, but this degree of control seemed largely limited to control over the order in which topics were taught, although some teachers did not seem to be aware of this. Examining teaching and assessment programs and text books is one way to begin to determine what content is being taught. Although there did not appear to be any difficulty in doing this, some researchers did not report on this aspect, perhaps because choosing a curriculum is an event which appears to be relatively rare in Ohio, so much so that no one ever thinks about it.

The perspective of nearly all teachers was Non-discriminatory, an exception being Ms Nando at Greenway whose Remedial perspective focused blame on students' lack of motivation which she in turn focused on the parents in order to account for her new teaching methods having little impact. A few of the other teachers talked about drastically changing their teaching practices as a result of participation in the SSI, but they continued to look to better materials, more resources and more cooperative learning as ways to improve student learning. The majority of teachers had little control over their curriculum content, with most districts mandating content and giving district-wide proficiency tests to encourage, or perhaps ensure, that teachers complied with these guidelines. It is not surprising, therefore, that most of these teachers did not consider curriculum content and context issues as important to take into account when trying to improve learning outcomes for all students. It must also be remembered that the SSI was not focused on curriculum development, but on reforming pedagogy through improving subject-content knowledge and acquiring teaching skills towards applying inquiry or problem-solving methods.

Each site was able to demonstrate at least some characteristics of the CEMC, and all aspects were observed at at least one site. The site which seemed

to have the most of these characteristics was Draper Middle School, which I visited twice. Given this, it might be tempting to assume that I saw those aspects because I was looking for them. After my first site visit, I was convinced that Ms Eckland was the most equitable teacher I had ever visited. While this may have been the case, the contrast between my first and second visits is of interest here. During my second visit, I witnessed aspects of her classroom that were contrary to my first impressions, particularly in the way she emphasised process over understanding (Draper field notes, May 1996). This reinforced the methodological limitation of conducting only one short site visit.

In the next chapter, the cross-site analysis is continued, this time focusing on issues that teachers reported to have helped or hindered them to implement reformed and equitable teaching practices in their classrooms.

CHAPTER SEVEN

SYNTHESIS OF FACILITATORS AND BARRIERS TO IMPLEMENTING EQUITY AND REFORM OBJECTIVES IN THE MATHEMATICS CLASSROOM

INTRODUCTION

Fundamental to this study was the problem facing reformers that equity goals tend to get lost in the reform process, particularly at the classroom or teacher level. It seems however that there has been little previous attempt to conceptualise this problem, or to find ways of informing practice which address this problem. The purpose of this chapter is examine the issues associated with implementing systemic reform encountered at the seven site-visit schools. It was anticipated that many issues would transcend sites; so it was decided that a cross-site analysis would be conducted using a framework proposed by Rossman (1993). In this framework, Rossman suggests that issues which arise when implementing systemic reform fall into one of four dimensions, which she named Technical, Cultural, Political and Moral. In Chapter Six, the analysis of each site was presented in the form of a thick description (Guba & Lincoln, 1989) of the context and equity observations made at each site. For the cross-site analysis, all data pertaining to the sites was re-analysed. For this second analysis, the focus was on the issues which either facilitated or inhibited the implementation of the features of the Connected Equitable Mathematics Classroom. An attempt was made to classify all issues which surfaced at the sites into one of the four Rossman dimensions. The definitions of these dimensions were outlined in Chapter Four and are repeated below:

- Technical: Professional knowledge and skills, and the means by which they are acquired.
- Cultural: Values, beliefs and school norms—both in terms of a general ethos and competing perspectives that contend with each other.
- Political: Matters of authority, power and influence, including the negotiation and resolution of conflicts.
- Moral: Matters of justice and fairness.

The Rossman framework accommodated nearly all of the issues identified; however there was sufficient evidence to suggest one possible further dimension. Once all of the issues were classified, the cross-site analysis, which synthesised how the issues in that dimension had impacted on the implementation of the CEMC, was completed. The results from the quantitative data analysis presented in Chapter Five were also interwoven throughout the cross-site analysis where appropriate. The multiple voices speaking through all of these analyses ensured the findings to be representative of as many viewpoints as possible. Thus a more complex understanding of the issues involved in implementing systemic reform and equity objectives has been gained through this cross-site analysis than would have been possible through merely analysing one site.

In the following sections, for each of the dimensions (the four Rossman dimensions and the extra dimension proposed here) a definition of the types of issues which were categorised in that dimension is followed by excerpts from the transcripts that represent the teacher, principal and student voices, and concludes with a discussion of how the dimension interacted with equity goals.

TECHNICAL

Technical issues concern matters associated with professional knowledge and skills and how they are acquired. Issues identified by the teachers included the importance of the professional development program in facilitating changes to their teaching practices; having sufficient classroom resources to effect change and devising ways to overcome problems of low or insufficient resources; having a support network of other teachers also trying to change their teaching practices; and having a well developed awareness of equity issues.

Professional Development

All teachers interviewed said that the professional development they had participated in through their involvement with the SSI had caused them to profoundly change not only their teaching practices but also the way they thought about teaching. Rebecca Eckland¹ encapsulated this sentiment:

I look at everything I teach now—every lesson that I have—wondering how I can do this in an inquiry method. And these things kind of rattle around in my brain. I come up with my best ideas when I'm lying in bed going to sleep, or in the summer time I start thinking about some lesson that I did last year, and

¹Please see Appendix P for a comparison of pseudonyms used in this document as compared to other reports on the Landscape Study.

"Well, I could have done this... and then if I do that, I could do this..." (imitating)... Though I still look at the things and think about it each time I have a new lesson that I'm coming up with. You know, how could I do this inquiry? It kind of sets the seeds going, and all of a sudden it kind of comes together. I let my brain do the working for me.

Rebecca Eckland, 5/16/95

Further, as the following interview sequence with Kathy Straub shows, teachers indicated that it was unlikely that they would have been able to make those changes on their own, or, if they could have, it would have taken much longer and been more difficult.

- I: How do you think your own attitude about teaching has changed?
- K: Before *Project Discovery* I was getting to the point where I was bored to tears. I just, you know, twenty something years of the same thing, over and over and over again, it was getting very tiring.
- I: What kind of teacher were you before you went to *Project Discovery*?
- K: I think I was a pretty good teacher pre-*Project Discovery*, too. According to the standards of pre-*Project Discovery*. You know, um, we did at that point in time, we still do, a lot of interactive, we didn't necessarily do a partner, but my class were always, "let's help each other, and let's work with each other and brainstorm with each other". This is one of the first years I haven't had like a pre-algebra class and we did an extreme amount of it in that class. The kids have always liked to be in my room and I think they have always come out with a better understanding of math than they did in the other rooms
- I: So, pre-*Project Discovery* there was still a lot of discussion, it sounds like, going on, but . . .
- K: It was still standard, this is your book, you do your problems.
- I: And now, post *Project Discovery*?
- K: Now, its "let's work with a partner and let's see if we can come up with the solutions together, or "let's work with a group, or let's get down on our hands and knees and find out the area of this room and the perimeter." You know, draw or make something that shows area, make something for me that shows perimeter. They actually have to show an understanding as opposed to just being able to do. I think that was the difference. Before maybe there wasn't an extreme understanding, just being able to do the problems.

Kathy Straub, 5/15/95

For some teachers though, the SSI experience was one of several major influences on their teaching practices. Ms Zoran for example, stressed that she had participated in many professional development activities focused on cooperative group work during her time as a Special Education teacher working with learning-disabled children. Her SSI experience had enhanced her teaching by helping her to make the transition into mainstream teaching, and to be more student centered in her classroom. She indicated that, although she had not really changed her teaching style a great deal, she had changed the focus of some of her

activities to make them more inquiry oriented, which she would not have done prior to her SSI institute. She also expected her students to have a deeper conceptual understanding than before.

Resources to Support Reformed Teaching Practices

Mathematics equipment

When are resources too few to support the creation of the Connected Equitable Mathematics Classroom? Nearly all teachers anywhere, when asked, would say that they either did not have enough resources, or that they would be able use more resources. None of the schools visited in *The Landscape Study* were wealthy. All were struggling financially, but this did not prevent some teachers from creating a connected, equitable classroom environment. Ms Eckland at Draper was ingenious in her use of resources, utilising everyday objects rather than relying on expensive equipment. The Apple II Plus computers in her classroom were at least 10 years old, but still served a useful purpose in helping some students improve their basic skills, which is an important aspect the CEMC. Ms Zoran at Troy had access to a wide range of equipment, but, being Head of Department, was concerned at the lack of equipment for the rest of her staff if she was always using it. She seemed to use the equipment infrequently, relying instead on group work and interactive questioning to involve her students. Ms Shortland at Lakeview felt guilty asking for money when she knew it was so tightly managed, particularly when she thought she was virtually the only person requesting money for extra equipment. Ms Dante at Obern had a room full of equipment that she never used, and, not surprisingly, she did not think that she needed any more. Her teaching style and classroom environment was the least equitable of all those visited as part of this study. So, for her, having a room full of resources did not mean that she was able or willing to utilise those resources to help students connect with mathematics. Thus, having the equipment did not automatically facilitate the creation of an equitable environment, and not having equipment did not necessarily create a barrier to achieving equity in the classroom.

Some teachers mentioned that their students were unable to supply their own calculators. To overcome the problem of students not having calculators at Draper, Ms Eckland had a box of mathematical equipment available at all times on each group of desks. If students did not bring, or did not own, a ruler, compass, or calculator, they were able to use the ones she provided. Items were

rarely lost or stolen from these boxes. Students respected the trust she showed them. At Troy, Ms Zoran had one class set of calculators which she used quite often, but when another teacher required them for a test, she had to go without. She was considering asking parents to buy a simple calculator for the next school year because she had been able to locate a supplier with very reasonable prices. At less than \$15, Ms Zoran thought that this seemed like a reasonable request, considering that the students were likely to use the calculator for the next three years at least.

None of the schools visited had the financial resources to take students on field trips to see mathematics in action in a real-world situation, thereby enhancing students' connection with mathematics. In the teacher questionnaire, teachers rated the importance of field trips as very low, and none of the teachers interviewed expressed any desire to take their students on field trips. This demonstrated that there was little awareness of the potential value of connecting classroom mathematics to real-world activities that might be encountered through field trips.

New technology installations, such as computer laboratories at Troy and Draper, were often financed by external grants from local corporations. Seeking money from outside sources was an important part of the Draper principal's strategy to improve the school, although this strategy was not followed by all principals.

In summary, financial resources, or the lack of them, does not have to be a barrier to creating an equitable classroom environment. Individual teachers can come up with creative ways of overcoming many difficulties imposed by financial constraints on the provision of equipment. Principals can seek external sources of funding for large projects.

Written curriculum materials

One issue that was important at a number of sites was the availability of appropriate written curriculum materials to support inquiry-based teaching. This was a particularly important issue for Ms Eckland at Draper. During the first visit in 1995, she did not use the text book her school district had adopted, relying instead on photocopying worksheets from a wide range of curriculum-support books. This was time consuming and expensive. She was not happy with this situation, and in 1996, she joined a national program known as Mathline, which she describes in the following interview segment.

Yeah, Mathline, they provided us with the video tapes that had three lessons on them, like that three or four, or three and an overview. Um, its an activity similar

to types we did with *Project Discovery*; they're inquiry type activities. They're actually done in a classroom and being videotaped happening in an actual classrooms and then they provided also for us the paper work to support it. It describes the activity and what materials you need and what lesson: what's being taught in it, what's being met in it, whether its probability or whatever and any kind of, if you need a game board or something, It gives you the master to duplicate for that so then you can present it in your class exactly the way it was done there or you can modify for whatever your needs are.

Rebecca Eckland, 5/23/96

During the second visit, Ms Eckland used the Mathline resources in a number of lessons I observed, and indicated that she had made extensive use of these resources throughout the year because she thought that the materials were very appropriate to the inquiry-based style of teaching she had adopted since her SSI involvement in 1992. The issue of availability of appropriate inquiry-style teaching resources was also raised at a number of other sites visited, although none of the focus teachers at those sites were using Mathline.

Teacher Support Networks

The model of change followed by the SSI concentrated on the individual teacher as the change agent, but recognised the need to provide teachers with continuing support. All teachers were given an email address and access to an electronic discussion group and other services. Since some teachers came from schools where there had been no other teachers previously involved with the SSI, the electronic network known as *DiscoveryNet*, established just for SSI teachers, proved to be an important element in facilitating the change process, as shown by the following comments by Barb Zoran.

- I: Do you use DiscoveryNet very much?
- B: Actually I do. I check the lounge a lot and see what's going on. Right now my system is down but I check it at home and see what's going on and talk to people.
- I: Is that an important thing to you?
- B: I think it's good because, especially, now here I have other people in my building who are Discovery. I have Mary, who is math, and I'm math. And then we have DJ with science. And there are two sixth grade teachers who did Discovery Science. We can talk to each other about "what are you doing". But in a building when you are the only one, I think that's very important to be able to communicate and ask, you know, gee I'm trying this, what ideas do you have. Or when you are trying to make changes, that at least you have some other people behind you that can say, look, you know, here are all these people out here that are doing this and how can we get involved here. And the instructors that we had were excellent and have been very supportive and I feel that I can contact them on Discovery Net when I've needed something. I need the address to this or how do I find out about that and they have responded. It's been good.

Barb Zoran, 5/15/96

Other avenues of ongoing support included the annual conference (organised by the regional offices of the SSI) for SSI teachers, and, for some, a continual involvement with summer institutes. In some cases, close friendships were formed between participants, helping to keep a support network going.

- I: What would you say are the most important things that you are taking from *Discovery*—the most important ideas about how learning happens?
- D: [long pause] Well, I think some of the things, and we did this in the follow-up, is where we shared ideas with other teachers from other parts of the state. You know, “I tried this in my classroom, and it worked, but you might want to try it this way.” Or, “This failed.” It’s like, gee, other people fail at things. This is how you can build on it and go from there. You try, you fail, you have a tendency not to try it again. But you could improve on it, and try again.
- I: So having a support group of other teachers who are doing this is very important?
- D: Yes. And I have met some friends that I would say are a long distance from here, and if I want to run an idea by them, if they are on the network I can use a computer and talk back and forth on the computer with them.
- I: Do you have access to *Discovery Net* from here?
- D: Not in our building, but I do at home.
- I: At home. Do you use that often?
- D: Yes. I use it quite a bit. Towards the end of the year I haven’t used it much. And I like to read the lounge, and see what the other teachers...and questions they have ... and I mean it’s a network of teachers that you can get into all over Ohio.
- I: Right, right. Do you have a chance to meet personally with other teachers who are doing reform, or are doing *Discovery*?
- D: Well, last summer I worked with a group from the Dayton area, at Sinclair, and this summer I’m going to be working with a group from Wright State. Some of the teachers I have contact with because they’re in my son’s school. And I see them at school when I go up. And some of my friends that I went to Miami with, we still get together and contact each other. So we still have a support group.
- I: How would it change things if you didn’t have that support network?
- D: I think that you get back into the same old routine, the same old rut. And kind of get discouraged. With that, you’re more likely to have a fresher outlook.

Diane Young, May 1995

For Rebecca Eckland, her involvement with another program that supported inquiry-based teaching gave her further opportunities to network with mathematics teachers across the country, an experience that she found extremely valuable. She describes this network in the following interview segment.

The Mathline itself is electronic bulletin board that connects math teachers all over the country through their PBS stations, so the PBS stations sponsor it. You become a member I think it cost like \$800 for us and the school paid for it. And that gave us all the video tapes, ten video tapes, ten video tapes I think it was and the membership for the year. I happen to also get a laptop computer from the mentoring programs for the county schools, which had a modem on it cause my

computer never had a modem on it so I couldn't use the email or anything without and I got on it from that and you just get into this bulletin board and you start talking about something or see something somebody has talked about and you give them suggestions or say well I do this and they say oh I like that idea or I do this or does anybody have any ideas how to do some things or I'm having trouble getting my kids to understand the distributive property here are the things I do what do you do and so people are like well I do this, this and this and you can get a lot of ideas from that. Some of the things we talked about on there that I find interesting was on how to determine advanced placement what kind of criteria they use to decide who goes into what classes scheduling teaming the kinds of things that you do in middle school its mostly middle school teachers that are on this if we're, if you've done something with one of these video lessons then it work real well and you want to share it or work real badly and you want to share it then you can do that. Then it also has a separate bulletin board for just the Mathline users that are from our PBS station and so we were able to ask questions about the videos we were supposed to go through and do certain one of them at least view them and give our opinions on them and if we had the opportunity to use them in the classroom that was fine but we weren't forced to use them in the classroom unless we wanted to. If we did use them to share the good and bad things that happened and what could make it better or any ideas that we had and it was just very productive and very informative and I hope I can find a way to be on it next year {laughing} I got a lot out of it.

Rebecca Eckland, 5/22/96

Awareness of Equity Issues

Gender issues

Ms Zoran was aware of potential gender issues in her classes. She and a colleague had discussed the idea of grouping the students into single-sex classes for mathematics because the perception was that some girls were afraid to answer questions in case they showed up the boys, hurting boys' egos. She commented on her own experiences of this phenomenon during the interview.

A lot of times either the boys are out to impress the girls or the girls are afraid to be perceived as too smart by the boys and it might make things easier if you had all girls or all boys in a class. Not that you would run the class any differently but the girls could then feel free to express themselves. ... I know that my husband will not bowl with me anymore because I beat him a couple of times and, you know, it was very damaging to his ego and I think that happens in classes too. That you know, you want to be popular and the cool guys don't want the smart girls.

Barb Zoran, 5/15/96

Ms Zoran noticed a distinct difference in those of her classes where there were more girls than boys. One class observed during the site visit had an imbalance of boys and girls, and this was discussed in the teacher interview.

Now that's not a problem in this last class that you saw because there are only 8 boys in that class. They're outnumbered by the girls. There are 21 girls. So the girls have no problem taking over in that class. But in some of the others, there

are kids that sit back and, you know they don't want to give the answer, they don't want to be seen as the one that has the right answer all the time.

Barb Zoran, 5/15/96

This issue has often been referred to as the "critical mass" issue: as indicated in Chapter Three, when there are more than a critical mass of girls in a class, boys are less of a problem.

It seemed that gender or racial equity issues were often the ones considered important by the teachers and administrators interviewed. During an interview with the superintendent at Lakeview, she was asked what equity issues she was aware of in the district. She told the researcher about some initiatives she had been involved with.

Equity in mathematics, I would like to see more girls involved; in fact I am a member of the AAUW, which is the American Association University Women. We have, every year we encourage, in the county the association chooses two of the top math girls and encourages them to go to a summer camp usually. We've even had people fight us on that oh well you're being discriminatory you should,

why can't a boy go and that sort of thing, but its real tough to explain to people that very few females go into this role go into this field.

Lakeview superintendent, 5/9/96

Later in the interview, the issue of availability of funds to supply basic science equipment came up. When the researcher referred to that as an equity issue, the Lakeview superintendent replied "When you said equity, I thought you were talking about ethnic minorities." The assumption that equity issues always referred to gender equity was a viewpoint held by Ms Dante as well. When asked what equity meant to her, she replied:

Equity to me is treating everybody equally, giving everybody a fair shake. I think I do that very well in here. If anything I favor my girls more than I do my boys, I push my girls harder than I push my boys. I have told my girls, you need to go out in the world and prove yourself which means your are going to have to work hard, so you have to expect more from yourself. I do more outside of class work with my girls than I do my boys. They'll come for extra help, they will come in during study hall after school, just to clarify and make sure they are doing things correctly.

Patricia Dante, 5/10/96

Socio-economic issues

Socio-economic issues were clearly important in all schools visited; however these issues were often not included in discussions of equity issues. Equity as a concept had been dealt with in the SSI institutes to varying levels and with varying foci. In some institutes, such as the one Ms Shortland had attended,

only cultural and racial equity issues were considered. Given the homogeneity of the population in her community, racial and cultural differences hardly existed and were not recognised by teachers as a problem, simply because the vast majority of the school and community population was white. When asked about the equity focus of her institute, Ms Shortland replied

We did a lot of sessions on that and it took up a lot of time and we actually were kind of resentful that it took up that much time, because in this area the thing we deal with more than anything is the difference. I really don't perceive any gender problems nor race problems in this area, it's more economic, and the emphasis was put on different cultures and we were mad. You saw our kids today, we just don't have that. We felt, I think, the people that I talked to and most of the people in my group (we were pretty close), we were kind of resentful that so much time was spent on that. Not that we don't think that its a problem, it probably is a problem in places where you have that mix.

Suzanne Shortland, 5/9/96

From Ms Shortland's viewpoint, equity issues associated with socio-economic status were more important to her and her situation at Lakeview, and these were not dealt with in the institute she attended. Thus, it may well be important for professional development to focus more specifically on equity issues directly relevant to participants' own experiences.

It was clear from the interviews that many teachers did not have an awareness of the impact of socio-economic inequities on their students. At Lakeview, this problem was particularly evident. The school was designed for elementary students but had middle-school students. As noted in Chapter Six, eighth-grade students, some of whom were nearly 180 cm tall (6 ft) had to sit at desks designed for six-year-olds. How students could be expected to learn effectively when they got a backache from sitting at their desk for more than a few minutes would have to be questioned. This issue of the disparity of funding between school districts was summed up by The assistant principal at Lakeview, the school where this problem was particularly obvious.

[The] equity issue here is that we're funded about 75 percent by the state and about 25 percent locally. Again I'm not exact on those figures, but I know those are close. But per pupil expenditure is very low compared to some schools, where they are spending double per pupil what we are. And obviously the equity issue is that we should be getting ore money. Money needs to be allotted up more equally but that hasn't happened. Whether or not it will happen is to go to court I suppose. They are supposed to be hearing the arguments and should be making a decision. Our legislators aren't going to make that decision, you know. I don't know, I cant really say that honestly that we should be able to take money from lets say [Somewhereville}, where they spend \$10,000 a kid and we spend about \$4,000, you know. Should we be able to take money from their community? I don't know.

Lakeview assistant principal, 5/9/96

The issue of distribution of wealth has been central to equity debates for decades, and is one not likely to be resolved simply or quickly.

Monitoring equity problems

Even those teachers who expressed their awareness of equity issues in their classrooms reported that it was difficult for them to be self aware of their treatment of different groups of students while they were teaching. Because of the shortness of the site visits, a detailed analysis by the researchers was not possible either, so it is not really possible to say whether an awareness of potential equity problems makes for a more equitable classroom. However, it would be difficult to imagine the opposite—awareness of equity issues leading to a less equitable classroom. Rebecca Eckland encapsulated this sentiment in her comments below.

But, I try to spread it around a lot, and I've heard a lot of the programs on sex equity. Where boys tend to get treated different from girls, or teachers tend to have higher expectations for what boys do in their classes—or in Math and Science classes, anyway—than girls. And I've never felt like I did. But, of course, I can't sit there and watch myself teach, so I don't know if I am or not. But, I may go the other direction, and I may expect more from the girls and less from the boys, for all I know. I don't think I do, but... I probably couldn't tell unless somebody was sitting there watching me, and telling me what I was doing. I've never had any kids complain that they felt like I treated boys or girls—one or the other—like I expected more of them. So... or like they were more intelligent, or had better answers, and... I know one of the things they said was teachers tend to let boys give detailed explanations of their ideas, and girls just give brief answers. And, I've never felt that I did that, I don't know—do you notice me doing that? (laughs)

Rebecca Eckland, 5/16/95

Summary: How Technical Issues Influenced the Implementation of the CEMC

From the analysis presented here, it seemed that there were certain technical issues which were critical in enabling teachers to create a CEMC. The actual professional development experience was one critical element, as was the existence of teacher support networks. With regard to the formation of teacher support networks, the point must be made that these networks do not form or sustain themselves without central facilitation or ongoing support. The Ohio SSI provided this support and most teachers interviewed mentioned the importance of the support networks. One technical issue raised by some teachers, which did not seem to have been addressed to any great extent in the institutes attended by the participants interviewed for this study, was how they could monitor their own

interaction patterns with students in order to determine how equitable those patterns were.

CULTURAL

The Cultural dimension is one which encompasses issues concerned with values, beliefs and school norms—both in terms of a general ethos and competing perspectives that contend with each other. A range of cultural issues which impinged on the implementation of the CEMC were identified across the sites. These were parental support, teacher expectations, student attitudes and school culture.

Parent Support

Parental support for the school appeared to be an important cultural influence at all site-visit schools. None of the teachers or principals interviewed reported a high level of parental support. Interestingly, the three teachers who reported the lowest levels of parental support were those who were least successful in their implementation of reformed teaching practices.

Ms Young from Kingsford said that she often had around 40% of her parents turn up for the first parent-teacher conference of the year, but that this percentage dropped sharply later in the year. In comparison to other schools, 40% was quite high; so the reported lack of support is a matter of perspective.

I think it's just...I guess I'm thinking there's not a lot of support from the home, which...when I give homework...a lot of them, their parents don't make them do homework, or they don't take any...involve themselves with their kid's education. And I think that carries over in the classroom, with the kids. "Well, I know I don't have to do this, my parents don't care. And if I fail, my mom can come in and pass me on to the next year." So they're not motivated from home. And we've got that to try to fight with, to get them motivated in class.

Diane Young, May 1995

The principal at Kingsford also mentioned that parents of children at his school were not supportive of education in general.

[Our population is] very poor. We have close to 80% kids free/reduced lunch. More free than reduced, a lot more. No support from parents. A lot of one parent homes. And they could care less about education. I've had most of them in school myself when I taught at South. Parents are my former students, a lot of them. And the problem here is kids having kids. And this is a big generation of those kind of kids. We've had several kids in the building that are pregnant themselves. What else do you want to know? [chuckle] They could care less about school, bottom line.

Kingsford principal, May 1995

Similarly, during her interview the focus teacher at Greenway constantly referred to poor support from parents, linking it to the students' lack of motivation. She felt powerless to alter this because of her perception that students lacked a "parental culture" to help them achieve in school. Her attitude appeared to be one of "blame the victim" instead of looking for ways to compensate and build on success. One student interviewed also commented that many of her classmates did not care about education because their parents or the people they live with (not always their parents) did not care and did not help them with their homework or study. This "blame the victim" attitude was summed up by Harriet Nando from Greenway.

- H: I also think that a lot of these questions [in the LTQ] are geared towards students who see a real value in education and I question how much value my students really do see in education.
- I: Why do you say that? I think that's a very important observation and I would like to know more.
- H: Most of their parents are minimally educated, whether it be high school or not high school yet. And it's something that is not important at home. They don't see the example at home and they don't see an importance. Most of the parents that I talk to, the first thing they say to me when they hear that I'm the math teacher is they say, "I never did well in math. That's why my child doesn't do well in math," which gets under my skin and it annoys me. I don't think this is just my students. I think that this is a national thing.

Harriet Nando, May 1995

The teacher at Obern, Ms Dante, also blamed her students' lack of cooperation in class on their parents. She felt that the most important thing that would improve her students' learning was changing their attitudes so that they valued education more. This she felt came directly from the parents. Again, this represented a "blame the victim" Remedial perspective from the teacher. Without the cooperation of her students, Ms Dante felt severely constrained in the types of activities she felt she was able to do. Although she said she would like to do more inquiry activities, she believed that her students could not be trusted to participate without getting out of control. The fact that she was White and most of her students African American was a big factor underpinning this belief, as indicated in this excerpt from her interview.

- I: On your questionnaire, one of the things I noticed particularly about your questionnaire was the way you responded about the parents, in terms of not feeling supported by the parents.
- P: Yeah. Lack of support, lack of understanding. It's always the teacher's fault, it's always my fault that their child is not learning. It's always my fault that their child is failing class and I tried to explain to them that I am presenting the information in several different modes and if your child chooses not to do what is asked then that is your child's fault not mine. Because I am presenting the information and it is really hard when the children say one thing and it is the complete opposite of what you've actually done in class.

Making parent contact is difficult, umm, a lot of times you don't get them to call you back.

I: Do you think there are any barriers when you are teaching math at this school?

P: Yeah, I think part of it is because I'm White and I think a lot of times the kids have a hard time with that. I think part of it is the mind set of the parents. A lot of our parents never finished high school and I think they really fear their children getting smarter than they are, that causes a problem.

Patricia Dante, May 1996

In summary, it was clear that the perceptions of teachers about the level of support they received from parents was a critical factor influencing the decisions about what kinds of activities could be done in class, and what kind of homework could be given to students. It was apparent that whether parental support was actually there or not was not really the issue. The critical factor was the teacher's perception of the level of parental support and whether they were prepared to initiate activities in this regard. Ms Zoran for example, reported lower levels than any other teacher interviewed of parent support for parent-teacher conferences and attending school events. She still managed however to conduct inquiry activities and was not concerned about homework not being done. Ms Zoran overcame the problem of parents not turning up to parent-teacher conferences by speaking on the telephone to those parents she needed to talk with rather than relying on them to make it to the school for parent-teacher conferences. Ms Zoran also mentioned that the school had an annual open day for parents which was very successful. Similarly, Suzanne Shortland at Lakeview involved parents in the school's mathematics program by organising a Family Math night which was extremely successful (despite warnings from the principal that it would "never work"). Lack of parent support in the form of not valuing education was certainly an issue for many schools in *The Landscape Study*. Finding ways to involve parents more and to help them to value their child's education was undertaken with some success by some schools.

Support—or lack of support—from parents is one important cultural influence on students, on the way they perceive themselves, and how they value education in general and mathematics in particular. As discussed in Chapter Two, Eccles (1987; 1989) pointed out the importance of parental expectations in influencing student achievement in mathematics. Kahle, Parker, Rennie and Riley (1993) (also discussed in Chapter Two) proposed a model that emphasises the links between teacher expectations, teacher behaviour and the socio-cultural context in which both students and teachers are situated. If teachers and the

principal believe that parents do not support the school in particular or education in general, this could cause them to have low expectations of their students, which could influence them in planning activities for their students. In *The Landscape Study*, the results of the analysis of the LTQ seemed to indicate that both SSI and Non-SSI teachers reported the same level of parent support, but that SSI teachers rated the importance of parental support higher than their Non-SSI counterparts, and in some cases, planned specifically to address this issue.

Teacher Expectations

Another aspect of school culture that influenced what types of classroom activities teachers implemented was the teacher's expectations of what students were able to do. Ms Dante at Obern was an example of someone who had been so influenced by what she thought her students were not capable of doing that she was unable, or possibly unwilling, to try many "risky" inquiry activities. When asked why she did not do more inquiry activities with her students she replied

Partially the kids they don't handle that kind of approach very well. I have a difficult time putting them in a situation where they get frustrated, and they get frustrated very easily with the inquiry. I don't know if they have never been exposed to it, I don't know if it's just the mind set that they have. If it causes a lot of distress then I back off from it.

Patricia Dante, May 1996

In Ms Dante's case, part of the distrust of her students was racially-based as mentioned in the previous section on parent attitudes. Again, it was clear that the fact that she was White while most of her students were African American was significant to her. The principal, himself African American, commented that

I just have to be open and honest with you, I have some people here that work with black kids and they just don't understand how to work with a black child, and it is obvious.

Obern principal, May 1996

In contrast to Ms Dante, Ms Young at Kingsford was a teacher whose involvement with the SSI had encouraged her to trust her students, at least initially. When asked how she had changed since her involvement she replied

Well, I probably, maybe once in a while tried group work and it was so chaotic that, "Well, I can't do this again." Or, if we're using manipulatives, the first thing I would have said, "Oh, well they'll steal them all, or, they'll throw them, they'll kill each other, I'm not even going to try it." Where, I'll try it, sometimes it doesn't always work, but I'll try it this way and know what to expect.

Diane Young, May 1995

Ms Eckland on the other hand, was willing to keep trying inquiry activities with her *Chapter 1* class, a small group of remedial students:

The students in *Chapter 1* classes do not have any of their own ideas (laughs). I mean they very seldom do, and as far as designing an activity to test it, they wouldn't have a clue. I could design something to test their ideas, but they don't want to bother. If they have an idea, they don't want to bother designing something to test it. Either it's right or it's wrong. Well, I don't just say "you figure it out". They would just turn off. But then that's *Chapter 1*. I can get that, I can work with my regular classes and get that in the regular math, but in the *Chapter 1* math I haven't been able to. Again, this is my first year doing *Chapter 1*, and I may find a way in the future, but right now I don't. It doesn't mean I won't. ... And sometimes I get surprised. Kids that I expected that wouldn't get involved with the exploration activities, do.

Rebecca Eckland, May 1995

Ms Eckland made these comments after the researcher had observed a lesson with the *Chapter 1* class in which the students had been attempting an inquiry activity (Draper field notes, May 1995). One group in the class was very successful, which surprised both Ms Eckland and the researcher. Had she avoided giving these students a chance at exploration, they would not have been able to surprise her.

The literature on teacher expectations reviewed in Chapter Two demonstrated that when teachers have high expectations of their students, the students perform better than when the teacher's expectations are low. Teachers' beliefs are shaped by many influences, including their perceptions of parental support, student attitudes and achievement, and support from administration (Fennema, 1990b). For the teachers visited for this study, their SSI involvement had enabled some of them to be more positive in their expectations of how their students would cope with inquiry-based teaching and learning activities. However, this was not the case for all teachers. Certainly in the case of Ms Dante, the general atmosphere of the school seemed to be unsettled and without a strong academic focus. The whole structuring of her classroom environment seemed to indicate that Ms Dante was afraid her students would become unruly if given even the slightest opportunity to do so. This may well have been the case if the behaviour of students in other classes observed around the school was anything to go on.

Student Attitudes

Another important part of the cultural context of the schools visited which impacted on the implementation of the CEMC appeared to be related to students' attitudes towards to the types of experiences they were having in the SSI classes,

which for many of them involved different learning experiences to those they had experienced in other Non-SSI classes. Learning to work cooperatively and experiencing success in mathematics were two aspects of students' attitudes that were encountered across a number of sites, and these will be discussed in the next two sub-sections.

Because most of the schools visited were racially mixed, it was anticipated that there might be racially-based conflicts between students which were adversely affecting the school culture and classroom environment. However, this did not seem to be the case, as will be discussed in the last sub-section of this section.

Learning to work cooperatively

Using cooperative learning and inquiry activities with students unaccustomed to sharing their ideas or answers caused problems for some teachers. It appeared to be a totally new way of working for most students, and, as shown by these teachers' comments, it took some getting used to.

I don't think they got a lot of chance to explore things in the elementary schools until recently. So a lot of these kids that we still have here haven't been through much of the things at the elementary level, besides just add, subtract, multiply, and divide, over and over and over again. So I'm finding occasionally now, especially with the better students like I have in Algebra and Pre-Algebra, have had a little more experience with that kind of exploration, and are ready to do some more. The kids who have less ability... I don't know if they have less experience, or they just are afraid to do anything besides, you know, "I want to know how to get the right answer, and that's all I want to know, because I want to make sure I do it right and that's all." (imitating) And they're afraid to do any kind of exploration.

The amount of time it takes to get the kids started so that they will explore things. I have spent almost a whole grading period one time trying with a group of kids to get them to explore things. And we didn't get much of anything else accomplished. I mean, if you're going to do that, you've got to just do that. And even then, though they were starting, they just weren't... They were still in this "I need to know what you want me to do, what answer are you looking for, and how do you get it?" (imitating) They're so stuck in that, and I think that starting at this age group is a real handicap, because by the time they're in eighth grade or even seventh grade they have 6 or 7 years of answer-oriented math. Answer-oriented everything! And their minds are no longer that flexible. I mean, you can change it, but to be able to change it quickly, I think it's something that needs to start earlier.

Rebecca Eckland, May 1995

I don't think the kids are used to [inquiry learning]. Just as when I first started with cooperative learning, it was very difficult for the students to accept that it wasn't cheating to share your ideas with someone else. This is difficult for them too, this last class that was in. In the beginning of the year they were going nuts. It was like "well if you would show me" because I would say "what do you think" "well, but you're the teacher, your supposed to tell me". So until they're more used to it and as we try to incorporate that into our sixth grade curriculum

and seventh grade, now when they go to eighth grade and get to Mary, she'll have an easier time because they'll be familiar with that. And that's generally what the difficulty is. They're still real dependent on the textbook. They want the security of "I have a math book. I have an assignment in the math book. I know exactly where I am, what I'm doing, what page I'm on."

Barb Zoran, May 1996

Students seemed to become accustomed to working in groups quite quickly, so that by the end of a year, they were much better at it, even in other subjects.

I was talking to one of the other ... the social studies teachers ... and I did a lot of cooperative work at the beginning of the year and so did he and he said, "you know, since you've been using cooperative groups in your class, it's much easier for me to do it in my class."

Diane Young, May 1995

Experiencing success

According to the Eccles (1985) model of achievement behaviours, students' motivations to succeed are influenced by their past achievement in mathematics. For many students of teachers interviewed in this study, past achievement had been very low. A series of demoralising "D" or "F" grades in mathematics had been what they were accustomed to. However, a cooperative, caring approach such as that taken by Ms Eckland for example, helped some students to experience success for the first time.

Well the class is, I like it because it helps me. Ms, Eckland, I had a whole year so she help me because last year I had an F and Ds and Cs, I didn't get a B or an A but then when I came to Ms Eckland's class this year I've gotten Bs and I think I got an A. I'm doing really well on the test too so Ms Eckland has helped me a lot.

Draper student 2, 5/23/96

Students in classes where a lot of activities were done looked forward to coming to class and seemed to genuinely enjoy these activities, and, as a result, had positive attitudes towards mathematics. Some students told their interviewer how much they enjoyed their mathematics class:

I: Is there anything else you'd like to tell me about this class or about this school?

S4: It's fun.

I: So you like it?

S4: Yeah. I like the math class too.

I: What makes it fun?

S4: We do a lot of activities a lot. We do experiments like the parachute drop, that was fun. We had to make our own parachute and I made a double one

and we were seeing our times and stuff and we almost got the best, Ms Eckland helped us out a little bit.

Draper student 4, 5/23/96

This change of attitude was particularly evident at Naylor, where Kathy Straub had noticed a change in the attitude of her students since she had been doing more hands-on activities. Her students were even thanking her personally.

K: Attitude, um, I don't hear so much anymore, "I hate math." I hear, "Math is my favorite class", "I enjoy going there", or "can we stay, and not go to the other classes today". You know, that is a very good feeling. And I have gotten notes this year again.

I: What do you mean by notes?

K: It used to be when you were teaching you would get notes from kids, "thank you for this", "thank you for that". And for years I hadn't gotten any, and this is from that first class you observed. They just gave it to me the other day and there was another big thing that went with it.

Kathy Straub, May 1995

The positive atmosphere of trust and mutual respect that most of these successful teachers seemed to have created appeared to help enable each student to fulfill his or her potential in mathematics, as indicated by this comment from a student at Lakeview:

I Is there anything else you'd like to tell me about the class?

S2 Well it's a really good class and I really like the teacher and she's, cause well she helps us out a lot and I really like it cause it has really helped me out a lot.

Lakeview student 2, 5/9/96

According to the Eccles et al (1985) model, experiencing success in mathematics (for the first time for some of these students) also influences students' confidence and motivation. It was clear from the interviews that students who were successful enjoyed their mathematics classes.

Racial harmony

Although there appeared to be an element of racially-based distrust at Obern between the teachers, who were predominantly White, and the students, who were predominantly African American, the students were not inclined to have racially-based conflicts among themselves, according to Ms Dante and the principal. Racially-based student conflict was not mentioned as a problem in any of the site-visit schools. Conflicts between students were more often based on other issues, as commented on by Barb Zoran:

It's pretty even. I don't notice any racial issues to speak of. Generally, and I don't know if this is going to come out right, but for example, in a confrontation or fight of some kind it's usually not black white. Or it may be but that's not the reason for it. It can be black black white white, both but the reason for the

disagreement or the confrontation is not necessarily racial. I don't find anybody who doesn't want to sit next to someone because they're white or black. Generally it's because they smell or because they aggravate them or they get on their nerves, but the race doesn't usually have anything to do with it.

Barb Zoran, 5/15/96

School Culture

The culture of the school concerns those widely held beliefs and values shared by the majority of the school population—teachers, students and parents. Each of the seven site-visit schools had its own unique cultural attributes; however, by far the most obvious culturally-based issues evident in this study were those which were associated with race. At three of these sites, Obern, Troy and Greenway, the students were predominantly African American but the teacher was White. This imbalance appeared to generate the most acute effects at Obern.

Walking around Obern while classes were being taught made it clear that Ms Dante's beliefs were well founded in assuming that her students would take every opportunity to make trouble—there seemed to be an unwillingness to work and a lot of shouting and moving about in many classrooms I noticed while walking around the school. The culture of this school appeared to largely condone this sort of behaviour. When students gathered in the gymnasium for a meeting, even the assistant principal could not get them to pay attention to what she was saying. The principal mentioned that other White teachers had problems dealing with the African American students. The principal also mentioned that, when he first came to the school as principal just two years before, the students were rude, nasty, disrespectful, unruly and had fought a lot. He had been trying to change this and felt that he was beginning to see some improvement. He also noted that the racial mix of the school had undergone a massive shift over very recent years from predominantly White to predominantly African American. At Troy and Greenway there were certainly noisy students, but there was not the same quality of "rebellion" in the students as there was at Obern. Admittedly at both Troy and Greenway there were security guards patrolling the halls during class—clearly the maintenance of discipline was high on the agenda for both of these schools.

There were also other important differences between the SSI teachers at these three sites. At Greenway, Ms Nando repeatedly mentioned the lack of motivation of the students. She felt that her students did not value education because their parents did not value education. She was prepared to try some different sorts of activities, but was never very hopeful that the students would get

much out of it. She placed the blame for these poor attitudes on the school culture which was in a constant state of upheaval due to administrative changes, a very transient student population, and poor parental attitudes. She described her students as “the bottom of the bottom of the bottom”.

At Troy however, Ms Zoran had a completely different approach. She was concerned about her students and never said anything about their lack of motivation, although it appeared to me that these students were essentially no different to the students at Obern or Greenway.

Comparing these three schools, the main differences appeared to be the teachers' attitudes towards their students, the principal's leadership style and the school culture, with the three influences inextricably linked. At Troy, the principal was a “go getter”, always after new projects and applying for grants. He exuded confidence and was very supportive of his staff. He was very keen to talk to me, and we spoke for over an hour. The staffing of the school had been quite stable, and staff seemed reasonably contented with the way things were, even though they grumbled to me at lunch time about the decline in discipline standards over the past few years. At Obern, the school culture had changed radically in a short period of time due to the changing nature of the population in the surrounding community. Teachers had not adjusted to the new demographic mix of the population, and the principal, being new to the situation and African American, seemed to be on the “opposite side” to the White teachers who had been there for a long time. At Greenway, there were many different programs going on at once, with large numbers of new teachers in the building each year. It appeared to be very difficult to build any cohesion between the staff. The student population was in a constant state of flux as well, giving the visitor the impression that everything was constantly changing, and there was little chance of stability. I visited Greenway for a few hours in 1996 and spoke at length to one teacher who had been there for a number of years, but who was resigning at the end of 1996. She confirmed that impressions of disorganisation and confusion were a correct evaluation of the day-to-day situation at Greenway.

At the other end of the spectrum was Draper, where the school culture was founded on stability and there was a great degree of cohesion amongst staff. The principal was very supportive of staff, and this school had a very orderly appearance. Students seemed to know that staff supported them and had high expectations of them. This contrasted sharply with the disorder and restlessness felt at both Greenway and Obern.

Summary: How Cultural Issues Influenced the Implementation of the CEMC

There were certain cultural dimensions that appeared to hinder some teachers and not others in their efforts to implement the goals of the CEMC. Why this was the case is very difficult to determine because of the complexity of influences operating in the classroom, and the short time spent in each of these schools. A disorganised, unruly atmosphere at a school, with poor parental support and low teacher expectations (like that at Obern and Greenway) appeared to be associated with some teachers having difficulty implementing reform. In contrast, an organised, stable, and disciplined atmosphere, with high teacher expectations (like that at Draper) appeared to be conducive to reform.

POLITICAL

The political dimension encompasses issues that are concerned with power, authority, influence and the resolution of conflicts. In this study, there were three major aspects of the political dimension: support from the principal, teachers' control over the curriculum, and the mandatory proficiency tests for all eighth grade students.

Principal Support

In all schools that took part in the SSI, there had already been some degree of principal support. Without the support of the principal for the change process, none of the teachers would have been able to participate in the SSI. This was because of the requirement for six days of release time during the following academic year. The principal was the person with the power to permit or prevent the teacher from being involved in the SSI. The degree to which the principal further supported the changes teachers were trying to implement varied greatly even across the seven sites visited as part of this study—from unconditional support for any changes through to active discouragement of change. Ms Shortland at Lakeview had wanted to go to the SSI summer institutes for a number of years before the principal had finally given his support. She felt that this new-found support was due to a new superintendent in their school district who had been involved with the SSI as an advisor prior to her appointment as superintendent. The principal was keen to be seen by the new superintendent as supporting change in his school.

The principal's degree of support for teachers in the years following their involvement with a reform also influenced the extent to which reformed teaching practices were implemented. For example, although the principal at Lakeview had supported Ms Shortland's request to attend the institute, he was not very supportive of her innovative instructional practices.

- S: My principal supports my innovative instructional practices, seldom and very important. Like I was telling you at lunch time he doesn't like, this it's not structured enough. It's like I told him I said we're are going to go out and shoot free throws. We'll be outside for approximately fifteen minutes. He was like "O.K." and rolled his eyes. You know it's just like you know he doesn't like it, but he really is getting better, he really is. He's been so much better.
- I: Is that due to the new superintendent?
- S: She's very supportive and he knows that and when you're in that position, you do what they, what ever's popular at the top, so he's turned around a lot.

Suzanne Shortland, 5/9/96

However, Ms Shortland did feel supported by the assistant principal, and could see that, when the principal retired in a year or so, the assistant principal would be the most likely replacement. She was "hanging on" until then.

In contrast to the situation at Lakeview, Ms Eckland at Draper felt that the support of the principal was one of the main factors that helped her take risks with new teaching practices.

Having [the principal] as supportive as he is makes it possible for me to do inquiry type activities because it eliminates a lot of the behavior problems that you would run into otherwise. Or it reduces them at least. It makes them less serious. So you have—you're a lot more flexible in doing things like that in your classroom, because you know it's supported, and the kids know that it's supported—and so they do what you ask them to do. I did a lot of group activities, but they had to be a lot more structured when I had a less supportive administration. And though they probably would have supported me, they didn't support a lot of the discipline around the building, and the kids pick up on that and just assume that they wouldn't support me either.

Rebecca Eckland, 5/15/95

Some principals were not accustomed to cooperative learning and the noise level it can generate in the classroom:

That was one thing that my principal had a hard time getting accustomed to was the noise level, because he is very straight, very quiet, this is the way it is. But he has adjusted real well.

Kathy Straub, May 1995

There were two schools whose principals were former mathematics or science teachers. Troy's principal was a former science teacher who had been involved with Biological Sciences Curriculum Study (BSCS), an inquiry-based

science program that was very popular some years before. He stressed how much he valued the inquiry approach above rote memorisation. He did, however, acknowledge that inquiry approaches might take longer to get to the same end in terms of knowledge. He was very supportive of his staff participating in the SSI. In contrast to this was the principal at Kingsland, a former mathematics teacher, who had very definite ideas about the order and content of the curriculum—and was “shocked” (when she visited Ms Young’s class) to find that Ms Young “had not done fractions” at that point in the year. She was also critical of the amount of noise generated by the class and thought that Ms Young could not control the class, and therefore should not be doing group work.

In summary, the issue of principal support emerged as a crucial one. Looking across all of the sites, the two sites that were most successful in terms of creating the equitable connected mathematics classroom were those with the very supportive principals. The principals of both Draper and Troy were regarded by the staff as strong leaders, well respected by the school community, and very proactive in encouraging all types of reforms in their schools. Teachers at these schools spoke of the strong support they and their colleagues felt from their principal. This was not evident at any other sites, although not all of the other principals showed as little support as those at Kingsford and Lakeview. Even with the lack of support at these latter two schools, however, both teachers managed to implement some reformed teaching practices; therefore lack of principal support does not necessarily prevent teachers from engaging with change, but appears to make this process much more difficult.

Teacher’s Control Over the Curriculum

The mathematics curriculum in Ohio was very tightly prescribed and controlled at the state and district level. Troy and Greenway were both located in a large urban-area district, where the content and order of everything that was taught in all schools in the district was determined at the district level. Barb Zoran described the way the curriculum was controlled by the school district.

The district has a course of study set up for each grade level. The pupil performance objectives are listed, those that are going to be tested on the proficiency test are listed. And it’s my responsibility to make sure that I cover all the objectives that are for my grade level. And they also determine through the math department from the supervisor, the order in which the topics will be taught because we are going to be having interim tests each marking period that will come from downtown to make sure that everybody’s covering the things that need to be covered.

Barb Zoran, 5/15/96

Teachers working in such districts had very little freedom to change their curriculum. Ms Zoran made use of cooperative group learning most of the time, used a lot of different worksheets and did not rigidly follow a particular text book. Her curriculum focus was on covering the mandated objectives.

For Ms Eckland at Draper on the other hand, the district did not have strict requirements regarding sequence of the curriculum. She said that because she was the only eighth-grade mathematics teacher at her school, she could select her own curriculum content and sequence, although she did have to make sure that she covered the content that would be tested in the proficiency test. It seemed as though the curriculum content was not negotiable, and that she regarded choosing a curriculum as equivalent to choosing the order in which to teach a fixed curriculum.

Overall, none of the teachers interviewed in this study had much regard for the power of the curriculum in producing and maintaining inequities, although there was variation in the degree of curriculum control across the schools visited. This lack of awareness of the power of the choice of the content, scope and sequencing of the curriculum may have been because the SSI was focused on pedagogy and content knowledge and not curriculum issues. But whatever the cause, only three of the seven teachers interviewed talked about using contexts that appealed to students' backgrounds or said that they were trying to connect school mathematics to students' experiences, a very important component in creating an CEMC. Four of the teachers did demonstrate some willingness to try to relate what they were teaching to the "real world", which is another important aspect of the CEMC. It seemed as though teachers rarely questioned the content of their curriculum. This could be partly attributed to the lack of control over the curriculum that many teachers faced. Even when teachers said they had a reasonable degree of autonomy in deciding curriculum-related issues, there was always the specter of the Ohio Proficiency Test hanging over their head. This issue surfaced in all sites and is discussed next.

Proficiency Tests

In the state of Ohio, all students are required to pass The Ninth Grade Ohio Proficiency Tests in reading, writing, citizenship, science and mathematics before they can be granted a high school graduation certificate. Great emphasis is put on these tests, as would be expected for such a high-stakes test. Students usually begin taking these tests in eighth grade, and must continue to take them until they have passed. This means that some students are still trying to pass the

ninth grade tests in twelfth grade, or beyond if necessary. [For example in 1996, approximately 1 500 out of a ninth-grade cohort of 116 000 students had not passed the mathematics proficiency test by the end of twelfth grade (Ohio Department of Education, May 1997)]. Importantly, the tests are also “high-stakes” in other ways than in terms of students’ high school graduation because they are used also to monitor schools and teachers.

About the same time [as the first eighth graders took the proficiency test], it filtered through, that one of the school districts, they are tracking kids who are deficient and if there is the pattern of the same teachers, those teachers are going to be gone. Well, this kid may just be, somebody who is doing nothing, and that is not fair. And that is another—you know, here you go again, are you going to have a job, are you not going to have a job, is it really going to be done that way?

Kathy Straub, May 1995

In all of the schools visited as part of *The Landscape Study*, teachers talked about the pressure put on them from principals, superintendents and other administrators in their school districts to improve their proficiency scores. Two teachers talked about this pressure.

R: Having the proficiency tests taken in the eighth grade [has made a big difference to the way I teach now.] There’s a lot more pressure on us to be teaching to the proficiency tests in the eighth grade.

I: Who puts the pressure on?

R: It’s still downtown administration. Indirect—it’s very indirect, but they... “You’ve got to be doing this, and you’ve got to be doing this, and we’ve got to get those test scores up, and if they aren’t up then it’s your fault...” (imitating) It’s not anything—they’re not coming out and saying, “You’ve got to teach it **this** way...” (imitating), but if you don’t teach it that way and the kids fail the proficiency test the first time around, then there’s just the feeling that they’re going to come back around and say, “Hey, you should have been doing **this**.” (imitating)

Rebecca Eckland, 5/16/95

I: You’ve talked about the power of the proficiency exam, do you want to talk about that a little bit.

K: Well, you know, this is the first year we’ve given the proficiency test in the eighth grade. And the amount of pressure that came to get these kids to pass this proficiency test was phenomenal. And I didn’t realise it until after it was over, and I could go phewww. Because we are a deficient school. And that is another pressure. Um, what was the question?

I: We were talking about the power of the proficiency exam.

K: Um, it was, stop and teach for about a month, for the proficiency.

I: Now, this sort of mandate came from?

K: Administration

I: From the principal level or above that?

K: Both.

Kathy Straub, May 1995

Teachers reported spending up to two months of teaching time doing almost nothing else but preparing students for the proficiency tests, as indicated in these comments of Ms Shortland at Lakeview.

... close to the time of the proficiency test, starting like in January—we take [the proficiency test in] the first part of March—[the administration] want to know and they ask a lot ‘What are you going to do to prepare for proficiency?’ So we really lose two months of teaching preparing them for the proficiency test and that’s what they want you to do, drill and practice for two months, and I just hate that.

Suzanne Shortland, 5/9/96

Some teachers also drilled their students on how to take standardised tests, as indicated by Ms Dante at Obern.

This year I spent the month of February going over how to take a standardised test, how to read the questions, what the questions are asking, strategies for how to answer the questions, way that they try to trick you by moving decimal points, not putting square units in for area, that kind of stuff. We talked about that, we actually practiced taking standardised tests and time limits, they learned to pace themselves.

Patricia Dante, 5/10/96

The influence of the proficiency tests did not stop there. Throughout the whole school year, teachers structured their day’s work around proficiency-test practice. There were a number of books available, such as one by Bassett and Arnold (1993), which focused on test-taking and problem-solving skills. Ms Straub at Naylor indicated how she included proficiency practice in her daily schedule.

Well everyday, on the side board there are three problems that are typical of problems that they will face on the proficiency exam. And they are taken from proficiency books or algebra books, or whatever. And they have to write them out, work them and then I give them double credit at the end of the quarter.

Kathy Straub, May 1995

The principal from Greenway was also very firm in her belief that the curriculum must match the proficiency test.

Basically in the state of Ohio we have proficiency tests and everything that we as public educators that’s what we must do. We must drive our curriculum to match that, what Ohio is saying our children need in order for them to be proficient. Regardless of any other curricular thoughts or ideas, those are negated simply because this is what our state that we live in says that we need from the ones that we’ve elected to represent us and what have you. Then we must drive our curriculum to meet those needs and to meet those objectives.

Greenway principal, May 1995

Other teachers talked of changing their preferred order of topics, leaving some things that would not be tested in the proficiency test until after the students had taken the test.

Some teachers liked having the proficiency tests because they were “forced to move along, not be in a rut...and it forces you to cover every area” (Barb Zoran, 5/15/96). Ms Zoran was accustomed to following a set curriculum in a set order and did not see anything wrong with a little bit of extra encouragement in the form of having to meet deadlines for the proficiency test.

Some teachers and principals also believed that inquiry teaching methods help to increase student understanding and, as a result, help to increase proficiency test scores.

[Our] proficiency scores as a result of using more hands-on more peer to peer helping have increased. Our scores went from, I think we had a 7% passing rate in math and it jumped up to 13% which is not great, but, it's almost double. And I didn't think it was that terrific until somebody from the district approached me and said 'what did you do in your building that made your scores go up that high? Everybody else's went down or stayed the same.' And we decided that it was because of using inquiry methods of having a proficiency class where the kids got some extra help using the computer lab, things like that, so that's helped the scores and I hope they're even higher this year.

Barb Zoran, 5/15/96

This is why initiatives like Discovery is so important to help us get where we need to go in driving that curriculum as well as assessing our students and see what they need to know and how much do they actually know.

Greenway principal, May 1995

This belief in the use of inquiry teaching as a way to improve proficiency scores was not shared by all teachers however. Some believed that inquiry teaching, although it resulted in greater understanding of concepts, was too time consuming and therefore should not be used when preparing for the proficiency tests. These teachers went back to lecturing, drill and practice, or rote memorisation techniques.

I find that I don't do inquiry things [before the proficiency tests] because they take so long for the kids to get anywhere with and I wouldn't even, there are a lot of kids that can pick things up with the lecture so I figure that I'm benefiting more of the kids with the lecture than I am without, though the depth of their understanding is probably not as good. They'll probably do better on the proficiency test which is what they want downtown.

Rebecca Eckland, 5/15/95

It appeared that the main barrier preventing teachers from using inquiry teaching methods when preparing their students for proficiency tests was their belief that inquiry methods were too time consuming. Related to this was

perceived pressure from school and district administrators who were also not fully convinced of the benefits of inquiry methods. Unfortunately the proficiency test scores were not made available to *The Landscape Study*; so it is not possible to compare SSI and Non-SSI teachers in terms of their students' proficiency test scores. However, analysis of data from the achievement test given as part of *The Landscape Study* (MDIT), presented in Chapter Five of this thesis, clearly showed that students in SSI classes scored significantly higher than students in Non-SSI classes on this test. This advantage was greatest for females, indicating that using inquiry methods appears to be associated with greater student understanding. Convincing administrators of the effectiveness of inquiry teaching remains a challenge for reformers, one that will be addressed in the next chapter of this thesis.

Summary: How Political Issues Influenced the Implementation of the CEMC

Political issues remain an important influence in the process of reform toward the CEMC. Principals have the power to block teachers from participating at all, and even when teachers do participate, principals can work against the reform at the school level through subtle and not-so-subtle means. State-wide mandated testing is also a powerful influence on classroom activities. District and school administrators who are not convinced of the efficacy of inquiry teaching in preparing students for proficiency tests can bring considerable pressure to bear on teachers to “teach the proficiency skills”, usually through drill and practice. Through the use of state-wide mandated testing, and in some cases district-level mandated testing as well, most teachers perceive that they have little control over the content, and sometimes the order, in which they teach prescribed curriculum content. This implication of this is that very few teachers recognise the power of the curriculum as a whole in maintaining the hegemony of mathematics.

MORAL

Moral issues identified through the cross-site analysis are those issues which are concerned with justice and fairness, both of which require some judgment on the part of the researcher. The two moral issues identified were tracking—the practice of providing differentiated curricula based on past performance—and encouraging change without providing sufficient resources to effect the change, both of which are issues of fairness.

Tracking

As discussed in Chapter Two, tracking has been shown to be a discriminatory practice that denies students the chance to fully participate in the scientific pipeline (Oakes, 1990; 1992). As the decision to track students is usually a school-policy level decision, it is not really an issue that the classroom teacher has any control over. All but one of the teachers visited in *The Landscape Study* spoke about some form of tracking or streaming at their school, often only in mathematics classes, but sometimes across several subjects by grouping the brightest students into one family for all core subjects. Ms Dante for example thought that it was better (in terms of discipline) to keep the brightest students involved and interested by moving from one topic to another at a fast pace. She did not wait for every student to fully understand a concept, but instead moved on to the next topic when about 75% of her students had a reasonable grasp of things. Sometimes the tracking was formal, with *Pre-Algebra* and *Algebra* classes in seventh and eighth grade. In other cases it was more informal or implicit in the way the curriculum was structured. At Obern for example, the most able students were grouped together into one grade-seven-and-eight family, and these students studied foreign language and advanced music programs which the other families did not.

The issue of tracking was not a focus for *The Landscape Study*, since as previously mentioned, it is an issue normally outside the control of classroom teachers. One thing that can be concluded is that the practice was evident to some degree at all seven sites visited, with teachers being generally in favour of it—no teacher mentioned that they were not in favour of tracking. In some schools, the practice was not “named” as such, and the practice of placing students in ability groups to study different mathematics courses was not seen as “tracking”. Most of the schools offered an advanced mathematics class—Pre Algebra or Algebra I, depending on the grade level. Students were selected for these courses on the basis of the results of an entrance test or teacher recommendation based on their previous performance—students were not able to choose for themselves. Whatever you call it, the practice of differentiating curriculum based on ability is a form of tracking, and, as shown by Oakes et al (1990, 1992), can lead to some students being inequitably treated.

The moral issue of inequitable treatment based on placement into a remedial class which receives a much watered-down mathematics curriculum appeared to warrant much greater attention at Draper, where funds for what was

known as “*Chapter 1*” classes were provided to the school based on the number of *Chapter 1* students enrolled. At Draper in 1996, there was enough funding to employ a full-time teacher’s aide. This person assisted in all of the *Chapter 1* classes, and also helped Ms Eckland in her other classes when she was available. All of Ms Eckland’s classes were tracked, and these included *Algebra 1*, *Pre Algebra*, *General Math* and *Chapter 1*. The level of work and general atmosphere in the *Chapter 1* class was very poor. The students were nearly all African American, and attendance was often low, with almost half the class absent every day of both of my visits in 1995 and 1996. The school did not mention that they had considered integrating these students into the *General Math* classes and having the teacher aide work more closely with them. This might have been much better for the self esteem of these students, which was very low—a point which I particularly noted during the time I spent interacting with them in their classes (I was present for three days on both visits and had a good opportunity to absorb the atmosphere). Mathematics was the only subject in which this happened—students were in mixed ability groupings for all other core subjects. However, Ms Eckland was convinced that Draper’s current practice of tracking was best for the students who were taking *Algebra 1* and *Pre Algebra*. She was just as convinced that her *Chapter 1* students would never pass the proficiency test, no matter what she did. She had not considered that placing her *Chapter 1* students into *General Math* classes, with the aide to assist, might have been more equitable for those students.

Financial Resources to Support Reform

As Apple (1992; 1995) and Tate (1995a) have pointed out, the issue of “fiscal equity for urban schools is one of the United State’s most critical dilemmas” (Tate, 1995, p.195). Is it moral to expect change without providing sufficient resources to facilitate that change? The NCTM standards and the implementation of inquiry teaching advocated by the SSI call for a radically different type of mathematics, requiring additional resources and smaller classes. In some of the institutes, participants were provided with a small range of mathematical equipment, thereby overcoming a potential problem of not having enough mathematical equipment to facilitate the hands-on activities that were so much a part of the process of inquiry teaching promoted by the SSI. At least these teachers had a collection of equipment to enable them to immediately incorporate hands-on activities. This was an important feature of involvement with the SSI, without which implementing desired changes would have been much more difficult for many teachers.

At the school level, the biggest resource issue facing most schools was that of providing computers and software. Students from those schools that could afford to provide these resources would appear to have an advantage over those students from schools that are unable to provide these opportunities. The NCTM documents advocate extensive use of calculator and computer technology, although do not address the financial issues of resourcing. Powerful visual graphics and an ability to interact with the software to investigate various mathematical phenomena changes the way students learn mathematics—students are able to construct their own understanding through investigating a concept in a way that would be impossible without a computer. There are much cheaper alternatives than a desktop computer now readily available. The latest graphics calculators, such as the Texas Instruments TI-92; which has a symbolic manipulation package, a version of Cabri Geometry, and full graphics facilities for drawing and manipulating functions of all types, are making the prospect of integrating mathematics software into their teaching much more real. These new calculators have a full suite of mathematics software which is more than sufficient to handle all mathematics traditionally taught in middle and high school. One of the main advantages of these calculators is that they are relatively (compared to a desk-top computer) inexpensive, and they are also readily portable. Providing this type of technology is much more affordable for schools, although it should be noted that at most schools visited during this study even the most basic four-function calculator was not readily available to most students. Although the cost of graphics calculators has decreased significantly, it seemed that even basic calculators were out of reach of many schools and their students. And there were other issues associated with using technology in the classroom—such as those of professional development and textbooks that incorporate the use of graphics calculators—which would need to be addressed before teachers who were part of this study could fully implement advanced mathematical software and technology in their classroom.

Summary: How Moral Issues Affected the Implementation of the CEMC

Issues of justice and fairness identified as moral issues in this cross-site analysis have impacted on the creation of the CEMC. Tracking is one issue that was practised in varying degrees at most sites visited as part of this study, and while seven is not a representative sample of classrooms across the state, this small number gives an indication that in mathematics, tracking is still commonplace. Providing a challenging curriculum for all students was a major goal of the SSI

and the CEMC, and tracking has been shown overall to work against this. Therefore, tracking should be seen as a barrier to implementing a CEMC. However, as previously mentioned, tracking is an issue usually outside the control of one classroom teacher; so the focus for change should be on those with the power to change these practices, namely district and school administrators.

The SSI anticipated that many teachers would not be able to purchase mathematics equipment to support the reformed teaching practices advocated by the SSI; so the teachers were provided with a small amount of equipment from the SSI funds. The provision of this equipment was essential for some teachers to be able to start the process of reform. Funding issues appeared to have prevented many schools from being able to afford computers; however some schools overcame this by seeking sponsorship from local businesses. Basic calculators were not evident in many classroom visited as part of this study; so it is difficult to imagine how teachers are going to implement the NCTM reform goals which advocate the widespread use of technology.

WHAT'S MISSING: PERSONAL PHILOSOPHIES OF TEACHING

In so many of the issues that have surfaced in the cross-site analysis, the underlying reason behind whether or not teachers have implemented measures to ensure a Connected Equitable Mathematics Classroom can be attributed to their personal philosophy of teaching, their personal sense of what is fair and equitable treatment, and their care and concern for their students' well-being. It is more than an issue of a person's morality, because in some senses it could be quite possible to have high moral standards without really "caring". Teachers who genuinely cared about their students demonstrated this in their every action, and students commented on this in the interviews. Both Ms Zoran and Ms Eckland were very caring and concerned for their students' well being. This is not to say that the other teachers did not care about their students, but that there was something extra that these two teachers had that the others did not. It was a sense of respect for the students as people, as human beings like themselves, that the students really connected with, and this is what really made the difference to the atmosphere in their classes, and their whole approach to teaching.

Teachers like Ms Zoran, Ms Eckland and Ms Shortland appeared to have implemented many new teaching practices predominantly because they thought these strategies would improve their students' understanding and learning. All three of them seemed convinced that inquiry teaching was a better way to teach

because, from their experiences, it enhanced student understanding and enjoyment of mathematics. The students' lack of motivation was not an issue for these teachers. They wanted to make their classes as interesting and valuable for their students as they possibly could, and inquiry teaching made that goal possible. The absence of sufficient resources, a supportive principal, an accessible network of other SSI teachers, parent support or control over the curriculum did not necessarily prevent them from trying to create an equitable classroom, although the presence of these elements could certainly enhance this outcome.

With so many interactions and factors affecting what happens in a classroom, it is impossible to say exactly what combination of elements are essential to create the equitable classroom. However, one thing that was common to all three of the teachers who created the most elements of the connected equitable classroom was the caring way in which they approached all of their teaching and student interactions. It is significant, in terms of the theories underpinning this study, that this aspect was not addressed in the Rossman framework. How to enhance these characteristics in every teacher is a challenge for those trying to effect school mathematics reform and will be discussed in the final chapter of this thesis, along with suggested modifications to and elaboration of the Rossman framework.

CHAPTER EIGHT

SUMMARY, IMPLICATIONS AND CHALLENGES FOR THE FUTURE

INTRODUCTION

The overall aim of this study was to explore how equity and reform goals interact in large-scale reform, and to determine ways of ensuring that equity goals do not get lost in large-scale reform. Focusing specifically on gender equity, the study had three main objectives. The first was to distill a definition of the ideal equitable mathematics classroom from a synthesis of the literature concerning both explanations as to why inequities have existed and interventions designed to make outcomes more equitable. The second was to take a particular example of reform, namely the Ohio SSI, and examine the extent to which mathematics teachers in Ohio had engaged with the reformed teaching practices advocated by the SSI aimed at producing more equitable outcomes for all students. The third was to develop an understanding of the facilitators and barriers mathematics teachers faced when implementing the reformed, more equitable teaching practices in their classrooms; thus shedding light on the equity/reform relationship and on ways of ensuring equity does not get lost in the reform process.

This chapter summarises the outcomes and implications of this study in relation to each objective, then proposes some hypotheses to explain the findings of the study, and then finally discusses the challenges and implications for various groups associated with research and practice. It will be seen that the significance of this study lies in the linking of equity and reform goals to produce

- a framework (the CEMC) for judging the success of reforms in meeting gender equity goals in the mathematics classroom derived from research based on multiple perspectives;
- a number of factors associated with implementing reform in mathematics classrooms, obtained through a cross-site analysis of a range of qualitative and quantitative data utilising the Willis (1996) and Rossman (1993) models and acknowledging the importance of taking into account the social and cultural positioning of those involved;

- the elaboration of a range of challenges for researchers, equity advocates, reformers and practitioners.

OBJECTIVE ONE: OVERVIEW AND IMPLICATIONS

The first objective of this study was to establish a detailed operational definition of equitable teaching and assessment practices in mathematics. This objective was accomplished through the analysis and synthesis of the literature concerning explanations for inequitable outcomes, and initiatives designed to improve inequitable outcomes. The review first examined a number of theoretical frameworks which proposed that there are different perspectives on equity, and, depending on the perspective, different explanations and solutions offered. The framework chosen for the review conducted for this study was that of Willis (1996) which was developed specifically to enhance understanding of the relationship between social justice and the mathematics curriculum. This framework categorised equity problems and solutions as emanating from four perspectives: Remedial, Non-discriminatory, Inclusive or Socially Critical.

Chapter Two presented the first part of the literature review. Studies were reviewed in relation to their focus, for providing an explanation for gender differences—the student, the teacher or the curriculum. Student-related explanations included a focus on differences in students' affective characteristics, spatial abilities, and developmental paths. Teacher-related explanations included a focus on teacher attributions and expectations, learning environments, the use of language in relation to stereotypes, and the use of different types of assessment tasks. Curriculum-related explanations focused on differences in students' curriculum experiences and mathematics backgrounds, emphasising issues related to (a) curriculum structure and its implication for limiting students' access to challenging mathematics curricula; and (b) curriculum content, associated with the value placed on the learning of mathematics, challenges to the social order through a redefined mathematics curriculum, and making the study of mathematics more relevant to current trends in the workplace.

The second part of the literature review was presented in Chapter Three, where initiatives designed to address gender-based inequities in mathematics education were reviewed. This review was also structured in three parts, mirroring the Willis (1996) framework. The first part examined initiatives designed to change students' choices, to encourage them to continue with more of the higher-level mathematics courses. It was demonstrated that these interventions tried to

increase enjoyment of or achievement in mathematics, and to raise awareness of the importance of mathematics, or increase students' confidence or motivation so that they would be more likely to continue with higher-level mathematics courses. The second part examined those interventions which were focused on changing the learning environment in some way, either by changing the pedagogy or the assessment methods. Given that the major focus of the NCTM reforms was on changing teaching practices, a discussion of these reforms is presented here. The third section of this part of the literature review examined those projects that had attempted to change the curriculum as a whole to make it more gender inclusive. Projects were reviewed by country—Australia, the United Kingdom and the United States—because of large differences in education systems.

The culmination of this lengthy literature review was a definition of an “ideal” mathematics classroom, named the Connected Equitable Mathematics Classroom (CEMC). This definition outlined what elements, given the current state of knowledge as revealed by research and practice, appeared to be essential in order to move towards an ideal CEMC. It presented characteristics which were focused on *students*, *teachers*, and the *curriculum*.

The focus on *students* included ensuring that all students have access to academically-challenging curricula, develop confidence and positive attitudes towards mathematics, develop basic mathematical computational skills so as to be numerate (mathematically literate) and able to use mathematics in their daily lives where appropriate.

The focus on *teachers* included ensuring that teachers develop student voice through negotiating meaning with the teacher and other students; have high expectations for all of their students; provide students with knowledge of careers which require a range of mathematical backgrounds; connect mathematics to the real world through use of contexts that have personal meaning to students; recognise and act on inequities in their classroom; and use a variety of teaching and assessment practices.

The focus on the *curriculum* included using non-stereotypical language; acknowledging the contributions of women to the history of mathematics; using real-world problems set in a variety of contexts that value and take into account the range of student backgrounds and experiences; focusing on social justice and ecology issues, possibly including some element of social action by students; and explicitly stating equity goals.

This definition of the CEMC was fundamental to this study in two ways. First, it was noted that many aspects of the CEMC had been embedded in *Project*

Discovery, the Ohio SSI which provided the focus for the empirical part of the study. Second, the definition developed here provided the basis for the data analyses undertaken in this study.

OBJECTIVE TWO: IMPLICATIONS AND EMERGING THEMES

The second objective of this study was to determine the extent to which reformed and equitable teaching and assessment practices were practised in mathematics classrooms in Ohio in the years immediately following the implementation of the SSI. This objective was accomplished by synthesising the results of the analysis of the wide range of quantitative and qualitative data collected as part of *The Landscape Study*, specifically using data from questionnaires administered to a random sample of teachers and students, and data gathered during site visits,

Summary Of Significant Findings

Quantitative Results

Some of the analyses provided comparisons between SSI and Non-SSI teachers. From the results of the LTQ factor analysis detailed in Chapter Five, it was apparent that teachers who had participated in the SSI reported their classroom practices and their views about mathematics quite differently to their Non-SSI counterparts.

In comparison to Non-SSI teachers, SSI teachers reported that they used certain reformed teaching practices more frequently, and agreed more with statements that represented mathematics as subjective, open to changes, subject to disagreement among experts, and continually being refined. There were no differences between SSI and Non-SSI teachers in their reporting of the frequency of parental and principal support behaviours.

For all of the Importance scales responses about teacher and student behaviours, principal support, parent support, and views about the nature of mathematics, SSI teachers reported that they valued these practices more than did Non-SSI teachers.

Some important differences between SSI and Non-SSI teachers were found in the responses to individual items on the LTQ that were concerned with aspects of the Connected Equitable Mathematics Classroom. SSI teachers reported actively engaging students in the learning process, extending students' thinking, and using a variety of teaching and assessment practices much more

frequently than their Non-SSI counterparts. All of these aspects were part of the focus of the SSI institutes and follow-up academic year workshops, as mentioned in Chapter One.

One area where there seemed to be little difference between SSI and Non-SSI teachers was in responses to “frequency” items concerned with connecting students to the mathematics being learned: through using real-world contexts for problems, talking about how mathematics is used by mathematicians or using contexts that students can relate to in some way. On only two of these items—arranging field trips to museums and discussing experiments from the history of mathematics—did the SSI teachers report more frequent occurrence than their Non-SSI counterparts. However, SSI teachers attached a greater level of “importance” to these things happening in their classes than did their Non-SSI counterparts, both on the previously mentioned two items, and also for discussing the work of mathematicians and using data to justify responses to questions. These aspects are all concerned with curriculum issues, or, in terms of Willis framework, emanate from the Inclusive perspective. It seems that overall, SSI and Non-SSI teachers held quite similar views about the content, scope and sequence of the curriculum. This could be explained in terms of the SSI focus being on teacher content and pedagogical knowledge and not curriculum issues. Curriculum development was deliberately not part of the SSI. Another explanation, as discussed in Chapter Seven, could focus on the perceived pressure to teach the proficiency test content, and the tightly prescribed curriculum documents teachers were expected to adhere to in most school districts.

Principal support was another area where comparisons were made between SSI and Non-SSI teachers. Given that some initial principal support was necessary before teachers could participate in the SSI, it might have been expected that there would be differences on the principal-support sub scale. However, analysis showed that SSI and Non-SSI teachers were quite similar in their reporting of the frequency of principal support, although there were a number of individual items on which SSI teachers reported significantly higher frequencies of occurrence than their Non-SSI counterparts. These were concerned with the principal accepting noise associated with an active classroom and supporting innovative instructional practices.

Perceived levels of parent support were also compared. Again, it was found that, although the overall results for the parent-support factor showed no differences between SSI and Non-SSI teachers, there were a few individual items concerned with parents support for reformed teaching and assessment practices

and different types of homework where there were differences between SSI and Non-SSI teachers. SSI teachers reported higher frequencies of parent support for different types of homework and much higher ratings for the importance of parent support for different types of homework. There was no difference between SSI and Non-SSI teachers however in terms of the way they perceived the frequency of parent support for innovative teaching practices and only a moderate effect size for the perceived importance of parent support for innovative teaching practices. While these findings may be unrelated to participation in the SSI, it is noteworthy that there was a component of parent and public education in conjunction with the SSI program. It could be, however, that SSI teachers, because they had volunteered to participate, were generally more committed to teaching and, as a result, more involved with parents.

Data gathered from students also informed the overall analysis. For the student questionnaire data, students in SSI and Non-SSI classes reported the same levels of frequency of occurrence for all teaching practices and socio-cultural influences, except for negative peer influences and attitudes. In both SSI and Non-SSI classes, Males and Whites reported more negative peer influences, and Males and African Americans reported more positive attitudes to mathematics.

For student achievement data obtained from the Mathematics Discovery Inquiry Test (MDIT), there were no interaction effects related to SSI participation; however there were significant main effects for sex, race and group: males scored significantly higher than females, Whites scored significantly higher than African Americans, and SSI students scored significantly higher than Non-SSI students. The sub-group analysis pointed to females, particularly African American females, in SSI classes scoring significantly higher than their Non-SSI counterparts, and indicated that females were closing the achievement gap with males in SSI classes.

Qualitative analysis

In Chapter Six, the background and context of each site visited during this study were described and analysed. The analysis was facilitated through the use of the computer software package NUD•IST. Each transcript was read and coded using codes derived from the definition of The Connected Equitable Classroom described in Chapter Three. This analysis established that all of the seven teachers visited had engaged with reformed teaching and assessment practices to some degree. Nearly all of the seven appeared to hold Non-Discriminatory (Willis, 1996) views of the mathematics curriculum, in that they saw the content of the

curriculum as fixed, but the pedagogy associated with that content as not fixed. Only one of the seven teachers interviewed or observed at the site visits indicated that she was aware of the implications of changing the content and scope of the curriculum, as well as the way it was taught, for improving student outcomes. Generally, the students interviewed enjoyed the inquiry style of teaching and learning where they had experienced it.

Issues Emerging from Objective Two

The analysis of both the quantitative and qualitative data presented here provides evidence for the conclusion that the reforms suggested by the SSI have been adopted by participants. Evidence for this conclusion comes from a number of sources. First, there were differences between SSI and Non-SSI teachers in the way they reported some of their teaching practices, and how important these reformed practices were perceived to be. These differences were most notable on the two scales about teaching practices and views of mathematics which were concerned with aspects of teaching over which the teachers had personal control: personal teaching style and views about mathematics.

Second, there were significant differences in achievement on the MDIT in favour of SSI students, and these differences were largest for African American and White females.

Third, there was considerable evidence from the classroom observations, teacher, student and principal interviews, that nearly all SSI teachers visited during site visits had implemented some elements of the CEMC since their involvement in the SSI.

However, the analysis of the LSQ data, did not support this hypothesis. In relation to this finding, three alternative explanations are presented here. First, there was the students' apparent difficulty in describing their experiences in mathematics classes. This became apparent during the student interviews: many students seemed to be unable to talk about what went on in their classes without a great deal of probing from the interviewer. This could have been because it was probably an unusual occurrence for middle-grade students to be asked to reflect on and remember what had occurred in their classes throughout the preceding year.

Second, the questionnaire items may not have been sensitive enough to detect differences in students' responses [although this was not the case for the analysis of the science students (Tims Goodell et al., 1997)].

Third, what happened in SSI classes may have been very similar to what happened in Non-SSI classes. This could have been due to two factors. First, given that the NCTM standards had been in existence for three years prior to the first SSI institutes, it is possible that there had been some reform in Ohio mathematics classes. Second, it is possible that the proficiency test so influenced what happened in mathematics classes, that there was very little difference between SSI and Non-SSI classes. This latter issue will be discussed further in the section concerning the outcomes of the cross-site analysis which will be presented next.

OBJECTIVE THREE: OVERVIEW OF EMERGING KEY ELEMENTS

The third objective of this study was to conduct a cross-site analysis of the seven case study classroom contexts. The computer software package NUD•IST was utilised again. The transcripts were re-read and re-coded, this time with codes that emerged from the data categorised as Technical, Cultural, Political or Moral according to the Rossman (1993) dimensions. From a synthesis of the similarities and differences across sites, an understanding of the facilitators and barriers to achieving equity in reforming mathematics classrooms was developed.

Key Elements Identified in Both Quantitative and Qualitative Analysis

The cross-site analysis pointed to a number of critical elements that were necessary to facilitate reform in the classrooms observed. Two of these elements provided further support for two of the themes identified from the quantitative analysis discussed previously.

First was the professional development experience itself. Many of the teachers interviewed thought that their experience with the SSI had enabled them to change not only their teaching practices, but also the way they thought about teaching. The perception of most teachers interviewed was that, without that experience, it would have been unlikely for them to have been able to make those changes. This finding supported the findings of the quantitative analysis showing that the Ohio SSI was associated with teachers adopting reformed teaching practices.

The second element identified in both the quantitative and qualitative data analysis was related to the influence of the proficiency test in determining not only what content was taught, but how it was taught. Interview data would suggest that many SSI teachers did not use inquiry teaching methods when doing

concentrated proficiency-test preparation because they did not believe that inquiry teaching would lead to better prepared students. Although students enjoyed inquiry lessons, and most teachers talked about how their use of an inquiry pedagogy seemed to enhance students' long-term retention of concepts, some teachers felt pressured by district administrators to resort to drill and practice methods when preparing for proficiency tests.

From the quantitative data analysis, it is noteworthy that the results of the LSQ and MDIT attitudinal factor analysis for mathematics classes contrast sharply to those for science classes in *The Landscape Study*. As discussed in Chapter One, all factors identified in the LSQ and SDIT (Science Discovery Inquiry Test) analysis showed a significant main effect for Group (Tims Goodell, et al., 1997). Students in SSI and Non-SSI science classes reported significantly different levels of occurrence of all factors investigated in this study. In contrast, for the mathematics classes there were no significant main effects for Group. SSI and Non-SSI students in mathematics classes reported the same levels of occurrence of all factors identified in the factor analysis. The factors identified by the factor analysis for mathematics and science students data were composed of almost identical items, and were named with the same name because it was felt that they were measuring essentially the same constructs. The fact that the results of the two analyses were so different in this respect (the way SSI and Non-SSI students responded to the same questions) points to a need to examine the differences between the way science and mathematics curricula are implemented in Ohio.

From such a comparison, it emerged that one major difference between the science and mathematics curricula in Ohio was that mathematics students were required to pass an externally-mandated proficiency test in ninth grade in order to graduate from high school, but this was not the case for science in 1995. (A proficiency test was going to be implemented for science in 1996, but teachers were not influenced by this in 1995 when this data was collected.) Another important difference between mathematics and science in Ohio was that, prior to the SSI, there had been a strong reform movement in mathematics education due to the influence of the NCTM standards which were discussed previously. As mentioned in Chapter One, the Ohio Model Curriculum (Ohio Department of Education, Not dated) was based on the NCTM standards and this preceded the SSI by at least two years. Thus, many Ohio mathematics teachers had already begun the process of reforming their teaching practices; therefore, by the time of this study, reformed teaching practices had been introduced in many classrooms,

not just SSI classes, thus lessening the differences between SSI and Non-SSI mathematics teachers. Such was not the case for science, given that The American Association for the Advancement of Science (AAAS) Standards-based reform documents for science education were not in existence until the Ohio SSI had been in operation for some years.

Elements Identified Using the Rossman Dimensions

A number of additional elements were identified through the cross-site analysis using the Rossman dimensions of *Technical*, *Cultural*, *Political* and *Moral*.

The Technical dimension

The first *Technical* element concerned the availability of appropriate classroom teaching resources to support the new pedagogies. For some teachers, a lack of resources did not prevent them from making their classroom equitable and connected. However, for other teachers, it made the process of implementing inquiry lessons a rather arduous task, resulting in a somewhat disjointed approach. During interviews, most SSI teachers reported, and students confirmed, that they had largely dispensed with using text books for most lessons, although for some teachers there was little else available to replace the text. This lack of suitable and available curriculum materials to support the goals of the reform was an issue at a number of sites. For example, Rebecca Eckland enrolled in a program which provided her with access to video-taped model lessons and printed curriculum materials to support these lessons in the classroom. In contrast, Suzanne Shortland, who was dissatisfied with the progress she had made in transforming her teaching to a more inquiry-oriented style in the year since her involvement, relied on modifying existing materials or inventing her own, a task that had been very difficult and time consuming. In the LTQ, overall results for SSI teachers indicated that teachers responded “very important” or “important” to statements about the importance of curriculum materials focused on problem solving and appealing to a diverse student group as ideas for improving student outcomes, indicating that this issue may have been important to many teachers.

The other *Technical* element was the availability of a network of colleagues in the SSI within which teachers could discuss their successes and failures. The electronic network provided by the SSI, *DiscoveryNet*, was especially valuable for those teachers who were the only ones in their school involved with the SSI. Being able to communicate with a similarly placed

colleague who had succeeded with inquiry activities appeared to be one of the most critical elements in encouraging teachers to take risks in their classrooms with new types of teaching methods. The negative consequences of limited inter-teacher communication were demonstrated by the case of Ms Dante at Obern. In terms of SSI-related outcomes, her teaching and assessment methods seemed to be the least reformed of all seven teachers visited during the site visits. Importantly, however, she was not using *DiscoveryNet* at the time of site visit to her classroom and, although many of the other mathematics teachers at her school had been involved with the SSI, there seemed to have been little communication between those teachers. This was possibly due to the structure of the school timetable which allowed no time for department meetings. Thus, unlike many of the other teachers interviewed in this study, Ms Dante's opportunities to discuss her successes and failures after trying new classroom activities were limited.

A third *Technical* element concerned the equity content of the professional development experience. This was illustrated most clearly by Ms Shortland at Lakeview, who mentioned that teachers in her institute were annoyed at the way the equity components of the professional development were handled—they felt that there was too much emphasis on issues that were of no concern in the rural areas where most of these schools were located. It appeared from other information provided by teachers in this study, however, that the equity components of the institutes may nevertheless have had some positive impact on teachers' awareness of equity issues, given that most teachers were aware of potential gender equity problems in their classrooms, although they did not relate how they came to be aware of such potential problems. It should be emphasised here that the SSI experience was not the only professional development experience available for Ohio teachers, and that an awareness of equity issues could have come from a variety of experiences.

The Cultural dimension

Cultural elements which emerged as important at a number of sites seemed to be concerned with aspects of the general atmosphere of the school. The culture of some schools seemed to be quite negative, even threatening for some teachers. At Greenway, the school population, both staff and students, was very transient. The principal appeared to be aware of the problems this caused, but had been unable to do anything about it. The teacher Ms Nando felt constrained in her teaching by the constant absence from school of many of her students. At Obern, Ms Dante said that she wasn't concerned over personal safety, but was aware that

some people were. However, she was afraid to take risks in her teaching for fear of her classes becoming uncontrollable, which many at the school appeared to be. These two teachers were amongst a number of teachers interviewed in this study who expressed their views of students from a Remedial perspective, in that they felt that poor attitudes were the main problem preventing students from maximising their potential, and they blamed the parents for passing on poor attitudes towards school to their children. In addition, some teachers tended to hold expectations of their students which were stereotyped in accordance with their perceptions of the students' background. They had low expectations of what their students were capable of, and as a result did not attempt many inquiry lessons. These cultural aspects seemed to adversely affect these teachers and inhibit their efforts at implementing reformed teaching practices.

There were, however, other examples where teachers were not so greatly influenced by the apparent nature of the school culture. Ms Zoran at Troy for example initiated contact with parents rather than waiting for parents to come to see her. Troy also had a homework hotline that students or their parents could call to check what homework had been given to the class if the student had been absent. The atmosphere of the schools in which teachers had made most progress towards the ideal CEMC—Draper and Troy—appeared to be more stable with a more cohesive staff, and a supportive principal. This was in contrast to those schools where the teachers appeared to have made least progress towards the ideal CEMC—Greenway and Obern—where a general feeling of unrest, disorder and a lack of support was felt by the visitors and teachers alike. This dimension overlaps with the Political dimension discussed below.

The Political dimension

An important *Political* element impacting teachers' moving towards an ideal CEMC was the principal's support of the teacher and of the teacher's efforts to implement reform. As indicated earlier, having a supportive principal who believed in them enabled some teachers to take risks with inquiry teaching that would otherwise have been much more difficult. While, as also indicated earlier, SSI teachers had already enjoyed a degree of support from their principal (because they had to have the principal's agreement in order to participate in the SSI summer institutes and follow-up Academic Year Seminars (AYS)) it seemed that, for some teachers, this initial support was not carried through to support for the "new ideas" they brought back to their classrooms. It appeared from the cross-

site analysis that the most supportive principals were also very strong leaders, respected by staff, and very involved with reform of all types at their schools.

The second important *Political* element identified through the cross-site analysis was the degree of control over the curriculum which teachers had. The curriculum content was tightly controlled by school districts and indirectly by the State of Ohio through the Ohio Model Curriculum on which the proficiency tests were based. Most teachers did not consider that changing the curriculum was an option for them. This inability to recognise or act on the curriculum as a source of inequity implies that moving outside the Non-Discriminatory perspective to include aspects of the Inclusive or Socially Critical as suggested by Willis (1996) would not have been easy. So it is not surprising that the analysis showed only one teacher interviewed had made this transition. Also, the focus in the Ohio SSI was a Non-Discriminatory one: teacher content knowledge and pedagogy were the main thrusts of the institutes and follow-up seminars. Curriculum development was deliberately not a focus for the SSI (Kahle, 1997).

The Moral dimension

The final dimension examined was the *Moral* one, concerned with issues of justice and fairness. The first issue identified here was the continued practice, in some schools visited during the site visits, of tracking or streaming by providing a differentiated mathematics curriculum for students grouped on previous achievement or ability. This practice has been shown by previous research (Oakes, 1990, 1992) to lead to inequitable education for some students; however the findings of such research appeared to have had little impact on the schools in this study.

The other moral issue concerned the morality of expecting teachers to incorporate hands-on activities when there was so little money available for them to purchase even basic equipment such as simple calculators. The Ohio SSI overcame this to some extent by providing participants with a small amount of equipment, enough to allow them to implement some inquiry teaching. One school in particular appeared to be very poorly funded, with not even enough funds to properly equip classrooms with suitable desks and chairs. The issue of disparity in funding between school districts in Ohio was the subject of a legal challenge in 1997, in some ways similar to the Kentucky challenge in 1989 discussed by Adams and White (1997). The outcome of this challenge was not known at the time of writing this chapter.

Proposed fifth dimension: A personal philosophy of caring

One aspect that seemed to enable teachers such as Ms Eckland at Draper and Ms Zoran at Troy to move closest towards achieving the ideal Connected Equitable Mathematics Classroom was a personal philosophy of teaching that was based on an overt care and concern for their students. Both of these teachers were able to overcome many obstacles faced by other teachers who did not appear to have this philosophy. Lack of classroom resources, poor student motivation, lack of parental support or lack of an accessible network of other SSI teachers was not a deterrent for these teachers. Their overriding focus was on the students, and they nearly always seemed to be able to find a way around Technical or Cultural obstacles in the way of helping students achieve their potential. Their success in overcoming Political or Moral obstacles was more limited however, possibly because classroom teachers generally do not have the power to influence such things. This suggests reforms need to move beyond the level of the individual teacher as the focus of change, towards a broader focus on the school and school district, particularly towards those administrators with the power to influence or change Political or Moral obstacles. Implications such as this are discussed in the next part of this chapter, focused on challenges for educational researchers, reformers, equity advocates and practitioners.

IMPLICATIONS AND CHALLENGES

This study has established, from teachers' reports and observational data, that in comparison to Non-SSI teachers, SSI teachers had implemented at least some of the reformed teaching practices advocated by the SSI. A tentative association between higher achievement, especially for females, and participation in classes taught by SSI teachers, has also been established. However, there are still many questions about how to achieve equity goals in reforming mathematics classrooms which need research-based answers.

Challenges for Researchers

One challenge faced in this study was a methodological one, and that was how to determine when a mathematics teacher was acting equitably, and when a mathematics classroom was equitable. Although this study has provided the foundations to begin to meet the challenge, problems encountered when visiting classrooms need further investigation. For example, although all site researchers tried to investigate issues of equity and reform that arose naturally out of the

teacher's or principal's response to their questionnaire, the differing perspectives of each of the four site visitors, in terms of how equity is achieved in a classroom, resulted in differing degrees of focus on equity.

While more discussion about the attributes of an equitable classroom might be seen as the solution, it is doubtful that this would be sufficient. As demonstrated by Willis (1996), views about equity are ingrained, and change requires long-term reform with sustained effort and self-reflection. To ensure that each of the site visitors looked for the same features of equity would have been extremely difficult. The only way to have lessened the range of perspectives presented would have been to devise a fairly rigid interview protocol that every site visitor would have had to use. This would have interfered with the main purpose of the site visit, which was to investigate issues that were pertinent at each site and to give voice to participants' concerns. The time spent with the teachers was precious, and needed to be used to examine participants' concerns in as much depth as possible; hence there was no set interview protocol. Each site visitor had to make judgments about which issues to follow up with teachers and principals during the interviews. As it was, these teachers generally gave up at least two hours of their free time over a three-day visit, or one hour over a one-day visit, to talk to the researcher. To fully explore all the equity issues across all sites would have required much longer and/or a larger number of site visits, which was not feasible given the time frame of *The Landscape Study*. The approach to analysis taken in the present study, where all original transcripts were used, was much more time consuming than it might have been had the site-visit reports been used as the basis of the cross-site analysis. The challenge for future studies such as this one is to help researchers capture the essence of equity in action in the classroom without resorting to using checklists of observable behaviours, which could run the risk of missing the important cultural and contextual aspects of the situation.

Apart from the problem of differing perspectives of researchers, the other difficulty with "observing" equity in action in this study was that aspects such as those defined for the Connected Equitable Mathematics Classroom were not, strictly speaking, "observable". It could be argued that the observers' interpretations were really just one person's opinion or judgment of a situation, and that one way of confirming a researcher's interpretations or judgments would have been to have multiple observers or to involve the participants in confirming those interpretations. The former is problematic from a logistical or budgetary point of view. The latter may also be problematic, especially if the researcher has

made some uncomplimentary interpretations of the teacher's actions, as was the case at some sites. Because of the ongoing nature of *The Landscape Study*, and the importance of maintaining strong links with the schools involved in the study, it was not feasible to involve participants in this way. Methodologically speaking, this may not have been ideal, but research is not conducted in an ideal world, and, in this case, the importance of this multi-level longitudinal research outweighed the importance of ensuring participant confirmation of researchers' interpretations. The challenge for future studies such as this is to find sensitive ways of presenting potentially unpleasant findings to participants so as not to alienate them.

Challenges for Reformers

An important finding from this study was that some SSI teachers chose not to use inquiry-based teaching practices to prepare their students for proficiency tests because they thought these practices were too time consuming and would therefore not adequately prepare students for the tests. This presents a challenge for reformers—how to convince teachers that the use of inquiry teaching does not disadvantage students. Related to this, is how to ensure that school- and district-level administrators support and understand the potential of the reforms offered, because teachers indicated in their interviews that it was often pressure from administrators that made them revert to drill and practice methods for preparing students for proficiency tests. Another related question is how to convince the large numbers of teachers who did not directly participate in the SSI to subsequently engage in reformed teaching practices. Mandated changes have been shown to have limited long-term impact (Fullan, 1993a), and there is rarely the time or money to reach all teachers using the Ohio six-week model (Kahle, 1997). Arguably, one skill that teachers should be given during a professional development experience is how to share their skills and knowledge with those teachers at their school who did not participate. Of the seven teachers studied, Suzanne Shortland presented a number of workshops for teachers in her district at the invitation of the district superintendent; and it should be noted that this superintendent had been involved with the SSI as an advisor prior to her taking up her position as superintendent, so perhaps this was a special case. To address this challenge, the Ohio SSI did provide “Resource Teacher Institutes” to help SSI teachers prepare professional-development activities for teachers in their own districts. This has proven to be an effective way of scaling up the reform to

reach much larger numbers that would be possible using an intensive six-week model (Schnipper & Tims [Goodell], 1996).

Another way to convince other teachers of the efficacy of the professional development experience would be to provide evidence of improved teaching by SSI participants and improved learning by their students. This makes it very important to continue to collect achievement data over time and to disseminate to teachers and district administrators results such as those found in this study. That process was started in 1996 with the publication of "A Pocket Panorama of *The Landscape Study, 1995*" (Kahle & Rogg, 1996), which set out the preliminary results of *The Landscape Study* in an easy-to-read brochure format that was sent to every school district in the state of Ohio, and other educational institutions around the country.

A final important challenge for reformers is how to help teachers adapt existing curriculum materials to support the goals of the reform, and how to identify appropriate new curriculum materials. In Chapter Three, a number of important NSF-funded curriculum projects were described. Many of these now have a large research base to validate their use and implementation in new situations, which future reformers could easily take advantage of. Evidence from this study suggests that the progress of reform could be enhanced if teachers were not continually faced with having to adapt resource and curriculum materials for every inquiry lesson.

Challenges for Equity Advocates

An important challenge for equity advocates is how to transmit equity goals to participants in a reform without engendering a backlash. An element of this backlash was hinted at by Suzanne Shortland from Lakeview when she described how the group of teachers attending her institute were resentful of the amount of time spent in that institute talking about equity issues, which they thought were not appropriate for their situations. Although only mentioned by one of the seven teachers interviewed, this could have threatened the success of the whole professional-development program. Thus, not only is it important to consider issues of state-wide or national concern, local concerns must also be incorporated into discussions about equity conducted during institutes.

Related to this, is the need for teachers to be given the skills to monitor their own classroom interactions with students. Interaction patterns once established can be difficult to change. Developing techniques to assist teachers in analysing their own patterns of interaction in the classroom should be a priority

for professional development programs focused on equity of process and outcomes, as this SSI clearly was.

A third challenge for equity advocates is how to ensure that classroom teachers are empowered to question and challenge the scope, sequence and content of the curriculum, so that they may adopt an Inclusive perspective as appropriate to their circumstances, particularly when the reform is concentrating on teacher content and pedagogical knowledge. Most of the seven teachers visited in this study seemed to hold Non-Discriminatory (Willis, 1996) views of the mathematics curriculum. Little evidence was found that they acknowledged the way in which the choice of mathematics curricula could advantage some groups of students over others. As indicated earlier, this is not surprising given that there was an explicit avoidance of curriculum development in the Ohio SSI.

Challenges for Practitioners: A Working Model of the CEMC

Throughout this study, the focus has been on classrooms and teachers, with the overarching aim of ensuring that equity goals do not get lost in reform. This final section of this thesis takes the form of a detailed description, in operational terms, of a Connected Equitable Mathematics Classroom. In many ways, a major challenge for practitioners concerns the implementation of the CEMC.

Student focus in the CEMC

The first area to focus on in a CEMC is the background knowledge and attitudes towards mathematics held by students. Lack of the necessary skills or poor attitudes towards mathematics can be detrimental to students' academic progress, and for a classroom to become equitable, these factors should be addressed. Characteristics of students that influence motivation, such as lack of self confidence and not seeing the importance of mathematics, need to be recognised and dealt with. Teachers can encourage the development of positive attitudes and self confidence by helping students to see the relevance and importance of mathematics to their everyday lives, and by exemplifying positive attitudes.

Another personal characteristic of students that must be developed in the CEMC is student "voice" or the ability to speak up for oneself. This characteristic is essential in enabling students "to evaluate knowledge critically, assess biased perspectives, analyse complex situations and make wise choices" (Baxter Magolda, 1992, p. 391). In the traditional mathematics classroom, students'

voices are rarely evident. Students copy notes and work problems quietly at their desk. In the CEMC, students negotiate meaning within a learning community. In this type of community, described by Frid and Winnett (1996), student voice is developed through students actively engaging with mathematics problems that are set in a context that is relevant to students' lived experiences.

In the CEMC, the development of student voice is enhanced through students actively constructing their own knowledge. This means that teachers can no longer be only knowledge providers, standing at the front of the classroom writing notes on the board for students to copy into their note books. The teacher must be the facilitator, helping students to construct their own knowledge by setting up learning situations in which this is possible. Students must be engaged with the learning activity, whether that be through hands-on manipulatives, whole class discussion, group discussion, or presentation of project work. When introducing a new concept, teachers should always strive to find an activity that leads students to discover the concept first, before presenting theory, rules and examples. Introductory activities should be set in real-world contexts that have personal meaning to students, so that students will be more likely to connect with these concepts. Student voice is also enhanced when the voices of all students are valued. This means that the teacher must believe that every student has something worthwhile to say. When a student volunteers a response, even when it is wrong, it is very important for the teacher to find a way to value it. An atmosphere of trust and mutual respect must be present in order for strong relationships to develop. Sarcasm and put-downs can never be used in this context.

A CEMC must also ensure that students have access to information about careers in order to make informed choices. Mathematics teachers also have a specific responsibility to inform students about career options in mathematics and related areas. A CEMC will demonstrate the importance of mathematics to students and allow them to see where mathematics fits into society and their futures.

Teacher focus in the CEMC

The second focus of the CEMC is teacher behaviour. In accordance with the definition developed in this study, an equitable teacher is one that is able to recognise and act on inequities in their classroom environment. Having this skill relies on being informed about how to recognise inequity. Being informed derives from initial teacher training, in-service education or personal commitment. Research presented in this thesis has shown that certain pedagogical and

assessment techniques have the capacity to introduce bias in the classroom. Teachers must be informed of these possibilities and empowered to act accordingly. For example, the disadvantage to some students of using multiple-choice tests is not widely known. This is particularly true in the USA where multiple-choice tests are still used extensively, especially in state-wide mandated testing and college entrance examinations. Although the NCTM assessment standards (1995) are highly critical of the use of multiple-choice testing, it is nevertheless difficult for one single teacher (or researcher) to challenge the format of state-mandated tests. However, individual teachers can ensure that their own assessments are varied in context and format, assess what is taught and valued in the curriculum, and allow all students to demonstrate their knowledge. For example, it is pointless for teachers to use extensive group work in class and then use only traditional paper-and-pencil tests for their assessment. Students will only value what is assessed, and if group work is not assessed it will not be valued. If group work is to be assessed, it is important to build into the assessment of group work some way of ensuring that different levels of effort by different group members are differentially rewarded. One way of doing this is to ask every student to rate the effort of each group member. Teachers can quickly identify those students that are not pulling their weight in a group and intervene to remedy the situation.

Teachers also need to be aware of the differential power structures within their own classroom. For example, they need to be able to identify which students dominate the lesson and demand most of their time. Research has shown that males dominate many aspects of most classrooms, and teachers must be able to recognise and compensate for this. Rowdy students must be attended to in order for the class to proceed with their work, but that doesn't mean that other students need be neglected. A good starting point might be to speak to every student in the class at least once each lesson, making a work-related communication or a social contact. Monitoring classroom interactions through audio- or video-taping is also a good idea.

The final aspect of teacher behaviour that is crucial to the CEMC is the setting of high standards for students. In their portrait of a connected teacher, Belenky et al (1986) described the teacher as "rigorous". Ladson-Billings (1995) also stressed the need for teachers to set high standards for all their students, and criticised the process of tracking as one which leads to not all students having access to challenging mathematics. Related to this is how teacher expectations are associated with student achievement. It has long been known from research that

teacher expectations are positively related to student achievement as shown by the meta-analysis of Smith (1980). Setting high standards and having high expectations of students are essential elements of achieving an equity pedagogy (Ladson-Billings, 1995) which is necessary for the equitable classroom.

Curriculum focus in the CEMC

A third area of concern in the CEMC is the curriculum: certain crucial elements must be present in order for equity to be achieved. First, the curriculum must value the culture and background experiences of all learners through the use of non-stereotypical language in texts and through using contexts that are inclusive of the range of contemporary students' experiences. As previously discussed, the Australian Mathematics Profiles attempted to do this, having been designed with social justice goals in mind. The contributions of women and minorities to the dominant culture, as well as to minority cultures, must also be included. Mathematics teachers should not consider that history is the sole province of the social studies teacher. Women and minorities have contributed to the history of mathematics, and these contributions should be acknowledged. It is also appropriate to discuss with students why the contributions of women and minorities have been ignored by the mainstream for so long.

A connected equitable mathematics curriculum should also aim to expose inequities in society. Through the application of mathematics to real-world problems, students should be able to use mathematics to challenge social conditions. World problems of poverty, health, ecology, population and the distribution of wealth should be used as contexts in mathematics, as these are the problems students of today will increasingly be facing in the future. A critical aspect of being able to apply mathematics to real-world problems is being able to understand the mathematics that is presented every day in the media. Newspapers and television news reports should be an everyday feature of mathematics classrooms.

The final aspect of the equitable connected mathematics curriculum is that it should include some form of social action. Tate (1995b) cites the example of students in an urban area in the USA researching and acting on the illegal liquor outlets near their school. This example emphasised the importance of the teacher concerned having the freedom to set her own curriculum and thus to allow her students to solve a problem that had personal meaning and relevance to them through the use of mathematics.

Naturally, as a precursor to this exercise, students must have some skills to apply, and some students may need to be taught particular skills in a traditional manner. However, with the rapid development of computer technology and the huge explosion, through the internet, in the amount of information available on any topic, it may well be now more valuable for students to be skilled at finding information and understanding its mathematical implications than learning a lot of dissociated mathematical facts and algorithms. The Connected Equitable Mathematics Classroom, as just described, with its emphasis on real-world connected problems and students jointly constructing their own meanings will facilitate students becoming seekers of knowledge, rather than remaining empty vessels waiting to have knowledge deposited in them.

CONCLUDING REMARKS

The focus of this study has been to define, in terms of current theories and practices, the goals of an equitable mathematics classroom; to examine, in terms of gender equity, the extent to which these goals were achieved in one state of the USA that had been engaged in reform over an extended period; and to investigate the barriers to and facilitators of reform as experienced by classroom mathematics teachers. The culmination of this investigation has produced a detailed operational definition of the ideal Connected Equitable Mathematics Classroom, which it is hoped will be of future use to researchers, reformers, equity advocates and, most importantly, classroom mathematics teachers. This study has posed many challenges for these groups. It has highlighted the importance of the teacher, and her or his personal philosophy of teaching as a crucial element in the implementation of reform in the mathematics classroom. The care and concern showed by some teachers towards their students facilitated a connected classroom atmosphere where students were expected to do well. The methodological challenge is how to determine when “caring” is happening, and how to document and share the successes of caring teachers. The challenge for future reform efforts is how to share this vision of equity and reform with all teachers. However, as mentioned previously, even the most caring and concerned teachers could not overcome some political and moral barriers encountered in this study. Hence, above all, equity advocates and reformers alike have to consider how to ensure that the reform involves those administrators with the power to overcome such political and moral barriers.

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APPENDICES

Note: For copyright reasons Appendices A1 to A5 (pp264-269 of this thesis) which contain letters from various people, have not been reproduced.

(Co-ordinator, ADT Project (Retrospective), Curtin University of Technology, 13.1.03)

APPENDIX B

Discovery Inquiry Test

and Landscape Student Questionnaire

Teacher Directions

YOU HAVE THE FOLLOWING:

- One set (30) of the white *Discovery* Inquiry Tests. This is your largest stack. Students should not write on these, because you will use them with two of your classes.
- Two sets (30 each) of the colored Landscape Student Questionnaires stapled to the colored *Discovery* Inquiry Test Response Forms.
- *Discovery* Test Information Form - 1.
- *Discovery* Test Agreement Form - 1.
- If you are the *Discovery* focus teacher, you also have one set (30) of *Discovery* Parent Questionnaires.

WHAT TO DO :

With your site visitor you have chosen two classes to receive the questionnaires. Please administer the questionnaires within one week after the site visit.

- On the day to administer the questionnaires, please follow these steps:

In the first of the two classes

- Distribute the colored *Landscape* Student Questionnaires *Discovery* Inquiry Test Response Forms.
- Distribute the large white *Discovery* Inquiry Tests. Emphasize that they **must not write anything on the tests but should respond on the colored Response Forms**. There is no time limit and you may decide on the order.
- When they are finished, collect all materials, and **check that the tests have not been written on**. If a test has been marked, please erase any marks before going to the next class.
- Use the same set of tests with the second class, following the same procedures.
- After all materials have been collected, place the *Landscape* Questionnaires and *Discovery* Inquiry Test Response sheets (the colored pages students have written on) back in the appropriate class envelope, put the class envelopes for both classes in the prepaid addressed large envelope and put it in the mail. Don't forget to include your completed *Discovery* Test Information Form and *Discovery* Test Agreement Form (white). Your site observer will discuss with you the best method to return the *Discovery* Inquiry Tests.

APPENDIX C

OHIO MIDDLE LEVEL MATHEMATICS AND SCIENCE EDUCATION LANDSCAPE STUDY

SUGGESTIONS FOR CLASSROOM OBSERVATION

(linked to teacher responses to Teacher Questionnaire:

“T” relates to teacher’s response to “How I teach”,

“S” relates to teachers response to “What my students do”)

IN ALL CASES PAY ATTENTION TO EQUITY ISSUES

Teacher Name School Name

Class Period Date

FOCAL AREAS	NOTES
<p>Student discussion (T1; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher arrange seating to facilitate student discussion as indicated in her/his response (T1)? • Does the discussion take place? • What is the “quality” of the discussion? • Does the teacher “facilitate” it? • Is the discussion developing math/sci literacy for all students (S10)? • Is discussion linked to real-world applications (S11)? 	
<p>Open ended questions (T2; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher use open-ended questions as indicated in her/his response (T2)? • To whom are they directed (target students etc.)? • Where do they lead? • Do the questions develop math/sci literacy for all students (S10)? • Are the questions etc. linked to real-world applications (S11)? 	

<p>Questions from students (T4; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher encourage questions from students as indicated in her/his response (T4)? • Whose questions are recognised? • Where do the questions lead (NB the target/valued student issue)? • Does this strategy help develop math/sci literacy for all students (S10)? • Are real-world applications picked up through student questions (S11)? 	
<p>Student evidence to support claims (T3; S1; S2; S3; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher require students to supply evidence and/or data to support their claims as indicated in her/his responses (T3; S1)? • Is evidence/data supplied as indicated in her/his responses (S1)? • How is this evidence/data dealt with? • Do students repeat experiments as indicated in S3? If so, for what reason? • Is disconfirming evidence/data taken seriously? • Is “real-world” evidence treated the same as “experimental” evidence? (S11) • Are there arguments/debate about the interpretation of data as indicated in S2? • How is the math/sci literacy of all students enhanced through teacher treatment of “evidence”? (S10) 	
<p>Students working at own pace (T5)</p> <ul style="list-style-type: none"> • Does the teacher allow students to work at their own pace as indicated in her/his response? • What effect does this appear to have on learning? • What strategies are employed? 	

<p>Student explanation of concepts to one another (T6; S6; S7; S8; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher encourage students to explain concepts to one another as indicated in her/his response (T6)? • Do students do this to the extent indicated (S7; S8)? • What effect does this appear to have on learning (S7; S8)? • Do students design activities to test their ideas, as indicated in S6? • Does this strategy help develop math/sci literacy for all students (S10)? • Are real-world applications picked up from student explanations (S11)? 	
<p>Student discussion of subject specific ideas (T10; S8; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher provide time for student discussion of subject specific ideas as indicated in her/his response (T10)? • What typically happens during this time? • Do the students actually talk with one another in ways which promote learning, as indicated in S8? • What is the outcome of such discussions? • Does this strategy help develop math/sci literacy for all students (S10)? • Are real-world applications picked up from student explanations? (S11) 	
<p>Alternative explanations (T7; S5; S10)</p> <ul style="list-style-type: none"> • Does the teacher encourage students to consider alternative explanations as indicated in her/his response (T7)? • Do the students do this to the extent indicated in S5? • How are alternative explanations presented and handled? • Does consideration of alternative explanations appear to be seen as integral to math/sci literacy? 	
<p>Use of multiple sources of information by students (S4; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher provide or draw attention to a variety of sources of information, including real-world sources? • Do students use these multiple sources to the extent indicated in S4? • How does this contribute to the development of students' math/sci literacy? 	

<p>Work of mathematicians/scientists (T9; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher encourage discussion of the work of mathematicians/scientists as indicated in her/his responses (T9)? • To what extent do such discussions <ul style="list-style-type: none"> (i) reinforce/challenge the dominant paradigm of math/sci ? (ii) reflect students' own cultural/gender identity? (iii) link math/sci to the real world? (iv) contribute to the development of all students' math/sci literacy? 	
<p>Experiments from the history of math/sci (T12; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher discuss experiments from the history of math/sci as indicated in her/his response (T12)? • To what extent do such discussions <ul style="list-style-type: none"> (i) reinforce/challenge the dominant paradigm of math/sci ? (ii) facilitate a racially and gender inclusive image of math/sci? (iii) link math/sci to the real world? (iv) contribute to the development of all students' math/sci literacy? 	
<p>Authentic assessment (T13; S10; S11)</p> <ul style="list-style-type: none"> • Does the teacher use non-traditional/authentic assessments as indicated in her/his response (T13) • What form do these assessments take? • Do all forms of assessment appear to be valued equally by teacher and students (and parents)? • To what extent do such assessments <ul style="list-style-type: none"> (i) reinforce/challenge the dominant paradigm of math/sci ? (ii) facilitate a racially and gender inclusive image of math/sci? (iii) link math/sci to the real world? (iv) contribute to the development of all students' math/sci literacy? 	
<p>Student use of educational technology in the classroom (S9; S10)</p> <ul style="list-style-type: none"> • Do students use ed. tech in the classroom to the extent indicated in S9? • Does their use of ed. tech appear to contribute to the development of the math/sci literacy? 	

Appendix D1

**OHIO MIDDLE LEVEL MATHEMATICS AND SCIENCE
EDUCATION LANDSCAPE STUDY**

Teacher Questionnaire

PART I - ABOUT ME AND MY CLASS

Your perspective is required about only one of the 6th, 7th, 8th or 9th grade mathematics and/or science classes you teach. Please disregard any of your other classes as you respond to the questionnaire. The random selection process below will enable you to identify the class (session/period/bell) for which you should respond.

Selecting my class

- Circle the number of **6th, 7th, 8th or 9th grade mathematics and/or science** classes you teach. 1 2 3 4 5 6 7
..... **A:**
- Circle the number directly below your **Row A** selection. 1 1 2 4 3 6 5
..... **B:**
- The number that you circled in Row B indicates the class for which you should respond. For example, if the number you circled in **Row B** is "3" then respond for the *third* science/math class you teach each day or most days. If the number is "2" respond for your *second* class, etc.

About my selected class

- The grade level of this class is: 6 7 8 9
- The subject and specific subject area for this class is:

<input type="checkbox"/> SCIENCE <hr/> <input type="checkbox"/> Biological Science <input type="checkbox"/> General Science <input type="checkbox"/> Chemistry <input type="checkbox"/> Physics <input type="checkbox"/> Earth Science <input type="checkbox"/> Integrated <input type="checkbox"/> _____ other science: (specify)	<input type="checkbox"/> MATHEMATICS <hr/> <input type="checkbox"/> General Mathematics <input type="checkbox"/> Pre Algebra <input type="checkbox"/> Applied Mathematics <input type="checkbox"/> Algebra I <input type="checkbox"/> Integrated <input type="checkbox"/> Geometry <input type="checkbox"/> _____ other mathematics: (specify)
--	--
- This class is characterized as (check all that apply):

<input type="checkbox"/> Remedial	<input type="checkbox"/> Introductory	<input type="checkbox"/> Advanced	<input type="checkbox"/> Honors
<input type="checkbox"/> Mixed ability	<input type="checkbox"/> Homogeneous ability	<input type="checkbox"/> Mainstreamed	<input type="checkbox"/> Multi-grade
<input type="checkbox"/> Required class	<input type="checkbox"/> Elective class	<input type="checkbox"/> _____	

other: (specify) _____
- The **number** of students in this class is: _____
- The **number** of students in this class with a limited English proficiency is: _____
- The **number** of students in each racial/ethnic group is:

_____ African American	_____ Asian or Pacific Islander
_____ American Indian/Alaskan Native	_____ Hispanic
_____ Appalachian	_____ White (not of Hispanic or Appalachian origin)

About me

7. I **currently** teach grade(s):

K **1** **2** **3** **4** **5** **6** **7** **8** **9** **10** **11** **12**

8. I am **certified** to teach grade(s):

K **1** **2** **3** **4** **5** **6** **7** **8** **9** **10** **11** **12**

9. I am **certified** to teach in the following field(s):

MIDDLE GRADES (4-9):

Mathematics

Science

HIGH SCHOOL OR COMPREHENSIVE HIGH SCHOOL:

Biological Science

General Science

Chemistry

Mathematics

Earth Science

Physics

OTHER (please specify): _____

10. My **background** is best described as:

African American.

Asian or Pacific Islander.

American Indian/Alaskan Native.

Hispanic.

Appalachian.

White (not of Hispanic or Appalachian origin).

PART II - MY OPINIONS ABOUT TEACHING AND LEARNING

The *SAMPLE ITEM* below shows how to respond to the statements in the remainder of this questionnaire. Please mark your responses using both Column A and Column B choices.

How I Teach

Please circle the responses that best reflect:

- A. How often this happens in my classroom.
B. How important this practice is to me.

SAMPLE ITEM:

In this class, I ...

1. expect students to work quietly at their desks.

In this class, I ...

1. arrange seating to facilitate student discussion.
2. use open-ended questions.
3. require that my students supply evidence to support their claims.
4. encourage questions from my students.
5. allow my students to work at their own pace.
6. encourage my students to explain concepts to one another.
7. encourage my students to consider alternative explanations.
8. arrange field trips to zoos or aquariums.
9. discuss the work of mathematicians/scientists.
10. provide time for my students to discuss subject-specific ideas among themselves.
11. arrange field trips to museums.
12. discuss experiments from the history of mathematics/science.
13. use non-traditional/authentic assessments.

		Column A.								Column B.			
		Almost Never								Very Unimportant			
		Seldom								Unimportant			
		Sometimes								Important			
		Often								Very Important			
		Very Often											
		AN	Se	So	O	VO	VU	U	I	VI			
1. arrange seating to facilitate student discussion.		AN	Se	So	O	VO	VU	U	I	VI			
2. use open-ended questions.		AN	Se	So	O	VO	VU	U	I	VI			
3. require that my students supply evidence to support their claims.		AN	Se	So	O	VO	VU	U	I	VI			
4. encourage questions from my students.		AN	Se	So	O	VO	VU	U	I	VI			
5. allow my students to work at their own pace.		AN	Se	So	O	VO	VU	U	I	VI			
6. encourage my students to explain concepts to one another.		AN	Se	So	O	VO	VU	U	I	VI			
7. encourage my students to consider alternative explanations.		AN	Se	So	O	VO	VU	U	I	VI			
8. arrange field trips to zoos or aquariums.		AN	Se	So	O	VO	VU	U	I	VI			
9. discuss the work of mathematicians/scientists.		AN	Se	So	O	VO	VU	U	I	VI			
10. provide time for my students to discuss subject-specific ideas among themselves.		AN	Se	So	O	VO	VU	U	I	VI			
11. arrange field trips to museums.		AN	Se	So	O	VO	VU	U	I	VI			
12. discuss experiments from the history of mathematics/science.		AN	Se	So	O	VO	VU	U	I	VI			
13. use non-traditional/authentic assessments.		AN	Se	So	O	VO	VU	U	I	VI			

My Views About MATHEMATICS/SCIENCE

Please circle the responses that best reflect:

- A. My views about mathematics/science.**
- B. The importance of these views being reflected in my class.**

In my opinion ...

1. mathematical/scientific knowledge is subjective.
2. mathematicians/scientists disagree about mathematical/scientific knowledge.
3. today's mathematical/scientific laws and theories may be changed in the face of new evidence.
4. mathematical/scientific knowledge is subject to review and change.
5. there are still many mathematics/science issues to be resolved.
6. mathematical/scientific laws, theories and concepts are continually being tested.
7. mathematics/science progresses by refining theories or by replacing them with new ones.
8. hypotheses must be supported by empirical evidence.

		Column A.								
		Strongly Disagree								
		Disagree								
		Agree								
		Strongly Disagree								
						Column B.				
						Very Unimportant				
						Unimportant				
						Important				
						Very Important				
	SD	D	A	SA	VU	U	I	VI		
1.	SD	D	A	SA	VU	U	I	VI		
2.	SD	D	A	SA	VU	U	I	VI		
3.	SD	D	A	SA	VU	U	I	VI		
4.	SD	D	A	SA	VU	U	I	VI		
5.	SD	D	A	SA	VU	U	I	VI		
6.	SD	D	A	SA	VU	U	I	VI		
7.	SD	D	A	SA	VU	U	I	VI		
8.	SD	D	A	SA	VU	U	I	VI		

Changes in my School's mathematics/science program

1. How I rate my school's program compared to what it was **4 years ago**:

- Much worse. A little better.
 A little worse. Much better.
 No change. I haven't been at this school long enough to answer.

2. What **changed** (teaching practices, proficiency scores, enrollment trends, etc.)?

3. What **caused** the changes (facilities, inservice education, state policies, etc.)?

My ideas for Improving learning OUTCOMES

A. Which of these alternatives hold the most promise of improving the science/mathematics learning outcomes of your students? Please indicate the relative **importance** of each idea (as before) and **rank order** them ("1" = most important to "10" = least important).

RANK

- _____ professional development during the school day
 _____ teaching materials that appeal to diverse students
 _____ flexible scheduling for mathematics/science classes
 _____ Ohio Proficiency Tests
 _____ equipment and supplies to support student inquiry
 _____ more time for instruction
 _____ curriculum that focuses on problem-solving
 _____ Ohio Model Curriculum
 _____ professional development sustained over time
 _____ materials for alternative assessment

	Very Unimportant	Unimportant	Important	Very Important
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>
_____	<i>vu</i>	<i>u</i>	<i>i</i>	<i>vi</i>

B. Do you believe that there are better ideas than those listed above? Please list them in order of their importance (1 = most important).

1. _____
2. _____
3. _____

Thank you for your contribution to the Landscape Study!

Appendix D2

OHIO MIDDLE LEVEL MATHEMATICS AND SCIENCE EDUCATION
LANDSCAPE STUDY

MATHEMATICS - STUDENT VERSION

1. Circle the box that matches the **first letter** of your **FIRST** name.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

2. Circle the box that matches the **first letter** of your **LAST** name.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

3. Circle the boxes that match the **MONTH**, **DAY**, and **YEAR** you were born.**Month**

Jan- uary	Feb- ruary	March	April	May	June	July	Aug- ust	Septe- mber	Oct- ober	Nov- ember	Dec- ember
--------------	---------------	-------	-------	-----	------	------	-------------	----------------	--------------	---------------	---------------

Day

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22			
23	24	25	26	27	28	29	30	31																

Year

1978	1979	1980	1981	1982	1983	1984	1985	1986	Other _____
------	------	------	------	------	------	------	------	------	-------------

4. Is English the language you speak most often at home? Yes No
5. If you answered "NO" to the above question, please list the language spoken most often at home _____.

DIRECTIONS

The items on the next page ask you to think about math and this math class. Please remember that this is not a test. There are no right or wrong answers. Your opinion is what is wanted.

How to Answer:

Circle the set of letters that match your choice.

In this class, my teacher...	
1. gives me homework.	AN Se So O VO

Almost Never
Seldom
Sometimes
Often
Very Often

How To Change an Answer:
Cross it out and circle a new one.

In this class, my teacher...	
1. gives me homework.	AN Se So O VO

Almost Never
Seldom
Sometimes
Often
Very Often

Remember to Answer ALL Items!

	Almost Never	Seldom	Sometimes	Often	Very Often
In this math class, my teacher...					
1. asks questions that have more than one answer.	AN	Se	So	O	VO
2. asks me to give reasons for my answers.	AN	Se	So	O	VO
3. encourages me to ask questions.	AN	Se	So	O	VO
4. lets me work at my own pace.	AN	Se	So	O	VO
5. discusses problems that real mathematicians solve.	AN	Se	So	O	VO
In this math class, I...					
6. learn that math cannot provide perfect answers.	AN	Se	So	O	VO
7. talk with my classmates about how to solve problems.	AN	Se	So	O	VO
8. repeat problems to check results.	AN	Se	So	O	VO
9. have a say in deciding what activities I do.	AN	Se	So	O	VO
10. learn from my classmates.	AN	Se	So	O	VO
11. use information to support my answers.	AN	Se	So	O	VO
12. am encouraged to apply math to after school activities.	AN	Se	So	O	VO
13. learn how math has changed over time.	AN	Se	So	O	VO
14. learn how math is used by people in other countries.	AN	Se	So	O	VO
My principal...					
15. visits my math classroom.	AN	Se	So	O	VO
16. talks to my teacher about what we are doing in class.	AN	Se	So	O	VO
17. complains about the noise level in my math classroom.	AN	Se	So	O	VO
My friends...					
18. talk about math outside of class.	AN	Se	So	O	VO
19. discuss things they have learned in math class.	AN	Se	So	O	VO
20. make fun of people who like math.	AN	Se	So	O	VO
21. work on math projects.	AN	Se	So	O	VO
22. enjoy doing math-related activities outside of class.	AN	Se	So	O	VO
23. are interested in math.	AN	Se	So	O	VO
24. make fun of people who get good grades in math.	AN	Se	So	O	VO
25. think math is dumb.	AN	Se	So	O	VO
At least one adult in my home...					
26. makes me do my math homework.	AN	Se	So	O	VO
27. asks about what I am learning in math class.	AN	Se	So	O	VO
28. helps me with my math homework.	AN	Se	So	O	VO
29. helps me work on my math projects.	AN	Se	So	O	VO
30. goes to science and technology museums with me.	AN	Se	So	O	VO
31. watches science T.V. programs with me.	AN	Se	So	O	VO

THANK YOU!!!

APPENDIX E

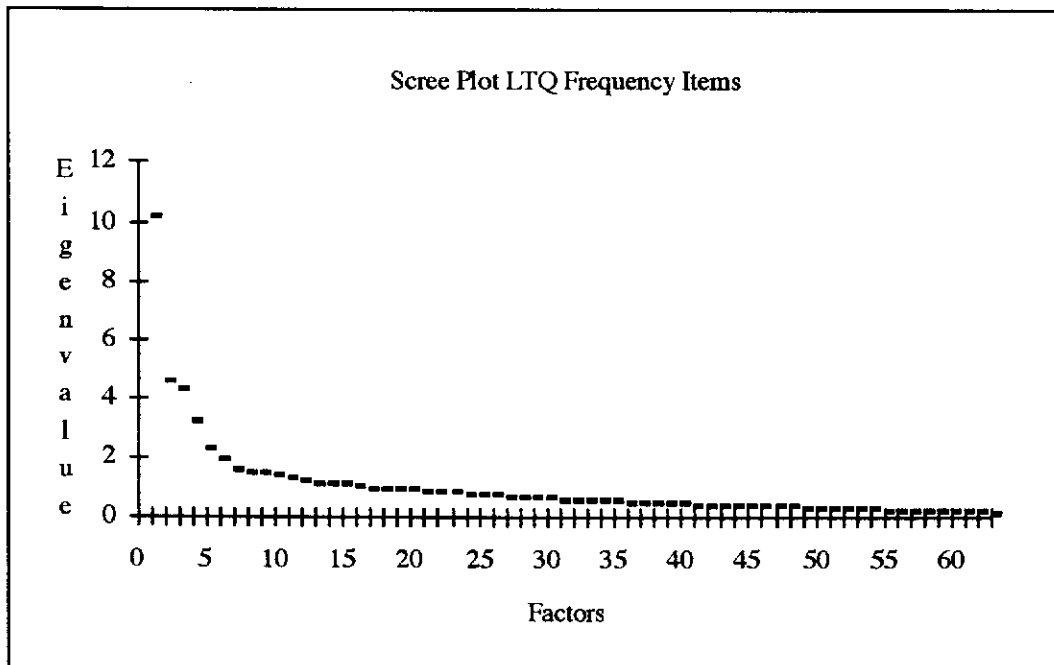


Figure E1 Scree plot for factor analysis of LTQ “frequency” items

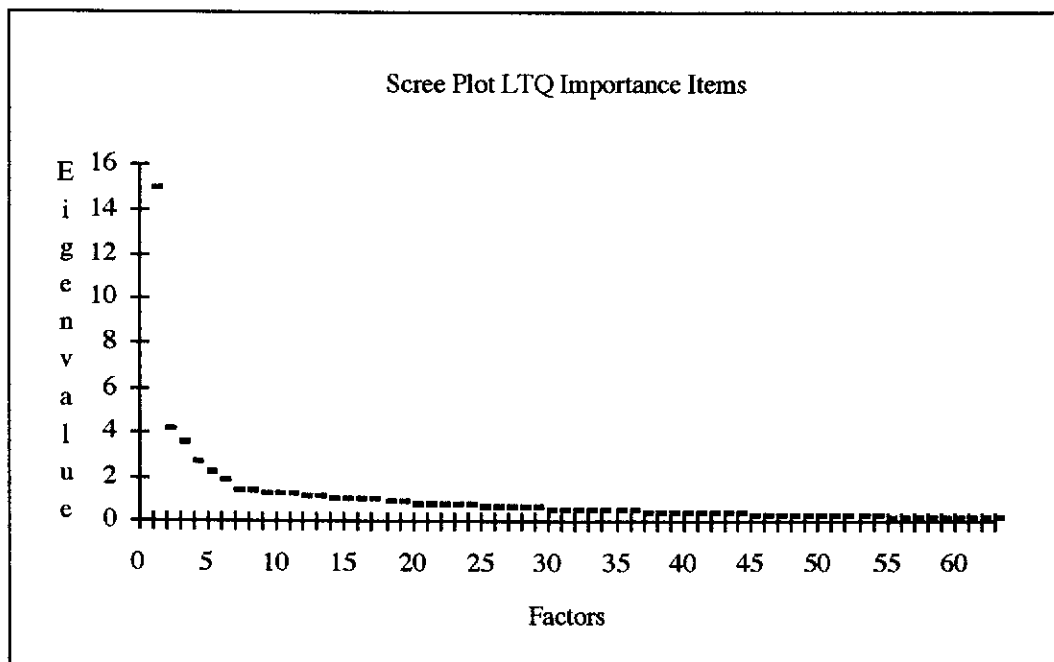


Figure E2 Scree plot for factor analysis of LTQ “importance” items

APPENDIX F

Table F1
 Factor Loadings of the LTQ Frequency Items Varimax Rotation

Variable	Factor loadings				Variable	Factor loadings			
	1	2	3	4		1	2	3	4
TEACHA1	50				PRINA9		44		
TEACHA2	40				PRINA10		52		
TEACHA3	41				PRINA11		72		
TEACHA4	34				PRINA12				
TEACHA5	35				PRINA13		56		
TEACHA6	61				PRINA14		57		
TEACHA7	54				PRINA15		61		
TEACHA8	30				PRINA16		70		
TEACHA9	48				PRINA17		56		
TEACHA10	66				PRINA18		52		
TEACHA11	33				PARENA1			49	
TEACHA12	44				PARENA2			43	
TEACHA13	59				PARENA3			67	
STUDA1	56				PARENA4			63	
STUDA2	64				PARENA5			73	
STUDA3	55				PARENA6			73	
STUDA4	61				PARENA7			75	
STUDA5	57				PARENA8			64	
STUDA6	61				PARENA9			72	
STUDA7	63				PARENA10			69	
STUDA8	66				PARENA11			33	
STUDA9	41				PARENA12			47	
STUDA10	40				PARENA13			56	
STUDA11	51				VIEWA1				
PRINA1		54			VIEWA2				38
PRINA2		41			VIEWA3				67
PRINA3		45			VIEWA4				75
PRINA4		43			VIEWA5				69
PRINA5		61			VIEWA6				79
PRINA6		57			VIEWA7				73
PRINA7		71			VIEWA8				37
PRINA8		65							

APPENDIX G

Table G1

Factor Loadings for LTQ Frequency Factor 1: CLASSTCH

Item Number	Load	Content
		<i>In this class I...</i>
TEACHA1	50	arrange seating to facilitate student discussion.
TEACHA2	40	use open-ended questions.
TEACHA3	41	require that my students supply evidence to support their claims.
TEACHA4	34	encourage questions from my students.
TEACHA5	35	allow my students to work at their own pace.
TEACHA6	61	encourage my students to explain concepts to one another.
TEACHA7	54	encourage my students to consider alternative explanations.
TEACHA8	30	arrange field trips to zoos or aquariums.
TEACHA9	48	discuss the work of mathematicians/scientists.
TEACHA10	66	provide time for my students to discuss subject-specific ideas among themselves.
TEACHA11	33	arrange field trips to museums.
TEACHA12	44	discuss experiments from the history of mathematics/science.
TEACHA13	59	use non-traditional/authentic assessments.
		<i>In this class, my students...</i>
STUDA1	56	use data to justify responses to questions.
STUDA2	64	argue or debate with one another about the interpretation of data.
STUDA3	55	repeat experiments to confirm results.
STUDA4	61	use multiple sources of information to learn.
STUDA5	57	consider alternative explanations to accepted theories.
STUDA6	61	design activities to test out their own ideas.
STUDA7	63	consult one another as sources for learning.
STUDA8	66	talk with one another to promote learning.
STUDA9	41	use educational technology in the classroom.
STUDA10	40	develop mathematical/scientific literacy skills.
STUDA11	51	learn about real world applications of mathematics/science.

Table G2

Factor Loadings for LTQ Frequency Factor 2: PRINSUPP

Item Number	Load	Content
		<i>In this class, my principal...</i>
PRINA1	54	provides support for my professional decisions on how to assess learning.
PRINA2	41	allows me to teach at a rate determined by student learning.
PRINA3	45	accepts noise associated with my active classroom.
PRINA4	43	supports my innovative instructional practices.
PRINA5	61	enhances the mathematics/science program by providing me with needed materials and equipment.
PRINA6	57	facilitates parental support of my program.
PRINA7	71	has a "feel" for my curriculum program.
PRINA8	65	draws my attention to ideas that can be used to improve instruction in my classroom.
PRINA9	44	expects that I change my teaching to implement improved standards/practices.
PRINA10	52	arranges for me to observe exemplary teachers.
PRINA11	72	demonstrates respect for teaching as a profession through public recognition.
PRINA13	56	supports recommendations of curriculum co-ordinators.
PRINA14	57	allows time for teachers to meet to share ideas with one another.
PRINA15	61	provides incentives (release time, substitute pay, etc.) for my professional development.
PRINA16	70	has a working knowledge of state and national trends
PRINA17	56	attends team/department meetings.
PRINA18	52	arranges schedules so that teams/departments may meet.

Table G3

Factor Loadings for LTQ Frequency Factor 3: HOME

Item Number	Load	Content
		The parents of my students ...
PARENA1	49	expect that I provide homework.
PARENA2	43	support different types of homework such as journals and activities/experiments.
PARENA3	67	assist their children with homework.
PARENA4	63	attend teacher conferences.
PARENA5	73	attend school functions such as plays, concerts, and athletic events.
PARENA6	73	attend school mathematics/science activities such as Math Counts, Olympiads, science fairs, etc.
PARENA7	75	initiate communication with me.
PARENA8	64	respond to my initiation of communication.
PARENA9	72	participate in parent-teacher associations.
PARENA10	69	are aware of what is happening in my classroom.
PARENA11	33	expect that textbooks are used.
PARENA12	47	assist me in the classroom.
PARENA13	56	support innovative methods of instruction.

Table G4

Factor Loadings for LTQ Frequency Factor 4: NATMATH

Item Number	Load	Content
		<i>In my opinion ...</i>
VIEWA2	38	mathematicians/scientists disagree about mathematical/scientific knowledge.
VIEWA3	67	today's mathematical/scientific laws and theories may be changed in the face of new evidence.
VIEWA4	75	mathematical/scientific knowledge is subject to review and change.
VIEWA5	69	there are still many mathematics/science issues to be resolved.
VIEWA6	79	mathematical/scientific laws, theories and concepts are continually being tested.
VIEWA7	73	mathematics/science progresses by refining theories or by replacing them with new ones.
VIEWA8	37	hypotheses must be supported by empirical evidence.

APPENDIX H

Table H1
Means and Effect Sizes for Frequency Scale Factors

Frequency Scale Factors	SSI Pop	SSI Mean	Std Dev	Non- SSI Pop	Non- SSI Mean	Std Dev	Effect Size
CLASSTCH	81	3.44	0.49	364	3.15	0.47	0.612
PRINSUPP	74	3.51	0.68	351	3.54	0.61	-0.048
HOME	76	2.98	0.55	374	2.99	0.61	-0.017
NATMATH	79	3.2	0.44	395	3.02	0.37	0.471

APPENDIX J

Table J1

Factor Loadings for Importance Scale Factor 1: IMPPRIN

Item Number	Load	Content
		<i>How important is it that my principal...</i>
PRINB1	59	provides support for my professional decisions on how to assess learning.
PRINB2	54	allows me to teach at a rate determined by student learning.
PRINB3	59	accepts noise associated with my active classroom.
PRINB4	54	supports my innovative instructional practices.
PRINB5	50	enhances the mathematics/science program by providing me with needed materials and equipment.
PRINB6	51	facilitates parental support of my program.
PRINB7	70	has a "feel" for my curriculum program.
PRINB8	56	draws my attention to ideas that can be used to improve instruction in my classroom.
PRINB9	58	expects that I change my teaching to implement improved standards/practices.
PRINB10	56	arranges for me to observe exemplary teachers.
PRINB11	61	demonstrates respect for teaching as a profession through public recognition.
PRINB13	52	supports recommendations of curriculum co-ordinators.
PRINB14	54	allows time for teachers to meet to share ideas with one another.
PRINB15	56	provides incentives (release time, substitute pay, etc.) for my professional development.
PRINB16	67	has a working knowledge of state and national trends
PRINB17	55	attends team/department meetings.
PRINB18	54	arranges schedules so that teams/departments may meet.

Table J2

Factor Loadings for Importance Scale Factor 2: IMPACTVT

Item Number	Load	Content
		<i>How important is it that I...</i>
TEACHB8	68	arrange field trips to zoos or aquariums.
TEACHB9	45	discuss the work of mathematicians/scientists.
TEACHB10	47	provide time for my students to discuss subject-specific ideas among themselves.
TEACHB11	71	arrange field trips to museums.
TEACHB12	54	discuss experiments from the history of mathematics/science.
TEACHB13	55	use non-traditional/authentic assessments.
		<i>How important is it that my students...</i>
STUDB2	45	argue or debate with one another about the interpretation of data.
STUDB3	58	repeat experiments to confirm results.
STUDB4	46	use multiple sources of information to learn.
STUDB5	61	consider alternative explanations to accepted theories.
STUDB6	61	design activities to test out their own ideas.
		<i>How important is it that the parents of my students...</i>
PARENB12	60	assist me in the classroom.

Table J3
Factor Loadings for Importance Scale Factor 3: IMPCOMM

Item Number	Load	Content
		<i>How important is it that I...</i>
TEACHB1	38	arrange seating to facilitate student discussion.
TEACHB2	45	use open-ended questions.
TEACHB3	66	require that my students supply evidence to support their claims.
TEACHB4	47	encourage questions from my students.
TEACHB6	56	encourage my students to explain concepts to one another.
TEACHB7	45	encourage my students to consider alternative explanations.
		<i>How important is it that my students...</i>
STUDB1	42	use data to justify responses to questions.
STUDB7	55	consult one another as sources for learning.
STUDB8	59	talk with one another to promote learning.
STUDB9	32	use educational technology in the classroom.
STUDB10	50	develop mathematical/scientific literacy skills.
STUDB11	51	learn about real world applications of mathematics/science.

Table J4

Factor Loadings for Importance Scale Factor 4: IMPHOME

Item Number	Load	Content
		<i>How important is it that the parents of my students...</i>
PARENB1	36	expect that I provide homework.
PARENB2	42	support different types of homework such as journals and activities/experiments.
PARENB3	56	assist their children with homework.
PARENB4	57	attend teacher conferences.
PARENB5	70	attend school functions such as plays, concerts, and athletic events.
PARENB6	66	attend school mathematics/science activities such as Math Counts, Olympiads, science fairs, etc.
PARENB7	71	initiate communication with me.
PARENB8	62	respond to my initiation of communication.
PARENB9	65	participate in parent-teacher associations.
PARENB10	61	are aware of what is happening in my classroom.
PARENB13	42	support innovative methods of instruction.

Table J5

Factor Loadings for Importance Scale Factor 5: IMPVIEW

Item Number	Load	Content
		<i>How important is it that this opinion is reflected in my class?</i>
VIEWB1	39	Mathematical/scientific knowledge is subjective.
VIEWB2	60	Mathematicians/scientists disagree about mathematical/scientific knowledge.
VIEWB3	77	Today's mathematical/scientific laws and theories may be changed in the face of new evidence.
VIEWB4	81	Mathematical/scientific knowledge is subject to review and change.
VIEWB5	81	There are still many mathematics/science issues to be resolved.
VIEWB6	80	Mathematical/scientific laws, theories and concepts are continually being tested.
VIEWB7	80	Mathematics/science progresses by refining theories or by replacing them with new ones.
VIEWB8	59	Hypotheses must be supported by empirical evidence.

APPENDIX K

Table K1
Means and Effect Sizes for Importance Scale Factors

	POPn	SSI Mean	Std. Dev	POPn	Non- SSI Mean	Std. Dev	Effect Size
IMPPRIN	76	3.345	0.37	353	3.206	0.391	0.359
IMPACTVT	86	3.497	0.315	392	3.294	0.325	0.628
IMPCOMM	69	2.862	0.391	350	2.595	0.438	0.620
IMPPAREN	78	3.333	0.362	3775	3.217	0.395	0.294
IMPVIEW	71	3.07	0.469	373	2.966	0.436	0.236

APPENDIX L

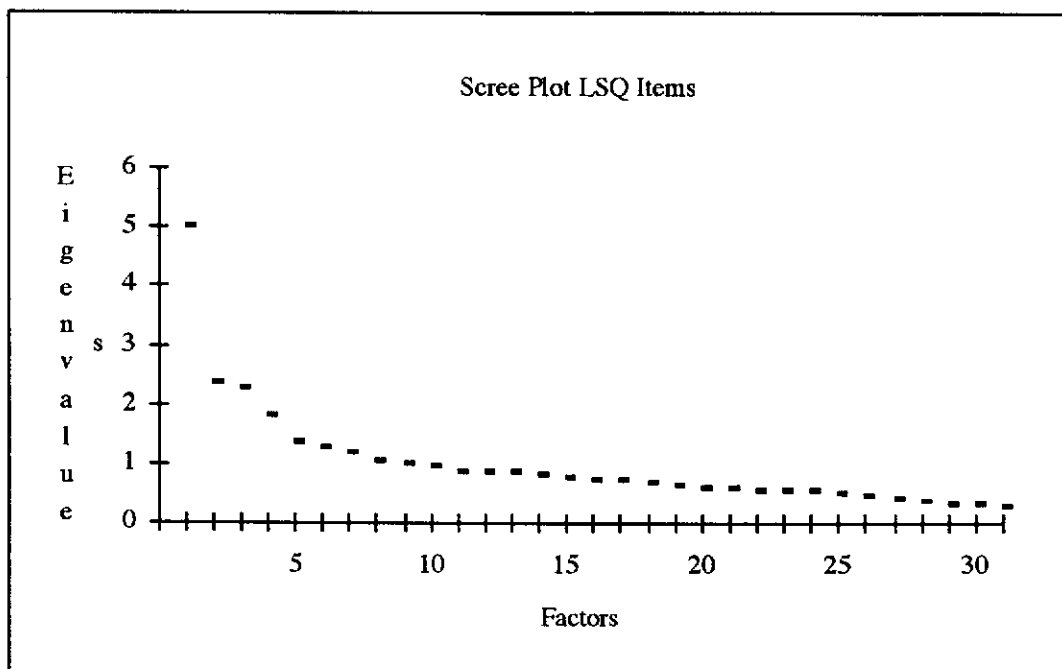


Figure L1 Scree plot for factor analysis of LSQ items.

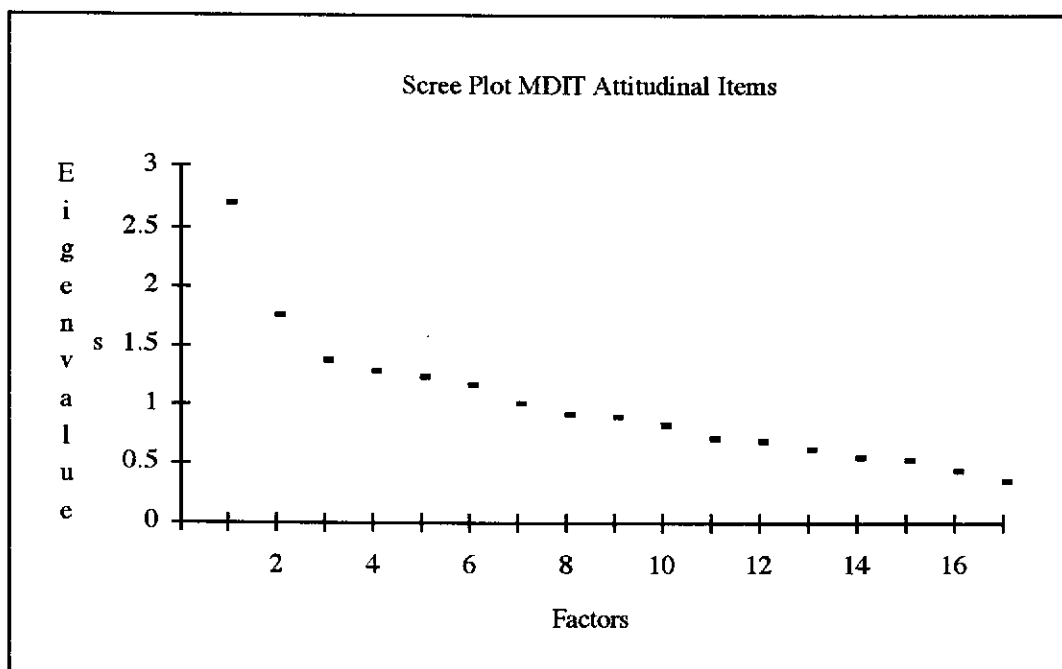


Figure L2 Scree plot for factor analysis of MDIT items.

APPENDIX N

Table N1

Factor Loadings for LSQ Factor 1: PEER

Item Number	Load	Content
view16	42	My principal talks to my teacher about what we are doing in class.
view18	73	My friends talk about math outside of class.
view19	77	My friends discuss things they have learned in math class.
view21	51	My friends work on math projects.
view22	68	My friends enjoy doing math-related activities outside of class.
view23	62	My friends are interested in math.
view30	42	At least one adult in my home goes to science and technology museums with me.

Table N2

Factor Loadings for LSQ Factor 2: CLASSTCH

Item Number	Load	Content
view2	49	My teacher asks me to give reasons for my answers.
view3	51	My teacher encourages me to ask questions.
view4	43	My teacher lets me work at my own pace.
view5	49	My teacher discusses problems that real mathematicians solve.
view7	42	In this math class, I talk with my classmates about how to solve problems.
view8	61	In this math class, I repeat problems to check results.
view9	41	In this math class, I have a say in deciding what activities I do.
view10	44	In this math class, I learn from my classmates.
view11	53	In this math class, I use information to support my answers.
view13	51	In this math class, I learn how math has changed over time.
view14	42	In this math class, I learn how math is used by people in other countries.

Table N3

Factor Loadings for LSQ Factor 3: HOME

Item Number	Load	Content
view26	73	At least one adult in my home makes me do my math homework.
view27	75	At least one adult in my home asks about what I am learning in math class.
view28	81	At least one adult in my home helps me with my math homework.
view29	75	At least one adult in my home helps me work on my math projects.
view31	40	At least one adult in my home watches science T.V. programs with me.

Table N4

Factor Loadings for LSQ Factor 4: NEGPEER

Item Number	Load	Content
view17	50	My principal complains about the noise level in my math classroom.
view20	78	My friends make fun of people who like math.
view24	76	My friends make fun of people who get good grades in math.
view25	70	My friends think math is dumb.

Table N5

Factor Loadings for MDIT Factor 1: ATTITUDE

Item Number	Load	Content
answer14	80	I like mathematics
answer15	79	I am good at mathematics
answer16	-69	If I had a choice, I would not study mathematics
answer17	69	I understand most of what goes on in mathematics

Table N6

Factor Loadings for MDIT Factor 2: HANDPROB

Item Number	Load	Content
answer6	65	I solve math problems in small groups
answer7	57	I work with hands-on manipulatives
answer8	60	I use a calculator
answer9	44	I use a computer
answer10	47	I write a few sentences about how I solve math problems

APPENDIX O

Table O1

Summary of F-values for Three-Way ANOVAs for Gender, Group and Ethnicity on LSQ and MDIT Factors.

Effect	CLASS TCH	PEER	HOME	NEG PEER	HAND PROB	ATTI TUDE
Group (A)	0.80	0.34	2.93	1.32	0.32	0.02
Gender (B)	0.81	0.01	0.93	9.92**	1.76	9.78**
Stud_eth (C)	0.04	2.03	0.00	4.95*	0.24	9.32**
A X B Interaction	1.46	0.03	0.21	0.05	2.17	0.01
A X C Interaction	1.51	0.00	1.07	1.71	1.68	0.31
B X C Interaction	0.85	2.31	0.03	0.43	0.18	0.01
A X B X C Interaction	3.04	0.01	0.10	0.58	0.50	0.67

NB: * $p < 0.05$, ** $p < 0.01$

Table O2

Mean and Effect Sizes for MDIT Sub-Group Analysis

	Non-SSI	SSI	Effect size
AA Female	38.19	48.48	0.531
AA Male	42.39	47.69	0.157
White Female	47	53.2	0.282
White Male	54.51	56.71	0.095

Table O3

Significant Differences for MDIT Achievement ANOVA Results

Variable	Comparison Group 1		Comparison Group 2		p
	Gender	Male	50.3	Female	
Stud_eth	White	52.9	AA	44.2	.0001
Group	SSI	51.6	Non-SSI	45.4	.0005

APPENDIX P

Table P1

Comparison of Pseudonyms Used in this Document as Compared to Other
Landscape Study Reports

School-name alias used in this thesis	Alias used in other <i>Landscape Study</i> reports	Teacher-name alias used in this thesis	Alias in other <i>Landscape Study</i> reports
Troy	J. Adams Middle	Ms Barb Zoran	Betty Michaels
Kingsford	West Side Middle	Ms Diane Young	Not visited again
Draper	Macon Junior	Ms Rebecca Eckland	Barb Arnold
Greenway	Urban Middle	Ms Harriet Nando	Freda Herman
Naylor	Not visited again	Ms Kathy Straub	Not visited again
Obern	Daniel Miller	Ms Patricia Dante	Pamela Fisher
Lakeview	Anderson Middle	Ms Suzanne Shortland	Annie Golf