Chapter 1: Rationale

Statement of the Problem

This study investigated the joint effects of two reforms that are beginning to have widespread impact on mathematics instruction in high schools throughout the United States and Canada. The first reform is adoption of a problem-centered mathematics curriculum initially designed to conform with the National Council of Teachers Mathematics' (NCTM's) *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). The second reform is adoption of a semestered block schedule.

Standards-based Curricula

In 1989, NCTM promulgated the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). The *Standards* called for mathematics classes to include less traditional teacher exposition and student practice, while increasing the amount of project work, group and individual assignments, and discussions between teacher and students and among students (NCTM, 1989, p. 10). The *Standards* reemphasized and strongly endorsed earlier statements by the NCTM that "problem solving must be the focus of school mathematics" (NCTM, 1980, p. 2; NCTM, 1989, p. 6). Later *Standards* documents (NCTM, 1991, 1993, 2000) provided a vision that was consistent with a problem-centered approach to mathematics instruction.

During the 1990s, researchers developed several new high school curricula specifically designed to conform with the vision described in the *Standards*. There has been considerable controversy about the worth of these new curricula ("An Open Letter to United States Secretary of Education, Richard Riley", 1999). Research to date has generally shown that these new curricula tend to have positive effects on student

achievement (Koedinger, Anderson, Hadley, & Mark, 1997; Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000; Merlino, Wolff, & Tolbert, 2000; Webb, in press). Nonetheless, the evidence is not conclusive, as these studies have generally been small in scale, with the number of schools in each study ranging from one to six. Further, in all cases teachers using the new curricula have been volunteers, and in many of the studies the students have been volunteers as well. More research is needed, to determine whether earlier results can be replicated and to extend study of reform mathematics to situations where results cannot be attributed to a volunteer effect.

Block Scheduling

Over the last decade, block schedules have become increasingly popular in high schools throughout the United States and Canada. For example, in North Carolina, the percent of high schools using a block schedule grew from 1.6% in 1992-3, to 35% in 1994-5, to 64.8% in 1996-7, to 73.6% in 1997-8 (North Carolina Department of Public Instruction, 1999). Under a traditional high school schedule, each student typically enrolls in seven courses at a time. Each course meets daily for about 40-50 minutes over a 180-day academic year. In contrast, under the most common type of block schedule, the 4x4 or "semestered" plan, each student typically completes four courses in each semester. Each course meets daily for about 80-90 minutes over a 90-day semester.

Block scheduling has become popular among administrators for a number of reasons. School atmosphere tends to be calmer, and many schools have reported fewer discipline problems under a block schedule (Carroll, 1994a; Hackman, 1995; Meadows, 1995; Reid, 1995a, 1995b; Sessoms, 1995). With fewer classes per day, there are fewer transitions, so students can spend more time in class instead of walking through hallways

between classes. Moreover, some surveys indicate that both students and parents tend to prefer a semestered block schedule to a traditional schedule (Stevens, 1976).

Principals and teachers have reported that low-achieving students find it easier to focus on four classes at a time, instead of the usual seven (Alam & Seick, 1994; Averett, 1997; Carroll, 1994a; Reid, 1995a, 1995b). Also, under a semestered schedule, students have more opportunity to retake courses that they have failed (Reid, 1995a, 1995b; Stevens, 1976; Williams, 1985). Perhaps for these reasons, case studies indicate that failure rates usually decrease after a school switches to a semestered block schedule (Hottenstein & Malatestsa, 1993; Governor Thomas Johnson High School, 1995; Hackman, 1995; Reid, 1995a, 1995b; Schoenstein, 1995b).

Finally, in response to concerns about student achievement stimulated by publications such as *A Nation at Risk* (National Commission on Excellence in Education, 1983), many states and school districts increased the number of credits required for graduation (Porter, 1998). A block schedule makes it easier for principals to meet these requirements, as more courses per year are offered.

Despite the advantages cited above, there is reason to be concerned that changing to a block schedule can actually decrease student achievement, especially in mathematics. Block schedules have been used widely in parts of Canada since the 1970s, well before they became popular in the United States. A number of large-scale studies have investigated achievement effects of block scheduling in Canada (Raphael, Wahlstrom, & McLean, 1986; Marshall, Taylor, Bateson, & Brigden, 1995; Wild, 1998). They have consistently reported that mathematics achievement under a semestered block schedule is lower than under a traditional schedule.

In contrast, anecdotal reports (Kramer, 1996), as well as some achievement data from North Carolina (Averett, 1994; North Carolina Department of Public Instruction, 1997) indicate that mathematics achievement may improve if a semestered block schedule is adopted at a school that implements instructional changes consistent with those called for by the NCTM *Standards* (NCTM, 1989). However, this possibility has never been systematically studied.

It is important to investigate how a semestered block schedule affects mathematics achievement at schools that are making substantial efforts to implement the reform called for in the NCTM *Standards* (NCTM 1989, 1991, 1993, 2000). As described below, there are three additional reasons to conduct further investigations of how block scheduling affects mathematics achievement.

First, research to date on block scheduling has often been confounded by a possible volunteer effect. Just as studies of *Standards*-based curricula compared achievement of teachers and students who volunteered to use the new curriculum to that of teachers and students who did not volunteer, so most studies of block scheduling have compared achievement at schools that voluntarily adopted a block schedule to achievement at schools that voluntarily maintained a traditional schedule. Data from North Carolina (North Carolina Department of Public Instruction, 1997) indicates that, *prior to the change*, schools that switched to a block schedule had systematically lower achievement than did schools that did not choose to switch. The volunteer effect may account for some of the discrepancies between results reported by the North Carolina studies, which controlled for prior school-level achievement, and the Canadian studies, which did not do so.

Another reason to conduct further research about the affects of semestered block schedules on mathematics achievement is the need for better measures than have been used in past studies. Previous studies have used only a single measure of achievement, either a standardized test (Raphael, Wahlstrom, & McLean, 1986; Marshall, Taylor, Bateson, & Brigden, 1995) or a standard end-of-course exam (North Carolina Department of Public Instruction, 1997; Wild, 1998). Research comparing student learning under traditional mathematics instruction to student learning under *Standards*-based mathematics instruction has found that the results can vary, depending on what type of test is used to measure achievement (Wood & Sellers, 1996; Huntley, et al., 2000). Tests emphasizing procedures and symbol manipulation tend to favor traditional instruction, whereas tests emphasizing problem solving in context tend to favor reform instruction. It is important to conduct research that not only investigates the joint impact of a block schedule and a curriculum designed to implement the NCTM *Standards*, but also uses a variety of measures designed to test the strengths both of the traditional schedule/curriculum and of the block schedule/*Standards*-based curriculum.

Finally, it is important to investigate how a block schedule affects mathematics achievement at a site where course syllabi have been adjusted to fit the schedule, by spreading mathematics content over a larger number of courses. In the United States, students generally take a larger number of courses per year under a block schedule, with fewer total minutes allocated to each course. For example, a school might change from a traditional schedule offering each student six or seven courses per year to a semestered block schedule offering eight courses per year (four each semester). Even though the total instructional time available is increased because students are spending fewer

minutes walking through hallways between classes, each individual course has fewer allocated minutes of instruction than would an analogous course under a traditional schedule. Thus, one would expect it to be difficult for teachers to cover as much content per course under a semestered block schedule as they would under a traditional schedule. In fact, teachers have reported difficulty with content coverage under a block schedule (Usiskin, 1995; Sturgis, 1995). It should be noted that both Usiskin and Sturgis reported teacher experiences under an alternating-day block schedule, an arrangement in which students take eight classes at a time, each class meeting every other day. However, an alternating-day block schedule affects allocated classroom time in precisely the same way as does a semestered block schedule, so problems in content coverage would likely be the same for both types of block schedule.

Thus, under a block schedule less content can be covered per course than under a traditional schedule. However, more courses are available per year under a block schedule than under a traditional schedule. One solution may be to change syllabi when moving to a block schedule, so that the same content is covered over a larger number of courses (Harter, 1994; Kramer, 1996). Unfortunately, in most cases research on achievement effects of block scheduling has been conducted at sites where this approach has not been implemented. The one exception was a study conducted by Zhang (2000) for the North Carolina Department of Public Instruction. His study compared 214 schools that had adopted a 4x4 block schedule between 1995 and 1997 to 68 schools that had maintained a traditional schedule. He reported that, after controlling for race, socio-economic status, and 1993-94 school level scores, students in the block scheduled schools outscored those in traditional schools on a state-mandated End-of-Course test in Algebra

1. Zhang attributed the improvement in part to the fact that some students in the 4x4 schools completed the End-of-Course test after taking "regular" algebra in a block semester, while others completed the test after taking Algebra IA and Algebra IB over two semesters.

Zhang's study investigated algebra achievement at the time students had completed a particular curriculum, delivered either in the "regular" algebra format, or the Algebra IA/Algebra IB format. It did not control for the possible costs to other mathematics learning of spreading Algebra I over two courses. For example, did fewer students in the schools using 4x4 schedules complete Algebra 2, so that by the end of high school they knew less algebra than did students in the traditionally scheduled schools? The current study addresses this possibility in the case of one particular school, by testing all students at the end of eleventh grade. Thus, instead of asking how much algebra students learned in one particular course, it asks how much algebra students learned as a result of their high school program through Grade 11, taken as a whole.

Possible Synergies Between a Standards-based Curriculum and a Semestered Block Schedule

There is reason to suspect that a *Standards*-based curriculum implemented together with a semestered block schedule might have a more positive effect on student mathematics achievement than would either reform by itself. It has been conjectured that lecturing is less effective under a block schedule than under a standard schedule (Kramer, 1996). In contrast, the kinds of group work, in-depth investigations, and problem solving emphasized by *Standards*-based curricula may actually be easier to accomplish in a

longer time block than in the shorter periods offered in a traditional schedule (Averett, 1994; Meadows, 1995, Sturgis, 1995).

Thus, adopting a *Standards*-based curriculum may help compensate for a weakness of mathematics instruction under a block schedule (the relatively poorer results of lecture), while allowing the advantages of the schedule (more total instructional time, better school atmosphere) to positively impact student learning. The semestered block schedule may facilitate successful implementation of *Standards*-based practices such as increased group work, in-depth investigations, and problem-centered instruction.