1996

An investigation of the achievement of 4 x 4 block-scheduled advanced placement calculus AB students

Carolyn Marie Keen
College of William & Mary - School of Education

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AN INVESTIGATION OF THE ACHIEVEMENT
OF 4X4 BLOCK-SCHEDULED
ADVANCED PLACEMENT CALCULUS AB STUDENTS

A Dissertation
Presented to
The Faculty of the School of Education
The College of William and Mary in Virginia

In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Education

by
Carolyn Marie Keen

December, 1996

Chair of Doctoral Committee: Robert J. Hanny, Ph.D.
AN INVESTIGATION OF THE ACHIEVEMENT
OF 4X4 BLOCK-SCHEDULED
ADVANCED PLACEMENT CALCULUS AB STUDENTS
AS INDICATED BY THEIR SCORES ON THE
1995 ADVANCED PLACEMENT CALCULUS AB EXAMINATION

by

Carolyn Marie Keen

Approved December 1996 by

Robert J. Hanny, Ph.D.
Chair of Doctoral Committee

James H. Stronge, Ph.D.

Thomas J. Ward, Ph.D.
Dedication

This work is dedicated to two excellent teachers. First, it is dedicated to my mentor, Dr. Robert J. Hanny, because without his patience and encouragement it never would have been written. Second, it is dedicated to my friend and colleague, Miss Anne R. Midyette, because she always took the time to find a way to help me through the rough spots.

For all those times you stood by me
For all the truth you made me see....
I'll be forever thankful...

You're the one who held me up
Never let me fall
You're the one who saw me through
Through it all

You were my strength when I was weak
You were my voice when I couldn't speak
You were my eyes when I couldn't see
You saw the best there was in me
Lifted me up when I couldn't reach
You gave me faith 'coz you believed

From “Because You Loved Me”
Words and Music by Diane Warren
Sung by Celine Dion (1996) on “Falling Into You” CD
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Abstract

The research investigated whether 4x4 block scheduling had any effect on students' achievement in Advanced Placement Calculus AB and described some of the dynamics involved in the shifts to 4x4 plans. Data from 51 schools (38 North Carolina, 13 Virginia) were divided into two groups: (Sample 1) 24 schools in which the course was taught in one semester (N=238) and (Sample 2) 27 schools in which it was taught in two semesters (N=355). Using two-tailed Z and $\chi^2$ goodness-of-fit tests ($\alpha=0.05$), the 1995 AP test mean score of each sample was compared to the mean of the 103,032 students who took the test. The Z test showed that Sample 1 had significantly lower scores. The effect size (−0.58) and $\chi^2$ test supported this conclusion. The $\chi^2$ test revealed significantly higher scores for Sample 2, but the Z test did not. The study also found that schools used diverse practices regarding both AP classes and the change process. The research has implications for instruction, staff development, and administrative decision-making related to block scheduling.
AN INVESTIGATION OF THE ACHIEVEMENT
OF 4X4 BLOCK-SCHEDULED
ADVANCED PLACEMENT CALCULUS AB STUDENTS
Chapter I

Introduction

"I have an offer you can't refuse!" claimed Carroll to educators in 1987 (p. 1). What he urged was a shift in perspective when considering the organization of schools. In proposing a change from the traditional organization of high schools to one built upon how students learn, Carroll created the opportunity for many educators to reconsider the benefits of reconfiguring school schedules. While his concept, the Copernican Plan, included various suggestions, its major focus was on establishing school schedules that utilized large blocks for instructional time.

Although versions of block scheduling had been around since the 1930's (Callahan, 1977b), Carroll's concept of block scheduling was part of what made his plan unique. According to Kadel (1994), while there are various ways to accomplish block scheduling, "the two basic approaches are (1) holding fewer classes per day that meet every other day for the full year (a typical even/odd or A/B schedule) or (2) scheduling fewer classes per term or more terms per year" (p. 7). Carroll's Copernican Plan focused on the latter approach, which has evolved into the 4x4 block method of scheduling.

With each passing year, more and more schools across the nation are making the shift from traditional approaches of schooling to various alternatives, many of which involve some form of block scheduling. Since the basic assumption behind block scheduling is that it accommodates quality instruction, perhaps the most serious concern to be raised is whether students learn as well and retain as much knowledge as students in traditional schedules. While the research is not extensive, what exists indicates that students learn at least as well in block scheduling and retain this learning over time.
In a case study of parallel block scheduling at the elementary level, Fogliani (1990) discovered that the approach was associated positively with student learning. Also, Wilson (1993) found statistically significant differences in mathematics achievement in favor of the parallel block-scheduled elementary school, when the effects of parallel block scheduling versus traditional scheduling were investigated.

At the high school level, one of the difficulties encountered with block scheduling, and with the 4x4 method in particular, is its impact on Advanced Placement (AP) courses. Since the AP tests are administered in early May of each year, students who take an AP course in a macroclass taught from March to June may not have covered all of the necessary material before taking the test (Kadel, 1994). Likewise, an AP course taught within the even/odd or A/B parallel block schedule might not have included all AP topics by the time the testing occurs. Additionally, if an AP course is completed first semester, several months may lapse between the instruction and the test administration.

As schools reorganize, educators need to consider how proposed changes will impact all students and programs. While the scant available research seems to favor block scheduling, is it beneficial to all students and programs? How does it impact on AP scores? Specifically, how does the 4x4 block scheduling method affect AP scores for Calculus AB students?

**Statement of Purpose**

The purpose of this study was two-fold. The research investigated whether 4x4 block scheduling (a tactic which may increase instructional units of time, yet may cause a delay between instruction and testing or a deletion of portions of the curriculum) had any
effect on students’ achievement in AP Calculus AB. An investigation of the 1995 AP Calculus AB test scores was conducted to determine if a difference existed in the achievement of AP Calculus AB students who took the course in schools utilizing the 4x4 method of block scheduling when compared with the population of AP Calculus AB students. A second purpose of the study was to describe some of the dynamics that created the shift from traditional scheduling to the 4x4 plans.

**Significance of the Study**

As conceptualized and operationalized for this research, the relationship between the method of scheduling and the achievement of AP Calculus AB students has implications for effectiveness of instruction, for student success in the next college-level mathematics course, for staff development, and for administrative decision-making. The available research on block scheduling focused on student achievement at the elementary or middle school level. Less was available that dealt with high school students and with AP students in particular. Knowing the relationship between the 4x4 method of block scheduling and student achievement in AP Calculus would be useful to educators who make scheduling decisions. Knowledge gained from this research would help school leaders obtain a more comprehensive picture of the manner in which scheduling changes effect all students and programs.

Even though school leaders had acknowledged the need to accommodate AP classes when the school was scheduled by the 4x4 method, the question remained about the method’s true impact on AP scores. With the concessions to AP classes, could it be said that those students would score differently depending upon the type of schedule...
employed? Would the arguments for longer periods of time hold true in the case of such content? While the 4x4 method of block scheduling accommodates the arguments for longer periods of instructional time, what result did it really have on AP scores? While it was true that longer periods of time may have allowed for diverse teaching strategies, including more hands-on activities, more active student involvement, and increased utilization of technology, was the time lapse between the first semester when the mathematics course was completed and the May testing dates a problem for students? Also, students who took Calculus during the second semester may have been taught by the traditional lecture method due to calendar time constraints, in which case changing the school schedule might not have served the purpose of improving instruction. Finally, the omission of objectives, no matter whether the course was taught first or second semester or with any of a number of instructional strategies, could have placed students at a disadvantage when they took the AP test.

The significance of this research derives from the importance attached to the power of the school schedule, which includes “the power to address problems, the power to facilitate the successful implementation of programs, and the power to make possible the institutionalization of effective instructional practices” (Canady & Rettig, 1995a, p. xi). As they seek to implement effective instructional practices, including the utilization of a variety of instructional strategies, teachers may find themselves confined by the traditional fifty- or sixty-minute period and resort to the lecture method due to its efficiency in delivering a large amount of information to many students in a short amount
of time. Thus, the manner in which the curriculum is delivered to students may be
governed to a large degree by the school schedule.

Hillson and Hyman (1971) contended that “changes in school demand a fresh look
at how the school schedules its time” (p. 263). In these authors’ opinions, “serious
attention to the dimension of time can serve to increase pedagogical opportunities . . . and
flexible time is a significant factor facilitating that end” (p. 265). They also cautioned that
educators considering making a change in scheduling should remember two assertions
made by Polos (1971): “that flexible scheduling of time is not a panacea for all the
problems which arise in a school” and “that it is not time which is flexible, but rather man
who is flexible in his arrangement and use of it” (p. 265). With regard to school divisions
questioning whether or not to initiate block scheduling, the words of Polos serve as a
cautions:

There are as many attitudes as there are educators, ranging all the way
from the “time is not ripe” educator to the “hollow imitator for publicity
purposes” educator suffering from that common school ailment known as
“bandwagonism.” Somewhere in the middle of this range is the judicious
educator who has carefully weighed all of the possibilities, examined
many programs that are in the field, and then proceeded with intelligent
action. (p. 287)

Research Questions

The research investigated whether 4x4 block scheduling had any effect on
students’ achievement in AP Calculus AB and what measures were taken to prepare for
the shift from traditional scheduling to the 4x4 plans. In 4x4 scheduled schools where AP Calculus AB was offered as a one semester course, did students have lower scores than the population? When the course was scheduled for two semesters in 90-minute blocks, did students perform better than the population?

**Research Questions**

The investigation was driven by the following research questions which were concerned with student achievement and with the dynamics involved in the change process to the 4x4 method:

1. Is there a difference between the achievement of students who take AP Calculus AB in a 4x4 method of block scheduling when compared to the population of AP Calculus AB students as indicated by the scores on the AP Calculus AB examination?

2. Were special accommodations made for AP Calculus AB classes at schools using the 4x4 block-scheduling method?

3. What prompted schools to make the scheduling change from traditional methods to 4x4 plans?

4. In schools that changed, who made the decision to switch to the 4x4 method of scheduling?

5. At the sites where the change was made to the 4x4 method, who had input into the decision process?

6. What measures were taken to prepare the administration, faculty, staff, students, and community for the implementation of the 4x4 method?
Population and Sample

Data were sought from all schools throughout Virginia and North Carolina that were identified as using 4x4 block scheduling and offering AP Calculus AB during the 1994-95 school year. The names of Virginia schools employing the 4x4 semester plan were found in the Directory of High School Scheduling Models in Virginia 1995-96; Study of Innovative High School Scheduling in Virginia (Rettig, 1995). Twenty-seven Virginia schools had completed at least one year of the plan by the end of the 1994-95 school year. A North Carolina State Department of Public Instruction publication, Block Scheduling, provided the names of 96 schools in that state that utilized the 4x4 block scheduling method during the period of time under investigation.

Methods

Data from each participating school were collected via questionnaire. The mean grade, standard deviation, and total number of candidates who took the 1995 AP Calculus AB test were found in the 1995 Advanced Placement Candidate Grade Distributions published by The College Board. Using a Z test, the sample mean was compared to the population mean by locating the sample mean on the standard normal distribution. Rejection regions were employed using a two-tailed test. Levels of significance were set at the .05 level of confidence. Also, a chi square ($\chi^2$) goodness-of-fit test was employed to compare the distribution of the scores in the sample and the distribution of the scores in the population.
Operational Definitions

To better understand the statement of the problem and the research hypothesis, the following terms relevant to this proposed research were defined.

1. **Block scheduling** was defined as the scheduling plan in which "[a]t least part of the daily schedule is organized into larger blocks of time (more than 60 minutes, for example) to allow flexibility for varied instructional activities" (Cawelti, 1994a, p. 73).

2. The **4x4 method of scheduling** was defined as the scheduling plan that divides the school year into two semesters in which the school day is divided into four instructional blocks of approximately 90 minutes each. At the end of the first semester, students receive credit for the four courses completed and enroll in four new ones.

3. **Student achievement** was defined as the performance by AP Calculus AB students on the AP Calculus AB test administered by Educational Testing Service (ETS) in May each year. Test scores are reported as 1, 2, 3, 4, or 5, with 3, 4, or 5 considered as passing marks.

4. **Calculus** was defined as the branch of mathematics which deals with differentiation and integration of functions and related concepts and applications. The AB level is a year course in introductory calculus with elementary functions, including topics in differential and integral calculus.

5. **Traditional scheduling** was defined as one that has classes meeting daily for 40 to 60 minutes.
6. **Population** was defined as the total number of students who took the 1995 AP Calculus AB test. The College Board (1995a) reported that students from 11,274 secondary schools participated in the testing that year.

**Limitations of the Study**

1. The sample was limited to schools in Virginia and North Carolina who were using a 4x4 form of block scheduling.
2. The study was limited to one year of data.
3. The questionnaire could have been completed by either the principal, an assistant principal, the AP coordinator, the guidance director, or the calculus teacher. Therefore, because of the personal biases or opinions of the respondent, the responses to some of the questions may not have been as accurate as possible. If another person in the same school had completed the survey, different data may have been collected, especially for the second page of survey questions.
4. No attempt was made to separate schools into samples according to whether the course was offered first or second semester. Since the AP test was given in May, the fact that first semester students may have had more instructional time than second semester students may have had consequences for the test scores.

**Assumption**

The basic assumption behind block scheduling was that it accommodated quality instruction. The major assumption of this study was that the 4x4 method of block scheduling impacted the achievement of AP Calculus AB students.
Chapter II

Review Of Literature

A review of the literature and research related to this study is presented in this chapter. Included are literature and research providing the rationale for linking use of time and school scheduling practices, current research, and literature concerning the Advanced Placement Program.

Theoretical Basis

When A Nation at Risk brought problems in our educational system to the nation’s attention in 1983, the necessity of educational reform reached the forefront. Citizens became “convinced that fundamental changes were necessary in the American educational system in order to raise performance levels, prepare students for lifelong learning, educate all students well, and create learning environments better suited to the needs of disadvantaged persons” (National Research Council (NRC), 1989, p. 73). Since the release of A Nation at Risk, numerous reports have analyzed various aspects of this problem. “Some call for changes in curriculum, others for changes in the structure of schools; some cite deficiencies in the ways teachers are educated, while others examine signs of decay in the social and economic structures of society. All agree that the present system must change” (NRC, 1989, p. 2-3).

Even before the advent of A Nation at Risk, educators realized that change was required. In 1971 Moore wrote, “If we are really serious about excellence in our high schools, then schools must break away from traditional practices and experiment with new and promising ideas” (p. 276). About that same time, one area that caught educators’ attention was the school schedule. Johnson (1971) pointed to this arena with his
contention that "at a time when teachers are increasingly concerned about a greater role in
developing the structure for learning in the school, it seems appropriate that all schools
look at current scheduling practice. All too often, we place students in an unnecessarily
rigid schedule which allows very little opportunity for teacher or student modification" (p. 275).

Fifteen years later, Cuban (1986) maintained that basic instructional practices and
school structures remained in place despite years of classroom-based reform efforts. The
cry was reiterated in 1994 by Oxley: "There seems to be no exit from traditional school
practices that include large size, academic departmentalization, homogeneous grouping,
50-minute periods, and whole class instruction" (p. 179).

Attempting to address the issue of school practices, Congress passed the
Education Council Act of 1991, which established an independent advisory body, the
National Education Commission on Time and Learning (The Commission), for the
purpose of conducting a comprehensive review of the relationship between time and
learning in the nation's schools. The nine-member Commission was directed to prepare a
report on its findings for the American people within two years of its first meeting. The
resulting document, Prisoners of Time, was released in 1994 and contained several
messages. The findings of the report were summarized by Commission Chairman Jones:

Learning in America is a prisoner of time. Times have changed, and the
nation's schools must change with them. We have been asking the
impossible of our students—that they learn as much as their foreign peers
while requiring them to spend only half as much time in core academic
subjects. The reform movement of the last decade is destined to founder unless it is harnessed to more time for learning. Time is the unacknowledged design flaw in American schools. (The Commission, 1994b, p. 3-4)

Use of Time in Schools

Carnegie Units. While seeking to answer the question of how much time is actually provided for academic learning in United States elementary and secondary schools, the Commission discovered that although there were variations across the states, clear patterns could be identified. At the secondary level a definite pattern was found. The secondary schools with which people are most familiar have organized students and teachers according to a pattern centered around a standard unit of instruction that was established in 1909 and known as the Carnegie Unit (The Commission, 1994b). Callahan (1977a) defined the Carnegie Unit as “the amount of credit granted to a student for devoting one period a day for the thirty-six weeks of the school year to instruction in a given subject” (p. 24). Based on Carnegie Units, states required that students take specified numbers of courses in subjects such as English, mathematics, and science in order to graduate. “Although the Carnegie Units do not control the level of rigor of courses students must take, they are intended to insure that all students will, at a minimum, be exposed to instruction in certain subjects for specified amounts of time” (The Commission, 1994b, p. 17). Since the Carnegie Unit was established as the norm, there has been opposition to the fact that time spent in class has been used as the criterion
for graduation rather than the mastery of basic concepts, skills, and attitudes (Callahan, 1977a; Carroll, 1987; Fogliani, 1990; Kadel, 1994).

**Time requirements.** In its April 1994 report, the Commission made the following observations about time schedules in America’s schools:

- With few exceptions, schools open and close their doors at fixed times in the morning and early afternoon.

- With few exceptions, the school year lasts nine months, beginning in late summer and ending in late spring.

- According to the National Center for Education Statistics, schools typically offer a six-period day, with about 5.6 hours of classroom time a day.

- No matter how complex or simple the school subject . . . the schedule assigns each an impartial national average of 51 minutes per class period, no matter how well or poorly students comprehend the material.

- The norm for required school attendance, according to the Council of Chief State School Officers, is 180 days.

- Secondary school graduation requirements are universally based on seat time—“Carnegie Units.”

- Staff salary increases are typically tied to time--to seniority and the number of hours of graduate work completed.

- Despite the obsession with time, little attention is paid to how it is used.

(p. 7)
According to the Commission's analysis, "an average of 41 percent of students' time over four years of high school is required to be spent studying core courses as defined by the Commission: English/language arts, mathematics, science, history, geography, civics, foreign language, and the arts" (1994b, p. 17). The remaining amount of time, a significant portion, was utilized for electives, which the Commission did not define. In states with time requirements or recommendations, there appeared to be a consistent common core of subjects which received most of the allocated time. The recommendations and requirements of these states pertained almost exclusively to the subjects of English, mathematics, science, social studies, the arts, and health and physical education (Commission, 1994b, p. 17).

Another finding of the Commission was a general movement away from specifying how time should be used. Over the past several years, a few states had abolished time requirements. These states tended "to adopt strategies of specifying desired results and giving schools and districts the responsibility of devising plans to achieve those results" (1994b, p. 18). Such strategies opened the door to diverse scheduling practices such as block scheduling.

**Efficient Use of Time.** For numerous years researchers have argued that time should be used more efficiently (Bloom, 1980; Justiz, 1984; Rossmiller, 1983; Walberg, 1988). Bloom (1980) declared that time had always been recognized "as a central factor in all learning," and that the variable of time-on-task should be considered as well as the concept of time available for learning. He defined time-on-task as "active learning time, time that students are engaged in learning" and contended that "if two students are in the
same classroom and one is actively engaged in learning for 90% of the classroom hour while the other is actively engaged for only 30% of that hour, there will be quantitative as well as qualitative differences in their learning during that hour” (p. 382). Bloom maintained that since the percentage of engaged time (whether for individuals or groups of students) was highly related to achievement and to indices of interests or attitudes toward the learning, attention should be paid to students’ amount of time-on-task. He believed that time-on-task could be altered positively (or negatively) by the instructional process with direct consequences for the learning that would take place (p. 383). With block scheduling, whether it be 4x4, alternate day, or some hybrid form, Bloom’s arguments still hold. Merely extending the time available for daily instruction without attending to the instructional process seems unlikely to produce positive gains.

In addition to Bloom’s concerns, other educators unveiled evidence that time was not being used in the most efficient manner. Rossmiller (1983) stated that a number of researchers had observed that approximately 60% of the school day was actually available for instruction. According to his work, the amount of time actually available for student learning is influenced by several factors: the length of the school year; the number of days a student attends school; the number of days school is not in session due to strikes or inclement weather; the time required for lunch, for changing classes, for announcements, or for other “housekeeping” activities; and the time needed for procedural activities within each classroom. In conclusion, Rossmiller declared that less than half of the number of hours “that constitute a typical school year are actually devoted to the instruction of students” (p. 46-47).
Another investigation that was concerned with the instructional time available during the school day was completed by Justiz in 1984. As a result of his work, he claimed that “we lose 55% of the time we allocate for learning in our elementary and secondary schools” and wondered why educators did not try to make better use of the time currently available instead of creating longer school days and years. His findings indicated that an average of 5% of time lost is due to attendance problems; an average of 16% is lost before students ever get to class because of “homeroom exercises, assemblies, class changes, lunch hours, and other regular noninstructional school functions”; and an average of 16% is lost in the classroom “in the process of organizing the class and by distractions resulting from student conduct, interruptions, and administrative processes” (p. 483). As a result of his research, Justiz cautioned that “if the time we allocate for academic learning is limited, student achievement will be restricted” (p. 484). With block scheduling, the available time for instruction would be impacted by all the factors noted by both Rossmiller and Justiz. This area warrants further research.

A few years after the work of Rossmiller and Justiz, Walberg (1988) commented that although there had been a substantial increase during the 20th century in the amount of time devoted to schooling in the United States, it was “difficult to argue that the time allocated is yet sufficient given the increasing cognitive demands of the job market, poor achievement scores of U.S. students by international standards, and the average of 28 hours per week they spend watching television” (p. 85). Because learning depends on what is being taught, the instructional method employed, and the aptitude of the student, the question of how much time is needed for learning cannot be answered in absolute
terms. Yet, Walberg maintained that "raising time allocations and engaging students for a greater fractions [sic] of allocated time are likely to help learning" (p. 85).

Later, in Fall 1993, Wang, Haertel, and Walberg (WH&W) authored "Toward a Knowledge Base for School Learning" with three primary purposes in mind, one of which was "to identify the relative effects of a wide range of variables that influence learning" (p. 250). WH&W found that teacher behaviors and classroom organization and management were linked to student outcomes and outlined eight categories encompassed by the theoretical construct they termed "Classroom Practices." Two of the categories, Quantity of Instruction and Classroom Management, incorporated the issue of the use of time in schools. WH&W claimed that variables within the Quantity of Instruction category had been well-researched and that strong agreement existed that "students need to be fully engaged in their academic pursuits and that teachers need to make wise use of instructional time (Berliner, 1979; Carroll, 1963; Harnischfeger & Wiley, 1976)." The variables in this category included: "length of school year and day; time on task; time spent on educational activities such as classroom instruction, homework, field trips, and viewing educational television; and...content missed in regular classrooms when students were removed for pull-out programs." The authors included Classroom Management as a category because they believed that "empirical findings" had "abundantly demonstrate[d] the effectiveness of particular classroom management techniques (Doyle, 1986). Effective classroom management has been shown to increase student engagement, decrease disruptive behaviors, and enhance use of instructional time, all of which results in improved student achievement" (p. 262).
School schedules. While educators have emphasized the need for school time to be utilized efficiently, there has been no consensus regarding the means to accomplish this goal. Extending the school year, lengthening the school day, and reconfiguring the school schedule have been among the suggestions offered by educators. From the options, numerous schools have seized upon the concept of block scheduling as a vehicle for managing time.

According to Canady and Rettig (1995b), a "well-crafted schedule" could be helpful in several ways: more effective use of time, space, and resources; improved instructional climate; solutions for problems related to the delivery of instruction; and the establishment of desired programs and instructional practices (p. 4). Providing quality time, creating a school climate, and providing varying learning time were identified by these educators as three issues facing all schools that redesigning the school schedule could help address. Fragmented instructional time was considered an issue because students traveling through a six-, seven, or eight period day will encounter the same number of pieces of unconnected curriculum each day, with little opportunity for in-depth study. A school's climate could be greatly effected by the daily schedule because traditional schedules create situations that may contribute to the number of discipline problems. "Many disciplinary referrals result from scheduled transitions, when large numbers of students spill into hallways, lunchrooms, and commons areas, or congregate in locker rooms and bathrooms. If students are not sent to the office directly, the problems often carry over into the classroom, where teachers must deal with them before beginning instruction" (p. 6). The traditional schedule also contributes to the depersonalizing nature
of high schools, since it is difficult to develop close relationships, which may help reduce discipline problems, when teachers are responsible for 100-180 students daily, and students must answer to six, seven, or eight teachers a day. Short instructional periods may also contribute to a negative classroom climate because students who misbehave and do not respond to quick correction may be sent to the office. With short class periods, any time taken away from classwork is unacceptable.

Because some students need more time to learn than others, Canady and Rettig believed that providing varying learning time was a third issue that confronts all schools. The Commission (1994b) reasoned that students learn at different rates due to different learning styles, different aptitudes, and differing levels of motivation (p. 22). After first-semester grades are reported, some students decide there is no way to pass a subject regardless of their performance during the second semester. Because they think they have nothing to gain by doing the work, some of these students create classroom disruptions or skip classes. "In a way, we have created a system to handle students who need more time to learn: we give them Fs and make them repeat the course during summer school or the next academic year" (Canady & Rettig, 1995b, p. 6).

For students who learn more quickly, the traditional schedule offers limited possibilities for acceleration. However, it seemed to Canady and Rettig that most school districts, do offer one "celebrated occasion for advancement." When students near the end of 7th grade:

Teachers must decide whether or not a student should enroll in algebra during the 8th grade. This inflexible system forces instructors to make
premature decisions about a student’s potential in mathematics. If the school schedule were not as rigid, perhaps educators could make the decision to accelerate students at more appropriate times. (1995b, p. 6)

**Instructional Time**

**Instruction time.** In its publication *Agenda for Action*, the NCTM (1980) declared that instructional time was a “precious commodity” that should be used wisely. These educators maintained:

What is learned relative to a topic, how long it is retained, how readily it is applied—all these depend on the learning process the students pass through and how effectively they are engaged in that process . . . Learning is a product of both the time engaged in a learning task and the quality of that engagement. Teachers must employ the most effective and efficient techniques at their command. They must apportion instructional time according to the importance of the topic, recognizing that the value of a skill or knowledge is subject to change over time. (p. 11)

Because of this position, the NCTM recommended several actions be taken by educators. Those that pertained directly to the use of instructional time were:

- 4.1 The major emphasis on problem solving in the curriculum must be accommodated by a reprogramming of the use of time in the classroom.
- 4.2 School administrators and parents must support the teacher’s efforts to engage students more effectively in learning tasks.
4.3 Teachers should use diverse instructional strategies, materials, and resources. (p. 11-12)

In order to accommodate some of these suggestions, the classes need to be lengthened. Some instructional strategies such as lab activities and cooperative learning are more time consuming than others. If teachers find themselves constrained by the minutes allocated by the traditional schedule, they may resort to the lecture method simply because more information can be disseminated quicker. Block scheduling would afford teachers more time for diversity which would allow for more active student participation.

Instructional practices. When exploring teaching practices that contribute to the negative effects of the design flaw in schools, the Commission (1994b) found that how productively learning time was used was determined by teachers' instructional methods and classroom management techniques. According to the research found by the Commission, "some teaching strategies promote more concentrated, efficient learning than do others" (p. 25). However, many teachers spend a majority of their day in their classrooms practicing what they already know because the time teachers can invest in instructional improvement is minimal and because schools place a low priority on professional development (p. 40-41).

In The New Direction in Educational Research: Alterable Variables, Bloom (1980) wrote:

If we are convinced that a good education is necessary for all who live in modern society, then we must search for the alterable variables that can
make a difference in the learning of children and adults in or out of the school. Such alterable variables will do much to explain the learning process, and they will do even more to directly improve the teaching and learning processes in the schools. (p. 385)

Furthermore, Bloom contended that group learning was central in schools and that it was difficult to provide adequate feedback-correctives for the teacher and the numerous learners in each classroom. As a result, much instruction may take place without adequate learning on the part of many of the students. He noted that the basic problem of group learning was "to find ways of providing feedback-corrective processes as an integral part of the classroom teaching/learning interactions" (p. 384) and believed that time was an alterable variable that could assist with this dilemma.

Agreeing with Bloom's idea that time on task can be increased or decreased depending on school organization, Ryan (1991) maintained that once a policy to reschedule time-on-task was activated, achievement would be affected. "Time can be an absolute factor that affects a given learning experience. The allocation of time is the single most controllable, and therefore, one of the most powerful operational decisions a school can make" (p. 26-27).

**Mathematics Instructional Time**

In recent years, technological advances have made computers and calculators affordable for schools, teachers, and students. The availability of these tools has led to their increased usage in classrooms and a broadening of the opportunities for students and teachers to view and manipulate phenomena that previously had been abstract or
unwieldy. Mathematics instructors have been encouraged to increase calculator usage, lab activities, and manipulatives by NCTM publications such as the *Curriculum and Evaluation Standards for School Mathematics* and, in some cases, by state mandates. Those teachers who have obliged have often found themselves restricted by the amount of class time available.

Viewing classrooms as "places where interesting problems are regularly explored using important mathematical ideas," the NCTM (1989) declared "that what a student learns depends to a great degree on how he or she has learned it" (p. 5). However, "in too many schools, teachers will find it difficult to teach the mathematical topics or create the instructional environments envisioned in . . . [the NCTM] standards because of local constraints, such as . . . inadequate time for instruction" (p. 254). According to the *Professional Standards for Teaching Mathematics*:

With the growth of professionalism comes the need for fundamental rethinking of the structure of schools. At the present time teachers are often faced with trying to teach mathematical inquiry in time periods that are entirely inappropriate. Changes, such as meeting classes less often but for a longer period of time, should be explored. (NCTM, 1991, p. 190)

Throughout the years, other educational commissions and groups have made suggestions similar to those taken by the NCTM. For example, in 1983, the National Science Board Commission on Precollege Education in Mathematics, Science & Technology (NSB Commission) recommended that time for teaching mathematics, science and technology be increased. From successful programs and their learning
environments should be gleaned three lessons: (1) quality teaching is critical; (2) early exposure is critical; and, (3) increased time for teaching of mathematics, science, and technology is required (p. 22-23). “If mathematics, science and technology are to be successfully learned, it is clear that the teachers must be of high talent, high motivation and must be allowed to function in a setting in which effective teaching is possible” (p. 22). To increase time spent in these areas and to devote more time to “hands-on” activities, “schedules must be changed . . . and ways must be found to use time more efficiently and effectively. Schools must become more efficient in the use of their academic day” (p. 23).

In its 1989 publication, Everybody Counts, the National Research Council (NRC) stated, “Mathematics education takes place in the context of schools. Like other subjects, mathematics is constrained by limits of school and society, of texts and tests. Much that needs improvement must be accomplished by systemic remedies that affect all subjects and schools” (p. 3). The principles of learning should take precedence over administrative convenience. Where the objective is the productive applicability of the learned technique to real-life problems, “reasonable standards of time-effectiveness and cost-effectiveness should be applied to the use of instructional time” (NCTM, 1980, p. 6). However, “the important interplay and integration of mathematics and its applications in learning should not cease because isolated course structure separates mathematics from disciplines that apply it” (NCTM, 1980, p. 19).

Because research in learning has shown that learners “construct their own understanding based on new experiences that enlarge the intellectual framework in which
ideas can be created," the NRC (1989) contended that "each individual's knowledge of mathematics is uniquely personal" (p. 6). Much of the failure of mathematics instruction can be tied to methods of teaching that are inappropriate to the way most students learn.

"There is little we do in America that is more important than teaching" (NRC, 1989, p. 57). Yet, the least effective mode for mathematics learning, lecturing and listening, is the one that prevails in most classrooms. While presentation and repetition help students do well on standardized tests and lower-order skills, they generally are not effective instructional strategies for long-term learning, higher-order thinking, and versatile problem-solving. Agreement with this notion was found in *Reshaping School Mathematics: A Philosophy and Framework for Curriculum:*

Research on teaching for higher-order thinking lends support to the notion that instruction needs to change from the traditional mode where the teacher presents the material to a less structured, more indirect style of teaching. Because the development of higher-level thinking in mathematics depends on autonomous, independent learning behavior, teachers (and parents) must learn how to encourage more self-reliance in students who are learning mathematics. (Mathematical Sciences Education Board (MSEB), NRC, 1990, p. 28)

Mathematics teachers need to encourage students to be actively involved in learning. Increased understanding may result when students are actively involved in the learning process. To encourage more active student participation, teachers should become consultants, moderators, and questioners. Classroom activities should be designed to
encourage students to express their approaches. Students "must learn to work cooperatively in small teams to solve problems as well as to argue convincingly for their approach amid conflicting ideas and strategies" (NRC, 1989, p. 61). However, ETS (1988) concluded:

Considering the prevalence of research suggesting that there may be better ways for students to learn mathematics than by listening to their teachers and then practicing what they have heard in rote fashion, the rarity of innovative instructional approaches is a matter for true concern. Students need to learn to apply their newly acquired mathematics skills by involvement in investigative situations, and their responses indicate very few opportunities to engage in such activities. To improve their understanding of mathematics and their ability to solve mathematical problems, students need the benefit of instruction that emphasizes application of their skills in real-world situations. (p. 76)

Although greater instructional effort may be required for less directive strategies of teaching, less teaching should yield more learning in the long run. "As students begin to take responsibility for their own work, they will learn how to learn as well as what to learn." (NRC, 1989, p. 61). One thing to keep in mind, however, is that less directive instructional strategies can require more continuous class time than the traditional 50- or 55-minute period allows. When the school schedule conflicts with the time requirements of new approaches, frustration and failure can lead to the discarding of innovations and a return to what works within the confines of the allotted time.
According to the *NCTM's Curriculum and Evaluation Standards for School Mathematics* (1989), the central focus of the mathematics curriculum should be problem solving. In its broadest sense, mathematical problem solving “is nearly synonymous with doing mathematics” and “serves not only to answer questions raised in everyday life, in the physical and social sciences, and in such professions as business and engineering but also to further extend and connect mathematical theory itself” (p. 23). Glum (1990) found that although most mathematics teachers agree that higher order thinking is important in mathematics instruction, they are unable to accomplish what they would like to be able to do. According to his work:

There are a number of plausible explanations for this contradictory state of affairs. The possibilities include (i) teachers really are trying to teach higher order thinking, but the students cannot or will not learn and/or cannot or will not apply what they learn; (ii) teachers think that they are teaching problem solving but, instead, they are teaching rote application of algorithms, narrow approaches to small classes of problems, or translation of words to equations; or (iii) although they would like to teach problem solving, teachers are not doing so because they don’t know how, student competency tests don’t include problem-solving items, or there isn’t time. (p. 73)

Block scheduling would allow longer periods of time in math classes, thereby providing the opportunity for more class activities that stressed problem-solving. With
appropriate staff development, teachers would be able to apply new techniques during instructional time.

**Educational Reform and Time Utilization**

Twenty-five years ago Polos (1971) argued that schools must change:

There is no doubt that the new school of the twenty-first century which is emerging from a traditional agricultural past will be 'time-oriented.' This is not due to the fact that teachers and students greet the new approach with acclaim and welcome this new horizon but because the burgeoning of knowledge of our nuclear age demands that educational time be used differently. (p. 291)

Emphasizing the continued need for educational reform, the NCTM proclaimed in 1989 that "schools, as now organized, are a product of the industrial age... created to provide most youth the training needed to become workers in fields, factories, and shops." The group further contended that the educational system of the industrial age did not meet the current economic needs and believed that new societal goals for education should "include (1) mathematically literate workers, (2) lifelong learning, (3) opportunity for all, and (4) an informed electorate. Implicit in these goals is a school system organized to serve as an important resource for all citizens throughout their lives" (p. 3). An examination of the organization of schools would highlight areas in need of revision in order to accomplish these goals.

According to Oxley (1994), in the 1980s school restructuring emerged "as a vehicle for dismantling the existing school structure to make way for new, more flexible..."
arrangements of people, space, and time" (p. 179). Since then, "many states and school
districts across the nation have set high expectations and goals for all learners and have
devised programs for helping students and schools in ways that allow them to reach those
high expectations" (Pandey, 1990, p. 39). Block scheduling frequently has been a
foundation for many of these reform movements.

As a result of its study on time and learning, the Commission counseled state and
local boards to "work with schools to redesign education so that time becomes a factor
supporting learning, not a boundary marking its limits" (1994b, p. 31). According to the
Commission, "For the past 150 years, American public schools have held time constant
and let learning vary. The rule, only rarely voiced, is simple: learn what you can in the
time we make available" (1994a, p. 7). American schools were criticized because
"schools and the people involved with them—students, teachers, administrators, parents,
and staff—are prisoners of time, captives of the school clock and calendar" (1994b, p. 7).
To remedy the situation, the Commission offered eight recommendations to the nation:

- Reinvent schools around learning, not time.
- Fix the design flaw. Use time in new and different ways.
- Establish an academic day.
- Keep schools open longer to meet the needs of children and communities.
- Give teachers the time they need.
- Invest in technology.
- Develop local action plans to transform schools.
• Share the responsibility. Finger pointing and evasion must end. (1994b, p. 7)

When explaining what was meant by the recommendation that the academic day be reclaimed, the Commission addressed, among others, two important questions. “Is student performance so poor that we should be worried about the amount of time spent studying academic subjects?” (1994b, p. 12-13) was answered with a qualified affirmative—if Americans believe our students should be competitive with other countries, believe the schools of today should be doing better than the schools of the past, and want to see students who are able to do what they should be able to do. “Why must we give serious consideration to the issue of time for academic learning if we expect students to achieve the high standards being set today?” (1994b, p. 12-13) was another point of interest. Evidence found by the Commission suggested that more time will be required if students are to meet national standards which define what students at different stages in their education should know and be able to do. As the standards are implemented, they should serve as guides for better utilization of time.

In 1991 Ryan maintained that, although traditional structures are hard to replace, students and families are changing; thus, forcing schools to adapt to new sets of circumstances. Therefore, “if the school is to fulfill its societal role, it must be ready to make fundamental operational changes that allow more time for enhanced student-teacher relationships by providing an environment that nurtures collaboration and mutual trust among students, teachers, and the changing society in which they live” (p. 29). By restructuring the time factor, secondary education may advance these goals.
Canady and Rettig (1995b) contended that it has been only in the last decade that educators have begun to capitalize on the potential of scheduling to improve schools. "With open minds and equal doses of creativity and technical expertise, school administrators, teachers, parents, and students can harness this power" (p. 10) and structure schools in less traditional patterns. The design flaw of time will continue to exist in schools as long as the assumption that all students can learn on the same schedule serves as the basis for their organization. The challenge for educators is "to devise structures in schools that provide instruction geared to student differences and permit students to learn at their own rates. Students who need more time to learn would receive it, while those that require the challenge of a fast-paced curriculum would be encouraged to move forward" (The Commission, 1994b, p. 22). School officials should be obligated to set priorities and adhere to them because "as with any scarce resource, we must treat time with respect and allocate it wisely" (The Commission, 1994b, p. 20).

In its 1996 report, Breaking Ranks: Changing an American Tradition, the National Association of Secondary School Principals (NASSP) declared: "The manner in which a high school organizes itself and the ways in which it uses time create a framework that affects almost everything about teaching and learning in the school" (p. 60). Accordingly, the group offered some recommendations. Within the format of block scheduling these suggestions could be accommodated. The NASSP advocated the following:

- High schools will create small units in which anonymity is banished.
• Each high school teacher involved in the instructional program on a full-time basis will be responsible for contact time with no more than 90 students during a given term so that the teacher can give greater attention to the needs of every student.

• High schools will develop flexible scheduling that allows for more varied uses of time in order to meet the requirements of the core curriculum.

• The Carnegie Unit will be redefined or replaced so that high schools no longer equate seat time with learning.

• The high school will reorganize the traditional departmental structure to meet the needs of a more integrated curriculum.

• Each high school will present alternatives to tracking and to ability grouping without restricting the range of courses and learning experiences it offers.

• The academic program will extend beyond the high school campus to take advantage of learning opportunities outside the four walls of the building.

• Schools will operate on a 12-month basis to provide more time for professional staff development, collegial planning, and the added instruction needed to promote better student learning. (p. 60-61)

Other reform movements also had been concerned with time utilization. One such movement was the Coalition of Essential Schools (The Coalition), a reform network of more than 150 member schools in 30 states founded in 1984 (Sizer, 1992). The Coalition
emerged from Sizer's desire to redesign the high school for better student learning and achievement and endorsed nine "Common Principles." In brief these were:

- The school should focus on helping adolescents learn to use their minds well.
- The school's goals should be simple: each student should master a number of essential skills and be competent in certain areas of knowledge.
- The school's goals should apply to all students, but the means to these goals will vary as these students themselves vary.
- Teaching and learning should be personalized to the maximum feasible extent.
- The governing metaphor of the school should be student as worker, rather than the more familiar metaphor of teacher as deliverer of instructional services.
- Students embarking on secondary school studies are those who show competence in language and elementary mathematics.
- The tone of the school should explicitly and self-consciously stress values of unanxious expectation...of trust...and of decency.
- The principal and teachers should perceive of themselves first as generalists...and next as specialists.
- Administrative and budget targets should include substantial time for collective planning by teachers, competitive salaries for staff, and an
ultimate per-pupil cost not more than 10 percent higher than at traditional schools. (Sizer, 1992, p. 207-209)

The principle which supported "the student-as-worker" idea had certain ramifications. Teachers found that they need larger blocks of time, so the daily schedules changed at many Essential Schools. "If students have to do the work, and master it thoroughly, the pace of the courses slows down. The student-as-worker mode, thus, tends to emphasize the importance of other matters, such as the allocation of time, the development of the curriculum, and the scope and expectation of tests" (p. 211).

The Commission was another group interested with time utilization in schools. In its September 1994 report, *Prisoners of Time: Schools and Programs Making Time Work for Students and Teachers*, the Commission presented brief program descriptions of 40 schools and revealed "remarkable creativity on the part of school personnel in reconceptualizing the use of school time." The report concluded that of the models included, the most common approaches to the issue of the use of time in descending order were "(1) redesigning available time; (2) employing technology; (3) extending the school day or year; (4) providing time for professional development; and (5) providing support services for children or families" (1994c, p. 11). At the secondary level redesigning available time was by far the most popular approach, although various strategies to accomplish that goal existed.
**History of School Scheduling Reform**

**Flexible scheduling**

Since the development of the Carnegie Unit, most schools have been restricted to traditional every-day, single-period schedules. However, there was a time in the 1960s and 1970s when some schools' leaders dared to be different and attempted scheduling reform in the form of “flexible scheduling.” Bearing a striking similarity to block scheduling, the flexible modular scheduling, also known as the Trump Plan after its originator J. Lloyd Trump, may be viewed as the forerunner to the 1990s school scheduling restructuring efforts.

As defined by Trump (1967), the goal of flexible scheduling was “to return to teachers and students as much freedom as is reasonable in the use of time, space, numbers, and content for instruction” (p. 394). What appeared to Trump to be necessary ingredients for flexible scheduling included the following:

- The class schedule may be changed daily on the basis of teacher requests;
- each student, under competent direction and with appropriate controls,
- makes decisions regarding his part in the established schedule; conflicts for students and teachers are reduced to a minimum; teacher loads and pupil loads are such to permit on the one hand maximum professionalization of teaching and on the other the maximum potential learning opportunities for students; the school knows what its students are doing and follows reasonably equitable personnel policies for teachers; the whole scheme is financially feasible and logistically operational. (p. 396)
The Trump Plan called for the school time of students to be divided among large-group instruction, individual study, and small-group discussion. Decisions made concerning time to be spent, sequences, and the most appropriate activities and resources were based on "the differences among individuals, groups, and subjects" and brought about "a variety of study patterns" (Trump, 1966, p. 367). The plan called for frequent regroupings of learners due to individual differences in abilities, interests, and needs.

Unruh and Alexander (1974) stated that the primary objective of flexible-modular scheduling was to improve the quality of education and identified four major categories of flexible schedules: block, open-lab, rotating, and flexible modular. When discussing flexible scheduling, Unruh and Alexander employed Heathman and Nafziger's definition (as cited in Unruh & Alexander):

Flexible scheduling is an operating framework characterized by classes of unequal length which meet at differing periods throughout the week and which are geared to the individual needs of students. Flexible scheduling may vary from merely rearranging time allotments and sequences of established courses to a complex modular approach in which schedules for each student are generated daily and picked up by the student each morning. (p. 130)

With the advent of innovations in the 1960s and 1970s such as team teaching, individualized instruction, and continuous progress, educators began to look at flexible scheduling as a means to plan for "using" school time rather than "spending" it to accomplish educational objectives. Some schools dropped the fifty-minute period as their...
basic unit and instituted the module, “a short length of time which can be used alone or in combination with other modules so as to fit the particular needs of the various activities going on simultaneously in the school” (Hillson & Hyman, 1971, p. 264). In these schools, educators considered the standard number of minutes required for the Carnegie units to be too long for some purposes and too short for others. Since it was thought that not all classes needed to meet daily or for the same amount of time, flexible modular scheduling allowed for a more efficient distribution of time.

However, the implementation of modular scheduling was “an administrative nightmare” because students spent “large amounts of time doing independent study” and disciplinary problems arose due to the lack of supervision (O’Neil, 1995a, p. 13). Another difficulty stemmed from insufficient training of teachers in varieties of instructional strategies to use in the altered class formats. Consequently, although as many as 15% of junior and senior high schools tried some form of flexible modular scheduling, the methods were eventually abandoned.

Canady and Rettig (1995a) reported that since the downfall of the flexible modular scheduling reform effort, “it has repeatedly been reported in the literature that the traditional schedule did not support many of the changes that needed to be made in high schools across the country” (p. 4). Out of these criticisms that have been directed against traditional school scheduling practices, the limiting of instructional possibilities for teachers and the lack of flexible time for teaching and learning seem to be the ones most directly related to student achievement.
Block Scheduling

**Early attempts.** In the 1960s and 1970s some school administrators achieved flexibility by using one of three methods to implement a variable schedule: block-of-time, floating or revolving classes, or time modules. Of the three methods, perhaps the block-of-time is an ancestor to Carroll’s design in his Copernican Plan, which will be described later in this work. According to Callahan (1977b), the block-of-time method used to achieve variability was “an offshoot of the core curriculum movement of the 1930s” that allowed for two or three consecutive periods with one teacher or team (p. 204). In addition to facilitating the integration and correlation of courses, the block-of-time method allowed more opportunity for teachers to know their students better and to devote more time to individual assistance and guidance.

**Recent interest.** Although block scheduling was tried in the 1960s and 1970s and abandoned, the method has seen a revival in recent years, albeit with some changes to the concept. Cawelti (1994a) defined “block scheduling” as the school scheduling practice where “at least part of the daily schedule is organized into larger blocks of time (more than 60 minutes, for example) to allow flexibility for varied instructional activities” (p. 23). Educators implementing block scheduling in the 1990s attempted to avoid the mistakes of the 1960s by providing “large blocks of time where classes meet on a consistent basis” with “little, if any, unscheduled school time . . . available for students” (Canady & Rettig, 1995a, p. 18).

The alternate day block schedule has been referred to as the A-B block schedule. If students take six or eight classes, half of the classes meet in double instructional blocks.
one day, while the other half of the classes meet in double blocks the next day. In schools that offer seven periods, six courses meet in double blocks every other day; while one course, a "singleton," meets daily in the single-period format (Canady & Rettig, 1995a, p. 31-32). Additionally, to meet their particular needs, some schools have made modifications to the basic alternate day block schedule.

Proponents of the method have maintained that block schedules were a catalyst for innovation in the classroom because longer class periods liberated teachers whose innovative methods did not fit the traditional schedule and "provided a nudge to teachers who 'stand-and-deliver'" (O’Neil, 1995b, p. 12). Additionally, educators in schools using block schedules have reported that overall school climate has improved as students and teachers spend more concentrated time with one another.

Available research. A search of ERIC Documents and Dissertation Abstracts revealed little in the way of research or evaluation studies concerning the effects of block scheduling on student achievement. At the elementary level, Fogliani (1990) discovered that block scheduling was associated positively with student learning. In mathematics achievement at the elementary school level, Wilson (1993) found statistically significant differences in favor of the parallel block-scheduled school. Also, from a review of available literature, Kadel (1994) determined that what research existed indicated that students learn at least as well in block scheduling and retain this learning over time. Finally, O’Neil (1995b) claimed that although many arguments for changing to block scheduling existed, hard data on the effects were scarce. However, he maintained that "in
general, research has found that teachers and students like longer classes, and that students do at least as well on measures of academic achievement” (p. 15).

**Challenges for educators.** Challenges for educators who instituted a block scheduling plan included ensuring that the instruction offered in block classes was appropriate for the longer format and offering staff development on instructional techniques and curriculum development (O’Neil, 1995b, p. 14). Another question that warranted concern about block schedules was whether as much of the curriculum was covered as the traditional schedule allowed. Depending upon the block schedule a school selected and the particular schedule it was using, there might be a decline in the total number of minutes devoted to each course. However, O’Neil (1995b) contended that the important issue was “how much students have learned, and students in block schedules are not scoring any lower on achievement tests, say educators using block schedules” (p. 14-15).

Additional concerns confronted schools using 4x4 block scheduling plans or other models that dropped year-long classes. Decisions had to be made about Advanced Placement and band courses. If band classes were offered year-round, students would receive two credits each year for the class. Educators also worried about whether half-year AP courses, especially those taken in the fall semester, would prepare students to take AP exams in the spring (O’Neil, 1995b, p. 15).

**The Copernican Plan**

Created by Carroll, the Copernican Plan was based on a shift in perspective when considering the organization of schools. The plan challenged the Carnegie unit, “which
has dominated the structure of secondary schools for almost a century," and
"fundamentally change[d] the way schools use time" (Carroll, 1994a, p. 106). Some
changes offered by the plan included "evaluation based on a mastery credit system,
individual learning plans, multiple diplomas and a new credit system with two types of
credits, and the dejuvenilizing of our high schools" (Carroll, 1994a, p. 106).

While the plan included these various suggestions, its major focus was on
establishing school schedules that utilized large blocks for instructional time. Classes in
the Copernican Plan were scheduled typically in large time blocks (90 minutes, 2 hours,
or 4 hours long) that met for 30, 45, 60, or 90 days per class. The reason for the schedule
change was to "create a classroom environment which fosters vastly improved
relationships between teachers and students and also much more manageable workloads
for both teachers and students" (Carroll, 1994b, p. xi). Summarizing the advantages of the
plan, Carroll wrote:

Virtually every high school in this nation can decrease its average class
size by 20 percent; increase its course offerings or number of sections by
20 percent; reduce the total number of students with whom a teacher
works each day by 60 to 80 percent; provide students with regularly
scheduled seminars dealing with complex issues; establish a flexible,
productive instructional environment that allows effective mastery
learning as well as other practices recommended by research; get students
to master 25 to 30 percent more information in addition to what they learn
in the seminars; and do all of this within approximately present levels of
funding. (1989, p. 15)

which chronicled efforts to evaluate the plan, Carroll reported the results of eight high
schools who used varying forms of the plan. According to Carroll, the eight schools, in
total, were “a fairly representative cross section of our nation’s schools” (p. 71).
Comparisons between all models except the one utilized by Masconomet Regional High
School were “based upon the relative change in the year to year comparisons for each
school” (p. 16). A separate evaluation was conducted for each of these seven schools.
Because they used the same evaluative criteria, these seven schools, as a group, tested the
evaluators’ conclusions about Masconomet Regional High School. With regard to
Masconomet, the team of evaluators, known as the Harvard Team, determined that
although the results could not be viewed as conclusive because they represented a small
sample and only two years’ experience, the Copernican program was found to be
significantly more effective than its traditional counterpart. Carroll contended that an
analysis of the data from the other seven schools supported the conclusion of the Harvard
Team that the implementation of a Copernican model can be accomplished with the
expectation of favorable pedagogical gains. Caution should be used when reviewing the
results of the evaluation report, however. Because the Copernican Plan was devised by
Carroll, some bias might exist in the report.
The 4x4 Method of Scheduling

According to Canady and Rettig (1995a), the 4x4 semester plan (sometimes referred to as the accelerated schedule, the concentrated model, the intensive model, the straight block model, or the four-block model) has been operating in selected high schools in Canada for more than 10 years. In the basic 4x4 plan, while the school year is divided into two semesters, the school day is divided into four 90-minute instructional blocks. During the first semester, students take four courses which meet daily. Instead of being spread out over the course of an entire 180-day school year, instruction is compressed into one semester of double-block periods. When first semester ends, students receive credit for courses that have been completed successfully. During the second semester, students enroll in four additional courses. Usually, the rule for teachers is that three blocks are utilized for instruction while the fourth is reserved for planning.

Advantages. The 4x4 plan offers several advantages as compiled by Canady and Rettig (1995a):

- All teachers benefit from increased “quality” instructional time.
- Teachers are able to plan extended lessons.
- The number of class changes is reduced.
- Teaching with a variety of instructional models is encouraged.
- Students have fewer classes, quizzes, tests, and homework assignments on any one day.
- Work missed because of a student’s absence is easier to gather and monitor.
• Itinerant teacher schedules can be simplified.
• Teachers work with fewer students during any one semester.
• Teachers prepare for fewer courses each day.
• Teachers must keep records and grades for only 50 to 90 students per semester.
• Students who have failed a course have an early opportunity to retake it; thus, they can regain the graduation pace of their peers.
• Students have greater opportunities for acceleration.
• Students may enroll in a greater number and variety of elective courses.
• Fewer textbooks are required. (p. 68-73)

Disadvantages. Several educators have outlined disadvantages to 4x4 scheduling. Williamson (1993) stated that the scheduling of itinerant and part time staff, pull-out programs, and lunch was complicated by the 4x4 plan. Kadel (1994) listed two additional difficulties with the 4x4 scheme: 1) students may have difficulty catching up after absences, and 2) students who plan to enter end-of-year competitions may be challenged by the schedule. Schoenstein (1994) commented that the biggest negative factor to the plan was that “we still have too many students who still haven’t bought into what we offer, pregnant girls, parents who don’t care about their own kids, teachers with larger classes than they should have — those issues have not gone away” (p. 12). Shortt and Thayer (1995) suggested several potential drawbacks to the plan:
• The scheduling of semester courses in a non-sequential order could create a retention problem for student success in the next level course.
Students who transfer to or from schools that are on different schedules present a problem for administrators and counselors with regard to assigning credit and subjects for the new student.

The 4x4 plan poses a challenge for students and teachers with regard to Advanced Placement courses.

Electives such as music or foreign language may be impacted.

The courses available to students and the schedules of teachers may be defined by the 4x4 plan.

The cost of implementation may not be one that some school divisions can afford.

Teachers have reported that they have concerns about academic pacing.

The noted advantages and disadvantages of block scheduling impact the use of time in schools. Many of the suggestions for improving mathematics education such as increased emphasis on problem solving and active student involvement could be addressed with longer class periods. With fewer students, preparations, record keeping, and assignments to correct, teachers would have more liberty to try new approaches to instructional delivery. However, the "pros" must be weighed against the "cons," especially for the AP classes. The issue of academic pacing must be resolved because the objectives for the course are national ones and each may be represented on the May examination. Ways must be devised to deal with the retention of the curriculum between the end of the course and the test administration.
Retention of learning. With the opportunity to complete a course in the first semester comes the possibility of a full semester and summer to pass before a student would be enrolled in the next sequential course. As a result of this possibility, two concerns arise: Is there a greater loss of learning, thus requiring an unreasonable amount of review? Will there be a problem when students who finished a prerequisite first semester are combined in the same class with those who completed it second semester? Canady and Rettig (1995a) attempted to answer those queries by citing both the findings of schools experienced with the plan and the results of research that dealt with the issue of retention of learning. Teachers reported "very little difference between the retention of students who had just recently completed a prerequisite course and other students with greater time lapses between courses" (p. 86). In addition, usually a need for some review existed at the beginning of a school year, and the inclusion of additional time away from a course did not seem to make a difference. After reviewing a 1993 study by Semb, Ellis, and Araujo which dealt with the retention of learning over time for college students, Canady and Rettig decided that because the 4x4 plan was similar to a college schedule, the results of research that dealt with college students and the retention of learning over time could be applied to high school students. Since Semb, Ellis, & Araujo (as cited in Canady & Rettig, 1995a) discovered that after the completion of a course, college students retained 85% of their learning after four months and 80% after eleven months, Canady and Rettig concluded the following:

One would expect, therefore, that high school students would retain slightly more than 85 percent of their original learning after a three-month
summer vacation, somewhat more than 80 percent of their original learning after a semester and summer (seven months), and slightly less than 80 percent of their original learning if an entire year came between enrollment in two sequential courses. Yes, students do forget more over time; however, the slight decline in retention from three months to either seven months or twelve months may be worth other benefits of the 4x4 semester plan. (p. 86-87)

**Minutes per course.** With a 4x4 method of scheduling, the number of instructional minutes allocated per course may be fewer than the number provided with a six- or seven-period schedule, unless the school day is lengthened. Therefore, some teachers have deemed it “necessary to re-examine their curricula, reduce review, and eliminate less important objectives” (Canady & Rettig, 1995a, p. 89). Because the curriculum is specified as a national one for AP courses, none of the objectives can be eliminated. Each one is likely to be represented on the AP test and should be mastered by students prior to the May testing.

**AP Classes.** According to Canady and Rettig (1995a), schools on the 4x4 scheduling plan have various strategies for addressing the issue of AP courses. One option is to schedule AP courses for both semesters and offer two credits. Another choice is to provide review sessions in the spring in preparation for the May exam. A third possibility is to continue the course year-long in a single period or an alternate day block in which a credit for research or independent study is offered for the second half of the block. Some schools handle the issue by offering two matched AP courses in single
periods or double periods on alternate days all year long. Other schools have established a nine-week elective course to precede or follow 27 weeks of AP instruction.

Schoenstein (1994) stated that prior to implementing the 4x4 model, AP classes at Wasson High School in Colorado Springs, Colorado, needed extra sessions on weekends or evenings in order for students "to get an adequate level of preparation for the AP exams" (p. 9). Two credits were offered for the year-long course. After the 4x4 schedule began, AP classes lasted three nine-week terms and carried two credits. Elective courses were offered the first nine weeks while the remaining three nine-week sessions were reserved for AP courses. While the opportunity existed for students to accelerate their programs of studies and take AP courses sooner than their senior year, Schoenstein made no mention of any change in AP test scores as a result of the scheduling switch.

However, the issue of AP scores was addressed by Edwards (1995) when he discussed the benefits to students at Orange County High School in Orange, Virginia. He discovered:

Advanced Placement students also appeared to be major beneficiaries of the move to a 4x4 schedule. Converting all Advanced Placement classes into two-credit year-long courses, school officials more than doubled the instructional time available in their AP classes. Student scores on the 1994 AP exams, like grades schoolwide, skewed to the upper end of the grading scale. The number of students scoring 4s and 5s increased from 44 to 58 percent. Those scoring 3s, 4s, and 5s increased from a previous high of 73 percent to 85 percent. For a school term in which more than 10 school
days were lost to inclement weather and could not be made up before the AP exam dates, these were significant increases. (p. 28)

The College Board's AP Program

Overview

The AP program consists of 29 college-level courses and examinations in 16 academic disciplines for highly-motivated students in secondary schools and is a cooperative educational endeavor between the College Board, colleges, and secondary schools. Over 10,000 high schools in every state in the United States, every Canadian province and territory, and 63 other countries offer AP courses. Nearly 2,900 U.S. and foreign universities and colleges recognize the program and offer credit, advanced placement, or both to students who satisfactorily perform on AP examinations (The College Board, 1995b). Though the AP program does not recommend textbooks, schedules for lessons, or teaching techniques, it does provide course descriptions, teaching materials, and examinations based on those descriptions.

History

During the twentieth century the populations at institutions of higher education grew in number and diversity. As a result, the curriculum tended to be a repetition of the high school curriculum. While some students were bored with the redundancy, others were unprepared for college work.

Throughout the era, "the armed conflicts, the technical ascendancy of the Soviet Union, the rapid pace of technological change, all pointed out the need for a well-educated populace, which in turn pointed out the need to optimize the articulation
between high school and college” (The College Entrance Examination Board (CEEB), 1995, p. 4). Through its Fund for the Advancement of Education, the Ford Foundation responded by placing very able high school seniors in college in 1951, ensuring them of two years of postsecondary education before they were eligible for the draft. The following year, the Fund recommended that some seniors take introductory college-level courses while in high school that would receive college credit through a series of examinations (CEEB, 1995, p. 4).

According to the *College and University Guide to the Advanced Placement Program*, the immediate parent of the AP program was the *School and College Study of Admission with Advanced Standing*, also known as the Kenyon Plan. In 1951 the Kenyon College faculty held a series of discussions about possible revisions in the requirements for the bachelor’s degree. Their intention was to encourage very able high school students to work at a pace consistent with their ability. Twenty-six schools began “Kenyon Plan” advanced placement programs in the fall of 1953 (CEEB & ETS, 1994, p. 8).

Three universities (Harvard, Yale, and Princeton) and three college preparatory schools (Exeter, Andover, and Lawrenceville) conducted a study that resulted in a 1952 report, *General Education in School and College*, which contained a proposal for an experiment in AP that would be conducted under the direction of the College Board. According to the proposal, the two major tasks of the College Board “were the screening of candidates and the design of three-hour tests in foreign languages, mathematics, chemistry, physics, biology, English literature and composition, and American history” (CEEB & ETS, 1994, p. 8).
The course outlines were studied and standardized by 11 committees and 81 scholars. In January 1954 their work was approved by 12 participating colleges, and seven pilot schools taught AP classes that fall. In October of that year the College Board became responsible for the AP Program. In May 1956 the first AP examinations were administered in 104 schools (CEEB, 1995, p. 4). “The growth of the Program since its inception suggests that its founders correctly analyzed a need. Some 2,900 colleges and universities now offer students credit and/or advanced placement; more than 200 universities abroad recognize AP Examination grades” (CEEB & ETS, 1994, p. 8). In 1995, more than 500,000 students took 785,000 examinations. In the words of Donald Stewart, President of the College Board, “The Program has become a vehicle that provides access to excellence for those willing to accept its challenges” (CEEB, 1995, p. 5).

**The AP Examinations**

Offered throughout the world in May each year, the AP examinations contain one section that is multiple choice and one that is free response. In June the examinations are graded by college and secondary school teachers who serve under the direction of a chief grader. The multiple choice section provides both high reliability and continuity (The College Board, 1995b). The questions in this section are scored with a correction factor to compensate for random guessing. Combining the points acquired from the free response questions with those received from the multiple choice section results in a raw score which is then converted to the five-point scale: 5-extremely well qualified; 4-well qualified; 3-qualified; 2-possibly qualified; 1-no recommendations (The College Board,
Students, their secondary schools, and their selected colleges receive the scores in July.

**AP Mathematics**

An AP mathematics course encompasses a full academic year of work in calculus and related topics comparable to college or university courses. Two levels of calculus courses and examinations are offered by the AP program: AB and BC. The AB level is a year course in introductory calculus with elementary functions, including topics in differential and integral calculus. Calculus BC is considerably more extensive than Calculus AB and includes such topics as infinite series.

**School Restructuring**

Planned, controlled, and directed social change is one of the dominant concepts that has emerged in the twentieth century (Owens, 1987). Not only are educational organizations expected to be vehicles for change, but also they are expected to preserve and transmit traditional values to students while at the same time preparing them to cope with an ever-changing world. In order to achieve this complex task, mutual trust and cooperation between all persons involved with schools must be developed (Brandt, 1990). In addition, Deal (1990) maintained that “restructuring or reforming schools assumes that old patterns need to be changed” (p. 7). For a successful transformation to occur, “educators need to navigate the difficult space between letting go of old patterns and grabbing onto new ones” (p. 12).

“Fiddling with organizational structure is a favorite device of educational policymakers and administrators because it communicates to the public in a symbolic way
that policymakers are concerned about the performance of the system” (Elmore, 1993, p. 121). However, there is little evidence that structural change leads to changes in how teachers teach, what they teach, or how students learn. In fact, Wang, Haertel, and Walberg (1993) discovered that “the actions of students, teachers, and parents matter most to student learning; policies at the program, school, district, state, and federal levels have limited effect compared to the day-to-day efforts of the people who are most involved in students’ lives” (p. 279). Although the manner in which a high school organizes itself and the ways in which it uses time create a framework that affects almost everything about teaching and learning in the school (NASSP, 1996), Wang, Haertel, and Walberg (1993/94) found that on the average, changes to a school’s organization yielded only moderate influence on student achievement:

The state, district, and school policies that have received the most recent attention appear to have the least influence on learning. Fifty years of research contradict educators’ current reliance on school restructuring and organizational variables as key components of school reform...Unless reorganization and restructuring strongly affect the direct determinants of learning, they offer little hope of sustaining improvement. Changing policies is unlikely to change practices in classrooms and homes, where learning actually takes place. (p. 79)
Definitions of School Restructuring

Establishing a clear definition of restructuring is difficult. When it has been attempted, the result has usually been more of a description or prescription than a definition. Such was the case when Cawelti (1994a) attempted the definition of the term:

The central goal of high school restructuring is improving student performance on important outcomes contained in the curriculum of the future. Thus, restructuring involves designing fundamental changes in the expectations, content, and learning experiences for a curriculum appropriate to tomorrow's world. To achieve this goal, restructuring utilizes creative incentives, different organizational structures, new and improved instructional technologies, and broader collaboration with community agencies and parents. (p. 3)

When Newmann and Wehlage (1995) addressed the issue, they acknowledged that the term had “no precise definition,” but it did suggest that “schooling needs to be comprehensively redesigned; simply improving parts of schools as we know them isn’t enough” (p. 1). “Decentralization, shared decision-making, school choice, schools within schools, flexible scheduling with longer classes, teacher training, common academic curriculum required for all students, reduction of tracking and ability grouping, external standards for school accountability, and new forms of assessment” were included in the authors’ list of structural reforms (p. 1). In their view, the quality of education depended more upon the commitment and competence of educators and on students’ efforts to learn than on specific techniques.
School Restructuring Blueprints

Circles of support. For Newmann and Wehlage (1995), the solution to restructuring was concentric “circles of support,” beginning with student learning and continuing outward with authentic pedagogy, school organizational capacity, and external support. Their work showed that “restructuring . . . advanced student learning when it concentrated on the intellectual quality of student work, when it built schoolwide organizational capacity to deliver authentic pedagogy, and when it received support from the external environment that was consistent with these challenges” (p. 3). They determined that “the most successful schools . . . found a way to channel staff and student efforts toward a clear, commonly shared purpose for student learning” and “created opportunities for teachers to collaborate and help one another achieve the purpose” (p. 3). In successful schools, it seemed that teachers took collective, as well as individual, responsibility for student learning.

However, Newmann and Wehlage also found that while school restructuring can help boost student achievement for all students, it did not assure a schoolwide focus on learning of high intellectual quality or authentic teaching. In their opinions, this was due partly to the fact that attention was diverted from the quality of learning because “as staff became involved with issues of student conduct, with supervision of extracurricular activity, with administrative and managerial tasks such as taking attendance or keeping records, and with students’ and parents’ emotional concerns, intellectual priorities could slip into the background” (p. 28). They also held that:
Restructuring initiatives themselves generated a host of new issues that could divert staff attention from the agenda for learning. For example, adoption of techniques such as cooperative learning groups, use of portfolios, or student independent research projects raised a number of issues about how to manage and supervise students. Adoption of shared governance and team planning expanded the potential for interpersonal conflict and power struggles. When significant reforms were implemented without full faculty support, sometimes reformers understandably became more preoccupied with how to generate support within the school than with the intellectual quality of teacher and student work. (pp. 28-29)

Whether or not a school is attempting to restructure, some of the factors mentioned by Newmann and Wehlage, such as student conduct, supervision of extracurricular activities, administrative and managerial tasks, and students' and parents' emotional concerns, daily interfere with the learning process. When a school begins restructuring, the added pressures increase the burden. The challenge to schools, as the authors acknowledged, is to learn how to "use new structures to enhance faculty and student concern for learning of high intellectual quality" rather than to just adopt an innovation (p. 29).

**Goal consensus and evaluation.** Wagner (1993b) organized his plan for restructuring in a different sequence and with only two main branches: consensus about goals and the best methods for measuring progress toward those goals. In order to carry out his plan, three sequential steps were required: "1) synthesize information from diverse
sources about what high school graduates need to know and be able to do, 2) conduct town meetings and media education campaigns, and 3) assemble task forces to determine specific curriculum goals and means of assessment” (p. 700). It was his opinion that:

If teachers and students are going to be motivated to work in different ways and if the schools are to cultivate long-term local support for ongoing change, there must first be consensus within the community about the goals of school reform and about the best ways to measure progress toward those goals. Individual communities, not professional organizations or the federal government, must decide what it means to be an educated person in America. (1993b, p. 696)

*CURRICULUM AND CRITICAL RESTRUCTURING ELEMENTS.* Cawelti (1994a) believed that while changes in organizational structure could facilitate improvement, it was essential that these changes be focused on improved student achievement, the real goal of restructuring. He maintained that the probability of significant improvement was highest when several elements of the system were simultaneously redesigned, and when curriculum, the central component of the restructuring model, was kept in the forefront of the reform effort. It was his opinion that:

Restructuring presents an enormous challenge to school leaders who are trying to establish a culture for change and transform their institutions into more productive places. Principals must provide experiences that will galvanize others into action. These include establishing teams, promoting study of alternatives, excursions to other schools, strategic planning, and
examining data about their school’s current performance. All the changes involve training for teachers and their leaders in developing new skills and roles in restructured high schools. (pp. 14-15)

His design for restructuring included seven critical restructuring elements: performance standards, authentic assessment, interdisciplinary curriculum, school-based shared decision-making teams, block scheduling, community outreach, and instructional technology. Each of these critical elements held “promise for most high schools as a way of providing more focus on improving student achievement” (p. 14). More than the plans outlined by Newmann and Wehlage and Wagner, Cawelti’s ideas seem to have practical application for educators entering into restructuring phases.

Organizational Change

Lessons to be learned. In 1991 Fullan wrote that “the capacity to bring about change and the capacity to bring about improvement are two different matters. Change is everywhere, progress is not” (p. 345). While both “ambivalence and dilemmas” are contained in all change, the key is to look at change as an opportunity, “to appreciate the good and bad of change and to approach it with a view to altering the mix by strengthening the good features and reducing the bad” (p. 345).

Fullan outlined his beliefs about the change process by presenting eight lessons that educators need to learn regarding innovation, reform, and restructuring strategies. Such lessons should serve as a foundation for educators who must make restructuring decisions:

Lesson 1. You can’t mandate what matters.
Lesson 2. Change is a journey, not a blueprint.

Lesson 3. Problems are our friends.

Lesson 4. Vision and strategic planning come later.

Lesson 5. Individualism and collectivism must have equal power.

Lesson 6. Neither centralization nor decentralization works.

Lesson 7. Connection with the wider environment is critical for success.

Lesson 8. Every person is a change agent. (p. 125-130)

According to Fullan, successful change efforts are “characterized by collaboration and close interaction among those central to carrying out the changes” (p. 349). If a school leader can form alliances with those persons who will be doing the extra work required to learn new techniques, a mutual trust can be developed which will allow those individuals to become facilitators for the change rather than threats to the process. Such alliances provide the opportunity to share and scrutinize the ideas and practices of each other. Collaboration and alliances need to be complemented with education and training. To be successful, institutions cannot be developed without developing the people in them. If some intervention is not done to assist with the change, people will not know how to behave any differently.

When a major innovation, such as 4x4 block scheduling, is initiated, its success depends, as Fullan pointed out, upon the manner in which the change process is handled. Different results will occur between the situations in which the change has been thrust upon the stakeholders without their input and those in which it started as a grassroots effort in which community members and organizations, students, parents, faculty, staff,
building administrators, central office personnel, and school board members work together. Mutual trust, support, and effective staff development combine in the latter scenario to achieve the goal of successful implementation of the innovation.

**Obstacles to change.** Four obstacles to change discussed by Wagner (1993b) were a lack of incentives and models, the changing student population, a lack of consistent community support, and a lack of clear goals and strategies. Because teachers have seen ideas come and go before with little difference in the classroom, they have become skeptical about 'new' educational trends. In addition, there were "no incentives for extra effort or risk-taking. Even when a few teachers...began to think about more fundamental kinds of change...they were stymied by a lack of familiarity with any alternative models" (p. 697). Without encouragement, models, the freedom to be risk-takers, and the time allocated for such endeavors, teachers will continue to teach in exactly the same ways, which usually means "lecturing."

"The profound changes in the high school population during the last 25 years are rarely mentioned as part of the problem of school reform. Yet they are all too painfully obvious and often overwhelming to most teachers" (p. 697). Teachers frequently complain that students no longer read or do homework and are becoming increasingly passive and unmotivated. Many students seem to prefer passive forms of entertainment and consumption, work more hours than ever before, come from single-parent or dual-career families, feel completely disconnected from much that they are asked to do in classrooms, and have become "extremely ambivalent toward all forms of adult authority."
As schools undertake restructuring initiatives, care must be given to finding strategies that help to address these issues.

**Stages in the change process.** Believing that lasting, significant improvement “can seldom be prescribed, managed, or directed by agencies or individuals outside of the school,” Gorton (1987) contended that the leadership for creating school improvement “must come from the organizational level of education where the change is to take effect” (p. 137). He prescribed a formula for the change process which included eight stages for educators to follow: conduct a needs assessment, orient the target group to the proposed change, decide whether to introduce the proposed change, plan a program of implementation (which includes a program of in-service education for those involved in the proposed change), implement the proposed innovation, conduct in-process evaluation, and refine and institutionalize the innovation. Decision-making, planning, organizing, diagnosing and evaluating were emphasized throughout the process. Also, Gorton thought it necessary for an administrator to make every effort to ensure that the faculty or its representatives were involved in each step of the change process, that they understood thoroughly the various aspects of the proposed innovation, and that they were provided with adequate opportunities to acquire the skills necessary to implement the change. His plan involved communication, commitment, and an evaluation component. One way to improve Gorton’s plan was to make it systemic.

**Systemic Change**

**Definitions.** Holzman (1993) decreed that for teaching and learning to improve for all students, change was needed, a fundamental change that affected every aspect of
schools and every school in school systems. What was prescribed was \textit{systemic} change. According to Holzman, educators currently use the word \textit{systemic} in five different ways: 1) working with school \textit{systems}--district bureaucracies or state departments--to effect change, 2) working with \textit{every school} in a system, 3) working with \textit{every aspect} of the school system, 4) "\textit{systematic}," and 5) "\textit{fundamental change}" (p. 18).

Concentrating his meaning on working with \textit{every aspect} of a school, Sizer (1993) commented that to succeed at significant school change, all the consequential parts of a school must be addressed at the same time. He warned educators who attempt to initiate change that:

\begin{quote}
In a school, everything important touches everything else of importance. Change one consequential aspect of that school and all others will be affected. Failure to take account of the synergistic character of a school either delivers its faculty into the frustration of institutional paralysis or smothers the change which had been introduced. (p. 236)
\end{quote}

\textbf{Systemic change.} Schools are like engines, humming along fine when all parts work in harmony, but sputtering or failing when any part weakens. When the mechanic attempts to repair the engine that has problems, he must address each part to successfully complete the job. While the analogy is not unique, it is useful, because, like the mechanic, educators must remember to address \textit{every aspect} of the system undergoing change. When a systems orientation is employed, in the opinion of Bonstingl (1992), over the long term improvement of student outcomes will be achieved. Learning processes must be continuously improved by teacher-student teams and the entire system supporting
those processes must be “continuously improved by administrators who create the context for optimal success within the school” (p. 41).

Fullan, Bennett, and Rolheiser-Bennett (1990) thought classroom improvement, teacher development, and school improvement should be systematically linked for substantial progress to occur. In their opinions, “the teacher-as-learner concept” was the “centerpiece linking classroom and school improvement” (p. 15). Focusing attention on the potential ways in which schools and classrooms could improve was more important, in their view, than any one particular innovation. Progress would be best served when people worked together rather than alone, and when systematic links were across classrooms.

Restructuring should only occur, according to Corbett and Blum (1993), for the educational good of the students. An “inherently messy process,” restructuring takes a lot of time, energy, and courage on the everyone’s part and requires much “talking, thinking, acting, sharing, and adjusting. Quite simply, if substantial, systemic change is to occur, all key groups of stakeholders must be engaged in a very time-consuming process” (p. 694).

Wagner (1993a) also struck upon the idea that systemic change takes a large amount of time. In fact, time was termed the “scarcest resource” because “even with help, change comes slowly” (p. 28). Time was required for many reasons:

- Time for teachers to discuss students’ needs, observe one another’s classes, assess their work, design new curriculums, visit other schools, and attend workshops. Time for teachers and students to get to know one another. Time for parents and community members to become involved in
children’s learning. Time for leaders at all levels to reflect and plan collaboratively. Time—perhaps five years— to rethink the purposes of education, reinvent teaching and learning, and create new school cultures. (p. 28).

Anderson (1993) believed that unless changes occurred in teaching and learning, all other changes had minimal value. As systemic change unfolded, six stages were traveled: maintenance of the old system, awareness, exploration, transition, emergence of a new infrastructure, and the predominance of the new system. At each stage, six key elements helped the process: vision, public and political support, networking, teaching and learning changes, administrative roles and responsibilities, and policy alignment.

**Block Scheduling as Restructuring**

Because block scheduling is a form of restructuring, educators would do well to utilize the results of research regarding school restructuring and change. To make that task easier, Hackmann (1995) wrote ten guidelines for implementing block scheduling. In his view, the following steps should be taken:

1. Employ a systems thinking approach.
2. Secure the support of your superiors.
3. Understand the change process.
4. Involve all stakeholders.
5. Consult outside sources.
7. Examine the budgetary implications.
8. Plan faculty inservices.
9. Include an evaluation component.
10. Share and celebrate your successes. (p. 24-26)

**Staff Development**

Adopting a 4x4 block scheduling plan is a major innovation for a school and impacts all programs and people. Therefore, it is important that such a change to the educational system be accompanied by information dissemination and training. Effective staff development is necessary for the plan to be as successful as possible. As Cawelti (1994b) pointed out:

Restructuring presents an enormous challenge to school leaders who are trying to establish a culture for change and transform their institutions into more productive places. Principals must provide experiences that will galvanize others into action. These include establishing teams, promoting study of alternatives, excursions to other schools, strategic planning, and examining data about their school’s current performance. All the changes involve training for teachers and their leaders in developing new skills and roles in restructured high schools. (p. 14-15)

The main focus of any educational innovation should be on student learning. Thus, improved student achievement should be the driving force behind staff development. Sparks (1995) maintained, “professional development must be viewed as an essential and indispensable part of the school improvement process” (p. 168). As an extension of this belief, he offered several recommendations that addressed the issues...
faced by school administrators and teachers when designing staff development programs in order to enhance the “learning of all students through the application of research by all teachers in all classrooms” (p. 163). These recommendations were:

- Keep the focus on student learning.
- Recognize that change affects staff members in personal ways.
- Change the organization's culture at the same time that individual teachers and administrators are acquiring new knowledge and skills.
- Use a systems approach to change because “...everything in a system is connected to everything else, and that a change in any part affects all the other parts and the whole.”
- Apply what is known about the change process to the improvement effort.
- Recognize the subtle tension between the importance of establishing readiness for change and the need to get people to try out new practices.
- Provide content-specific staff development that addresses both deeper forms of content knowledge and instructional strategies most effective in that discipline.
- Make certain that the learning process for teachers models the type of instruction that is desired.
- Encourage various forms of job-embedded learning.
- Make certain that when training is the learning mode that is being used, it is well designed and includes sufficient follow-up support in the classroom over a sustained period of time.
• Provide generous amounts of time for collaborative work and various learning activities. (p. 163-167)

One outcome of staff development should be the application of the lessons learned from educational research to classroom activities. The time spent in staff development should provide faculty with exposure to new approaches, knowledge of how and why the new ideas will work, and practical applications related to subject area content. “While it seems reasonable to expect an individual teacher to learn and apply the behavioral prescriptions of effective teaching research within his or her classroom, it is patently foolish to expect individual teachers to be able to learn and apply the ideas of current research by themselves” (Elmore, 1993, p. 120).

For staff development initiatives to accomplish their mission, a collaborative effort must be employed on the part of administration and staff. In a review of current literature concerning effective staff development, Moye (1996) concluded that it would require “the collective efforts of teachers and administrators to plan and implement staff development that is directly related to providing individual and organizational growth opportunities that specifically target content and strategies that improve student achievement” (p. 12). She further stated that the amount that student achievement would be increased was “related to whether staff development opportunities sustain individual and organizational growth. Such growth is dependent upon a carefully planned and implemented interactive system of staff development” (p. 11). An interactive staff development program was identified as one “that fosters individual and organizational
development through three kinds of efforts: an individual component, a collective component, and a systemic component” (p. 4).

The need for faculty involvement with the process was emphasized by Sergiovanni and Starratt (1988) when they maintained that staff development was “not something the school does to the teacher but something the teacher does for himself or herself” (p. 391). When teachers are involved, they are more willing to contribute, share, and apply the lessons learned during staff development sessions. In the same vein, staff development should be positive and growth-oriented rather than negative and corrective; as Sergiovanni and Starratt noted, it should assume “a need for people at work to grow and develop on the job” rather than assuming deficiencies in individuals (p. 391).

The success of staff development initiatives varies from site to site. In cases where its impact is limited, it may be the focus of staff development activities or the number of persons to which the training will apply that limits the usefulness or application of the information presented during the sessions. Newmann and Wehlage (1995) noted that “staff development activities may focus only on techniques and procedures, rather than the quality of student work, and staff development may benefit only a few people, rather than building schoolwide capacity” (p. 49). While they found “some examples of entire staffs immersed in continuous and coordinated programs” in which the impact was schoolwide and...powerful,” they also located programs where the training was fragmented and inconsistent (p. 43). These authors drew attention to a design flaw in the staff development of some school programs:
In many cases . . . only a small portion of a school's staff participated in these opportunities. Individual teacher choice to participate in staff development was typical in many schools. Some staff often became excited about an idea or practice, but frequently many of their colleagues remained uninformed and unmoved. The result was fragmentation, rather than consistent schoolwide effort. (p. 43)

Staff development needs to be a continual and consistent process. The conclusion of Wang, Haertel, and Walberg (1990) that “consistent engagement with the subject matter to be learned” was “critical to school success” is applicable to teachers-as-learners as well as to students-as-learners (p. 37). It takes time and constant attention to learn and to implement new techniques and procedures. “Faculty development takes time; time to collaborate, communicate, ponder, and reflect with others is essential” (Watts & Castle, 1993, p. 307).

Summary

The need for change in the way schools operate has been documented by numerous researchers throughout this work. As schools restructure, the use of time has continued to be a critical issue. Over the years various plans have been implemented with the goal of efficient and effective utilization of time in mind. While administrators must remember that it is but one resource available for change, time can have a tremendous impact.

Currently, crowded school days make it difficult to focus on achieving rigorous academic standards. At the root of the problem lies the battle between current uses of
time and the desire for successful learning by students. Indeed, "the way time is used in schools may be the most significant structural barrier to student learning" (The Commission, 1994b, p. 20-21). Several educators have been identified who have proclaimed that redesigning the school schedule was the vehicle for removing this barrier and who have supported their own choice for the method to be used. In traditional schools, time has driven the schedule and dictated teaching strategies and classroom activities. With block scheduling, no matter which option was selected, more opportunities for student-directed activities and varied instructional approaches existed. As Edwards (1993) observed:

Although a simpler schedule in and of itself will not improve performance, it does afford students a better chance to do so. Teachers can give greater attention to their students' individual learning needs and the planning of effective lessons. Less complex teacher schedules will facilitate team teaching, interdisciplinary studies, and other cooperative teaching strategies. All this should have a positive impact on the quality of instruction, and ultimately improve student performance. (p. 79)

As the current restructuring plans are implemented and altered, new options for using school time to assist student learning should emerge. Educators are challenged to recognize that "American students will have their best chance at success when they are no longer serving time, but time is serving them" (The Commission, 1994c, p. 16).

Block scheduling is a complex innovation that impacts all persons, programs, politics, and resources. Because of its widespread ramifications, it should not be entered into lightly. Careful consideration of issues, much communication and free-flow of ideas,
willing acceptance by stakeholders, and detailed pre-planning are in order prior to the actual implementation of block scheduling. At all stages of the restructuring, applying the ideas presented by Fullan (1991) regarding the change process and those of Hackmann (1995) regarding the implementation of block scheduling in particular would improve the likelihood of success.
Chapter III

Methodology

Problem

This study investigated the achievement of 4x4 block-scheduled AP Calculus AB students as indicated by their scores on the 1995 AP Calculus AB examination and sought information regarding the change from traditional scheduling. This chapter presents a discussion of the study methodology which includes research questions, population and sample, procedures, research design, analysis techniques, and summary of methodology.

Research Questions

The investigation was driven by the following research questions which were concerned with student achievement and with the dynamics involved in the change process to the 4x4 method:

1. Is there a difference between the achievement of students who take AP Calculus AB in a 4x4 method of block scheduling when compared to the population of AP Calculus AB students as indicated by the scores on the 1995 AP Calculus AB examination?

2. Were special accommodations made for AP Calculus AB classes at schools using the 4x4 block-scheduling method?

3. What prompted schools to make the scheduling change from traditional methods to 4x4 plans?

4. In schools that changed, who made the decision to switch to the 4x4 method of scheduling?
5. At the sites where the change was made to the 4x4 method, who had input into the decision process?

6. What measures were taken to prepare the administration, faculty, staff, students, and community for the implementation of the 4x4 method?

**Accessible Population and Sample**

Data were sought from all schools throughout Virginia and North Carolina that were identified as using 4x4 block scheduling and offering AP Calculus AB during the 1994-95 school year. The names of Virginia schools employing the 4x4 semester plan were found in the *Directory of High School Scheduling Models in Virginia 1995-96; Study of Innovative High School Scheduling in Virginia* (Rettig, 1995). Twenty-seven Virginia schools had completed at least one year of the plan by the end of the 1994-95 school year. A North Carolina State Department of Public Instruction publication, *Block Scheduling*, provided the names of 96 schools in that state that utilized the 4x4 block scheduling method during the period of time under investigation. These 123 schools were invited to participate and 87 schools (71%) accepted the offer.

Sixty-six of the 96 North Carolina schools responded to requests for participation and information. Twenty-two of those schools reported that AP Calculus AB had not been offered during the 1994-95 school term. Three of the twenty-two schools identified themselves as alternative schools; one of the three was not using 4x4 scheduling. Of the 44 schools offering the course, two opted not to report numerical data, one declared that no students took the test, and one remarked that “all scores except 1 was a 1.”
Additionally, two schools scheduled the course as a daily 55-minute class. Numerical data from the remaining 38 North Carolina schools were included in the analysis.

Twenty-one of the 27 Virginia schools returned questionnaires. Five of the 21 schools reported that AP Calculus AB had not been offered during the 1994-95 school term. Also, one did not employ 4x4 scheduling and one scheduled the course as a daily 55-minute class. Another site scheduled the course for 27 consecutive weeks. Therefore, numerical data from the remaining 13 Virginia schools were included in the analysis, which made a total of 51 schools to be studied using scores from the 1995 AP test.

Although some schools did not offer the AP Calculus AB course, with the exception of the alternative schools and one other North Carolina school, those using the 4x4 method of scheduling answered the remaining questions on the survey form which dealt with their change from traditional scheduling. These responses were included in the study.

Procedures

After an accessible population was identified, data from each participating school were collected via questionnaire. Each school's AP Calculus AB scores for the 1995 test were requested. In addition, each school was asked to describe any special accommodations made for the AP classes and to answer a few questions about how the transition to the 4x4 method occurred.

In April 1996 the questionnaire and a cover letter explaining its purpose were mailed to the principal of each school identified as utilizing the 4x4 method of block scheduling (see Appendices A and B). A stamped, self-addressed return envelope was
provided. Follow-up contacts were made in May for those who did not respond initially (see Appendix C). Participants were assured of confidentiality of responses and offered a copy of the results of the research at no cost to them.

**Research Design**

The purpose of this study was to investigate the achievement of students who took AP Calculus AB in a 4x4 method of block scheduling as indicated by their scores on the AP Calculus AB examination and to describe some of the dynamics involved in the shift from traditional scheduling to the 4x4 method. The study was both causal-comparative and descriptive. It was causal-comparative because it was aimed at the discovery of the effects on students' achievement in AP Calculus AB of varying the method of scheduling and descriptive because it reported factors associated with the change to the current method. According to Borg and Gall (1989), the primary advantage of causal-comparative research is the ability to study cause-and-effect relationships under conditions where experimental manipulation is difficult or impossible. Because the effects were studied after the intervention (the 4x4 method of scheduling) had been applied, the research was an ex post facto study. Kiess (1989) cautioned that because ex post facto studies are confounded, cause-and-effect relationships cannot be established. Therefore, this study could only show that a difference existed and that 4x4 scheduling could have been a possible causal factor.

**Data Analysis**

When planning research, the general rule is to use the largest sample possible so that it will be most representative of the total population. According to Borg and Gall
(1989), in causal-comparative research, it is desirable to have a minimum of 15 cases.
Since data was gathered on 51 schools (38 in North Carolina and 13 in Virginia),
statistics were computed on the data acquired.

The data were divided into two groups: (Sample 1) the 24 schools in which AP
Calculus AB was taught in one semester (N=238) and (Sample 2) the 27 schools in which
the course was taught in two-semesters (N=355). The mean grade (2.79), the standard
deviation (1.31), and the total number of candidates (103,032) who took the 1995 AB
Calculus AP test were found in the 1995 Advanced Placement Candidate Grade
Distributions (The College Board, 1995) (see Table 1). Using a Z test, each sample mean
was compared to the population mean. Levels of significance were set at the .05 level of
confidence.

In addition to the Z test, a \( \chi^2 \) goodness-of-fit test was employed to compare
the distribution of the scores in the sample and the distribution of the scores in the
population. If test scores were unrelated to the scheduling method, then the percent of
occurrence of each score should have equaled those of the population.

For the first research question, the compiled data were analyzed statistically by
hand and through the use of the IBM version of the Advanced Statistical Package for the
Social Sciences (SPSS 6.1 for Windows). For the remaining five research questions, the
data were reported in summary form.
Table 1. 1995 AP candidate grade distribution

<table>
<thead>
<tr>
<th>Examination Grade</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>12,172</td>
<td>11.8</td>
</tr>
<tr>
<td>4</td>
<td>19,632</td>
<td>19.1</td>
</tr>
<tr>
<td>3</td>
<td>28,904</td>
<td>28.1</td>
</tr>
<tr>
<td>2</td>
<td>19,019</td>
<td>18.5</td>
</tr>
<tr>
<td>1</td>
<td>23,305</td>
<td>22.6</td>
</tr>
</tbody>
</table>

Number of Candidates 103,032

3 or Higher 60,708 58.9

Mean Grade 2.79

Standard Deviation 1.31
Ethical Safeguards

This study was conducted in a manner that protected the anonymity of the school divisions and individuals who participated in the study. The research plan was developed so that there was no need for the names of students, teachers, administrators, schools, or school divisions. Nonetheless, the potential existed for high schools or school districts to be identified unless the data was managed responsibly.

In order to protect the confidentiality of those involved, a numbering system was employed with every school division and high school being assigned a code number. These numbers were used to collect the data for the study and to present the information in the text of the dissertation. The researcher was the only individual with access to the code list.

In the letter of transmittal, the researcher promised to protect the confidentiality of the participating school divisions, high schools and personnel. In addition, the research proposal was submitted for approval to the Human Subjects Committee of The College of William and Mary.
Chapter IV

Results

This chapter presents the results of this study of the achievement of students who took AP Calculus AB in a 4x4 method of block scheduling as indicated by their scores on the AP Calculus AB examination and of the description of some of the dynamics involved in the shift from traditional scheduling to the 4x4 method. The evidence represented data from 51 schools (593 students) that were collected from each participating school via a questionnaire. Each school’s AP Calculus AB scores for the 1995 test were requested. In addition, each school was asked to describe any special accommodations made for the AP classes and to answer a few questions about how the transition to the 4x4 method occurred. Also, a space for comments or suggestions was placed on the questionnaire. The information written in this area may be found in Appendix D.

The guarantee of confidentiality prevents disclosure of the identities of the participating school systems, schools, principals, teachers, or students. Thirteen schools were located in Virginia; 38 were North Carolina schools. All 51 schools utilized 4x4 scheduling and offered AP Calculus AB in 1995. In 24 of the schools the course was offered for 90 minutes per day for one semester. The remaining 27 schools taught the course for 90 minutes a day for two semesters. Table 2 reflects the distribution of scores by semester option.
Table 2. Distribution of AP scores by semester option

<table>
<thead>
<tr>
<th>Number of Semesters the Course was Taught</th>
<th>AP Score</th>
<th>Number of Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>104</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>49</td>
</tr>
</tbody>
</table>

N = 593

Although the request for information was sent to the principal, the data analyzed (1995 AP scores) or summarized (special accommodations made for the AP Calculus AB courses or information regarding the change to the 4x4 method of scheduling) was provided by the principal, the mathematics department chairperson, the AP Calculus AB teacher, an assistant principal, the guidance department chairperson, or the AP coordinator of each school. Results of the study were mailed to each respondent who requested the information.
Research Questions

Research Question 1

Research Question 1: Is there a difference between the achievement of students who take AP Calculus AB in a 4x4 method of block scheduling when compared to the population of AP Calculus AB students as indicated by the scores on the 1995 AP Calculus AB examination?

The Z test. Using a Z test, each sample mean was compared to the population mean. The mean, standard error of the mean, and $Z_{obs}$ for each sample may be found in Table 3. Levels of significance were set at the .05 level of confidence and a critical value, $Z_{crit}$ (~1.96), was identified (Kiess, 1989, p. 620). A replication of the computer printout that showed the results of the statistical tests may be found in Table 4.

Sample 1. Since $Z_{obs}$ (~10.45) was less than $Z_{crit}$ (~1.96), the difference between the sample mean of 2.03 and the population mean of 2.79 was statistically significant. The sample of students who took the course over one semester achieved lower scores on the 1995 AP Calculus AB test than the population of students who took the test.

Because a statistically significant difference was found, an effect size was computed using the following formula: $|\mu - \bar{x}| + \sigma$ (Kiess, 1989, p. 505). For this sample, the effect size was 0.58. According to Cohen (as cited in Kiess, 1989, p. 505), this effect size is a medium one. An effect size of 1.0 would mean that the sample mean and the population mean would differ by one standard deviation. An effect size of 0.58 would indicate that the two means would differ by more than one-half of a standard deviation. In the case of Sample 1, the shift was in a negative direction.
Table 3. Statistics for samples

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Population</th>
<th>Sample 1</th>
<th>Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{x}$</td>
<td>2.79</td>
<td>2.03</td>
<td>2.91</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>1.31</td>
<td>1.12</td>
<td>1.18</td>
</tr>
<tr>
<td>$\sigma_x$</td>
<td>.004</td>
<td>.072</td>
<td>.063</td>
</tr>
<tr>
<td>$Z_{\text{obs}}$</td>
<td></td>
<td>-10.45</td>
<td>1.86</td>
</tr>
<tr>
<td>$\chi^2$</td>
<td>84.87</td>
<td></td>
<td>19.24</td>
</tr>
<tr>
<td>$N$</td>
<td>103,032</td>
<td>238</td>
<td>355</td>
</tr>
</tbody>
</table>

**Sample 2.** Since $Z_{\text{obs}}$ (1.86) was less than $Z_{\text{crit}}$ (+1.96), the difference between the sample mean of 2.91 and the population mean of 2.79 was not statistically significant. The observed difference between the sample mean and the population mean may have been due to sampling error.

**Chi square goodness-of-fit test.** In addition to the $Z$ test, a $\chi^2$ goodness-of-fit test was employed to compare the distribution of the scores in the sample and the distribution of the scores in the population. A critical value of $\chi^2 = 9.49$ was identified (Kiess, 1989, p. 627). The population and sample frequencies may be seen in Table 5. Four degrees of freedom were used in each case.
Table 4. Statistical results of the Z-tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Cases</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>238</td>
<td>2.03</td>
<td>1.12</td>
<td>.072</td>
</tr>
<tr>
<td>Test Value</td>
<td></td>
<td>2.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Difference</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-.76</td>
<td>-.899</td>
<td>-.614</td>
<td></td>
<td>-10.45*</td>
</tr>
</tbody>
</table>

* Significantly Different

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Cases</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 2</td>
<td>355</td>
<td>2.91</td>
<td>1.18</td>
<td>.063</td>
</tr>
<tr>
<td>Test Value</td>
<td></td>
<td>2.790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Difference</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.12</td>
<td>-.007</td>
<td>.241</td>
<td>1.86</td>
<td>354</td>
</tr>
</tbody>
</table>

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Table 5. Population and sample frequencies

<table>
<thead>
<tr>
<th>Score</th>
<th>AP Population</th>
<th>Sample 1 Frequency</th>
<th>Sample 1 Expected</th>
<th>Sample 1 Observed</th>
<th>Sample 1 Residual</th>
<th>Sample 2 Frequency</th>
<th>Sample 2 Expected</th>
<th>Sample 2 Observed</th>
<th>Sample 2 Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23,305/ 22.6%</td>
<td>53.73</td>
<td>104</td>
<td>50.27</td>
<td>80.15</td>
<td>49</td>
<td>-31.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>19,019/ 18.5%</td>
<td>43.99</td>
<td>57</td>
<td>13.01</td>
<td>65.61</td>
<td>82</td>
<td>16.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>28,904/ 28.1%</td>
<td>66.81</td>
<td>47</td>
<td>-19.81</td>
<td>99.66</td>
<td>114</td>
<td>14.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>19,632/ 19.1%</td>
<td>45.41</td>
<td>25</td>
<td>-20.41</td>
<td>67.74</td>
<td>73</td>
<td>5.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>12,172/ 11.8%</td>
<td>28.06</td>
<td>5</td>
<td>-23.06</td>
<td>41.85</td>
<td>37</td>
<td>-4.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>103,032</td>
<td>238</td>
<td>355</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Sample 1. In this sample $\chi^2 = 84.87$. Since the critical value of $\chi^2 = 9.49$ was exceeded, the distribution of scores in the sample did not follow the pattern of the distribution of the scores in the population.

Sample 2. For this sample $\chi^2 = 19.24$. Because the critical value of $\chi^2 = 9.49$ was exceeded, the distribution of scores in the sample did not follow the pattern of the distribution of the scores in the population.

Research Question 2

Research question 2: Were special accommodations made for AP Calculus AB classes at schools using the 4x4 block-scheduling method?

A list of options used by 4x4 scheduled schools to accommodate AP Calculus AB may be found in Table 6. Although not all respondents answered this query, the remarks of those who did indicated that special accommodations made at schools offering AP Calculus AB for only one semester included review sessions in the spring, no review sessions at all, and instruction presented via satellite or interactive video. When the course was taught first semester, six schools reported offering some review during late spring and one school declared that no review time was established for students. While seven schools which offered the course second semester provided extra review sessions during the spring, 13 schools scheduled no review sessions.
Table 6. Types of special accommodations for AP Calculus AB

<table>
<thead>
<tr>
<th>1st Semester only</th>
<th>2nd Semester only</th>
<th>Two Semesters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring review</td>
<td>Spring review</td>
<td>Traditional daily 55-minute classes</td>
</tr>
<tr>
<td>No review</td>
<td>No review</td>
<td>Required test for credit for course</td>
</tr>
<tr>
<td>&quot;Extender&quot; course offered</td>
<td>as a no credit elective</td>
<td>Interactive television used for instruction</td>
</tr>
</tbody>
</table>

Statistics "follow-up"
course which included some Calculus review

At one location, the course was scheduled for "one semester and a nine week period second semester. The difficulty encountered with this plan was that administrators needed to find a nine week course (that the) teacher could teach the second nine weeks" of second semester. Another plan was found at a school where students taking AP Calculus took Probability and Statistics for the first nine weeks and earned one-half of a credit. For the next 18 weeks they took AP Calculus AB for one credit. The year was completed with nine weeks of Computer Math for another one-half of a credit. Although ultimately they were not included in the analysis of the first research question because of the manner in which they were scheduled, three other schools that returned the survey...
stated that the AP Calculus AB classes were accommodated by being scheduled in traditional 55-minute classes that met daily.

Other comments regarding special accommodations for AP Calculus AB were centered around the review aspect. One respondent stated that although the entire course was offered first semester, a follow-up course was offered second semester as an elective with no extra quality points. “Many students took AP first semester and didn’t do the review 2nd semester. Many students discovered that they could ‘buy’ extra quality points by just taking the test—the scores weren’t important.” Another school representative declared, “We offered a ‘follow-up’ course which included review time but also had to cover new material—we concentrated on statistics. However, there was a period of time when no calculus was done (just statistics) and then we reviewed for 3 weeks prior to the AP exam.”

Since the questionnaire was mailed in the spring of 1996, one respondent commented about both the 1994-95 and the 1995-96 school year. In 1994-95, “AP Calculus AB was offered 1st and 2nd semester → different students each semester (therefore, only one credit). Review sessions were offered to those students who took Calculus 1st semester. Second semester we barely had enough time to cover all of the objectives.” However, in 1995-96 AP Calculus AB was offered both semesters (2 credits). According to this person, this plan “worked much nicer!”

Of the schools that offered AP Calculus AB as a two-semester course, one commented that the school system provided funding and required that students take AP
exams in order to receive credit for the course. Another school reported that the course was taught both semesters over interactive television.

One school responded that although no AP Calculus AB was offered, twelve students took a college credit course offered by a university (no AP affiliation). Also, another school declared that AP Calculus AB was not offered, but commented that calculus was taught through a dual-enrollment program with a local community college, using their curriculum and their book. "We find this a better arrangement than AP since all students who earn a grade of 'C' or better have a transferable credit without taking an overpriced exam."

**Research Question 3**

**Research question 3:** What prompted schools to make the scheduling change from traditional methods to 4x4 plans?

It appeared that the major reason school systems made the change was to offer students the opportunity to take more elective courses. Providing teachers with the time to utilize more diverse and time-consuming instructional strategies ranked second in popularity. The questionnaire offered six reasons why schools changed to the 4x4 scheduling method. Respondents were able to select all options that were applicable. Each option and the number of times it was selected were:

- **54** To allow students greater opportunity for acceleration
- **78** To offer students the chance to enroll in more elective courses
- **74** To provide teachers with the opportunity to utilize more diverse, but possibly more time-consuming, instructional strategies
70 To reduce the number of class changes during the day
27 To help with budgetary concerns (fewer books, staff, materials, etc.)
20 Other

When the last option was selected, respondents provided their reasons, which they considered to be different from those suggested by the researcher. Because some of the reasons were duplications, a list of the different responses was composed by the researcher and may be found in Table 7.
Table 7. Alternative reasons for changing to 4x4 scheduling

<table>
<thead>
<tr>
<th>Stated reason</th>
<th>Number of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>To allow students to focus on only four courses per semester</td>
<td>2</td>
</tr>
<tr>
<td>To give students and teachers a new beginning each semester</td>
<td>1</td>
</tr>
<tr>
<td>To provide teachers time to work more closely with students</td>
<td>2</td>
</tr>
<tr>
<td>To offer a broader range of choices (not an accelerated offering)</td>
<td>1</td>
</tr>
<tr>
<td>To permit more in-depth study in an area of interest</td>
<td>2</td>
</tr>
<tr>
<td>To reduce the drop-out rate and to help drop-outs re-enter school in the</td>
<td>2</td>
</tr>
<tr>
<td>middle of the year</td>
<td></td>
</tr>
<tr>
<td>To allow early exit of seniors who have completed course requirements</td>
<td>1</td>
</tr>
<tr>
<td>To schedule more classes per teacher per year</td>
<td>1</td>
</tr>
<tr>
<td>To provide better use of facilities</td>
<td>1</td>
</tr>
<tr>
<td>To reduce teacher preparations and to provide additional planning time</td>
<td>3</td>
</tr>
<tr>
<td>To increase student attendance</td>
<td>1</td>
</tr>
<tr>
<td>To increase A/B Honor Rolls</td>
<td>1</td>
</tr>
<tr>
<td>To increase End of Course test scores</td>
<td>1</td>
</tr>
<tr>
<td>To reduce the failure rate</td>
<td>1</td>
</tr>
</tbody>
</table>
Research Question 4

Research question 4: In schools that changed, who made the decision to switch to the 4x4 method of scheduling?

The responses indicated that most frequently the decision to utilize the 4x4 method was made by School Planning Councils or Staff Advisory Committees. The questionnaire offered four choices for the respondents who answered this query. Respondents were able to select all options that were applicable. Each option and the number of times it was selected were:

- **25** Superintendent/Central Office
- **36** Building Principal
- **56** School Planning Council/Staff Advisory Committee
- **30** Other

The respondents who selected the last option provided titles of other persons or groups that they considered to be different from those suggested by the researcher. Because some of these answers were duplications, a list of the different responses was composed by the researcher and may be found in Table 8.
Table 8. **Persons/groups who made the decision to change to 4x4 scheduling**

<table>
<thead>
<tr>
<th>Person/group</th>
<th>Number of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire Faculty</td>
<td>15</td>
</tr>
<tr>
<td>Staff and principal recommended (the decision) to the superintendent</td>
<td>4</td>
</tr>
<tr>
<td>All people involved (community, schools, administrative offices)</td>
<td>4</td>
</tr>
<tr>
<td>School Board</td>
<td>1</td>
</tr>
<tr>
<td>Students and parents</td>
<td>2</td>
</tr>
<tr>
<td>Group decision: All high schools in the county went together to plan the change. Then the recommendation was voted on by School Board.</td>
<td>1</td>
</tr>
<tr>
<td>Faculty initiated; then the request “went up the chain.”</td>
<td>1</td>
</tr>
<tr>
<td>Task Force on 4x4</td>
<td>1</td>
</tr>
<tr>
<td>Resource committee and staff</td>
<td>1</td>
</tr>
</tbody>
</table>
Research Question 5

Research question 5: At the sites where the change was made to the 4x4 method, who had input into the decision process?

From the evidence it appeared that faculty, parents, and students frequently had input into the process. The researcher suggested six choices for the respondents. Respondents were able to select all options that were applicable. Each option and the number of times it was selected were:

- 79 Faculty
- 70 Students
- 78 Parents
- 46 Community members/Businesses/Religious organizations
- 46 Researchers/Guest speakers
- 15 Other

Those respondents who selected the last option provided titles of other persons or groups that they considered to be different from those suggested by the researcher. Because some of these answers were duplications, a list of the different responses was composed by the researcher and may be seen in Table 9.
Table 9. Persons/groups who had input into the decision to change to 4x4 scheduling

<table>
<thead>
<tr>
<th>Person/group</th>
<th>Number of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superintendent/Central Office/Board of Education</td>
<td>9</td>
</tr>
<tr>
<td>Principal</td>
<td>2</td>
</tr>
<tr>
<td>Other schools on 4x4 (visits to these campuses)</td>
<td>3</td>
</tr>
<tr>
<td>Site-based management committee</td>
<td>1</td>
</tr>
</tbody>
</table>

**Research Question 6**

Research question 6: What measures were taken to prepare the administration, faculty, staff, students, and community for the implementation of the 4x4 method?

Staff development. Staff development was conducted on numerous topics in a variety of ways. A compilation of topics and strategies may be found in Table 10. From the responses, it appeared that in some schools extensive measures were taken to prepare the staff for the innovation. In other systems, minimal preparations were made.
Table 10. Staff development topics and strategies

<table>
<thead>
<tr>
<th>Topics</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>learning styles</td>
<td>seminars</td>
</tr>
<tr>
<td>• critical thinking</td>
<td>• visits from experts on 4×4 scheduling</td>
</tr>
<tr>
<td>• pacing guides</td>
<td>• TV programs</td>
</tr>
<tr>
<td>• concept mapping</td>
<td>• county-wide brainstorming sessions</td>
</tr>
<tr>
<td>• authentic assessment</td>
<td>• personnel from other 4×4 schools</td>
</tr>
<tr>
<td>• grading practices</td>
<td>• luncheons</td>
</tr>
<tr>
<td>• math strategies</td>
<td>• activities provided by in-house experts and</td>
</tr>
<tr>
<td>• seminar teaching</td>
<td>• breakfasts</td>
</tr>
<tr>
<td>• brain research</td>
<td>• stipends</td>
</tr>
<tr>
<td>• manipulatives</td>
<td>• central office staff</td>
</tr>
<tr>
<td>• integration activities</td>
<td></td>
</tr>
<tr>
<td>• reading to learn</td>
<td></td>
</tr>
</tbody>
</table>

Also, it was apparent that schools incorporated a diverse combination of approaches to staff development. For example, staff preparation at one site included a learning styles workshop, 4-MAT training, one week of additional pay for preparing pacing guides, and visits to other 4×4 schools (by 85% of the staff). At another school,
planned activities included: formatting, cooperative learning, pacing, curriculum alignment, a team building retreat, integration activities, reading to learn, off to a successful beginning seminar, and various other workshops for departments and individuals. In one building, staff development opportunities included county-wide departmental brain-storming sessions. Yet another site conducted staff development for one-half of the year, using teams from other schools as workshop leaders. The central office staff and the principal also contributed to the effort at another school by outlining instructional practices for the faculty.

Most schools planned staff development activities that would train teachers in the use of diverse instructional methods. However, no attempt was made by this study to determine whether or not teachers' methods changed as a result of the institution of the 4x4 scheduling process. Further research might reveal whether or not teaching methods were altered by the restructuring.

The time factor. Time allotted for staff development varied from school to school. In some cases, teachers met during the summer; in others, they met during the year. In many schools teachers received training both during the summer and throughout the school year. Some teachers met for one week prior to the opening of school and revisited the staff development topics after each semester. At one site, teachers were employed for an additional week in the summer prior to implementation and attended staff development activities all year. Some teachers met for one week prior to the opening of school and revisited the staff development topics throughout the year prior to and during implementation. The representative for another building explained that extensive
staff development opportunities had been provided and that each faculty member had been required to attend 10 hours of staff development dealing with alternate teaching strategies. On another campus, the respondent claimed that teachers were provided 10 extra days of staff development. Yet another educator declared that various types of staff development activities were held over an 18-month period.

Other acknowledged time devoted to staff development by various institutions included (a) 27 hours of staff development offered from June to October, (b) 2 weeks of teacher inservice held during the planning year and summer, (c) 40 summer workshops used to prepare the staff for the change, (d) 3 inservice class opportunities given prior to the change that demonstrated cooperative learning techniques, and (e) approximately 3 inservice days utilized to discuss, learn about, and explore instruction in 90 minute periods. One principal required staff members to attend four half-day staff development sessions during the school year; provided hands-on training by staff from successful programs in specific curriculum areas, and required pacing guides and 10 days of lesson plans. Since the half-day sessions were held during the school year, stipends were not paid. In addition, summer sessions (3 days prior to opening of school) for staff development were organized and teachers attended on a voluntary basis. Many topics that had been requested by teachers were available. These sessions were run in 90 minute (block scheduling) to provide teachers opportunities to be a student of block scheduling. Teachers could select four sessions daily and received stipends and renewal credit as appropriate.
Sometimes teachers were paid for extra work accomplished. For example, for planning done over the summer, all staff members at one school were given a stipend. To receive a stipend at another location, all teachers had to attend summer meetings on pacing.

Although few of the answers to this research question were negative, the staff development efforts at one school did receive some criticism. In that case, the respondent commented that the staff had not been given enough inservice on teaching methods.

**Other implementation efforts.** Implementation plans were as diverse as staff development activities, although numerous schools did many of the same things. In addition to the topics outlined under staff development, implementation strategies employed by schools in the study included other steps. Table 11 contains a summary of the various implementation plans.
Table 11. Implementation strategies for 4x4 block scheduling

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Number of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation achieved gradually over several years</td>
<td>1</td>
</tr>
<tr>
<td>“Trial run” in semester prior to the change</td>
<td>1</td>
</tr>
<tr>
<td>Input from faculty</td>
<td>5</td>
</tr>
<tr>
<td>Visits to 4x4 scheduled schools</td>
<td>1</td>
</tr>
<tr>
<td>Speakers</td>
<td>2</td>
</tr>
<tr>
<td>Open houses/public forums/sessions for students and parents</td>
<td>12</td>
</tr>
<tr>
<td>Notification accomplished prior to change</td>
<td>9</td>
</tr>
<tr>
<td>Surveys</td>
<td>2</td>
</tr>
<tr>
<td>Meetings of curriculum committees/advisory boards</td>
<td>4</td>
</tr>
<tr>
<td>Presentation to School Board</td>
<td>1</td>
</tr>
<tr>
<td>Curriculum fair</td>
<td>1</td>
</tr>
</tbody>
</table>

In one case, the respondent maintained that the planning and implementation occurred over several years at that school. During 1991-92, a traditional 7 period day had been scheduled. In 1992-93 there was an “A” day and a “B” day which were comprised of three 110-minute periods per day. In 1993-94 there continued to be an “A” day and a “B” day, but class lengths were changed to four 85-minutes periods. Then, in 1994-95 the classes were scheduled in a true 4x4 method. As a result, claimed the respondent, “after having taught 110-minute blocks, 90 was easy.”
Summary of Results

This chapter presented data that were used to analyze certain research questions. While participants were provided an opportunity to offer comments or suggestions, these were not included in the research questions. The commentary found on the questionnaires was compiled by the researcher and may be found in Appendix D. The following narrative presents a summary of the results of the data analysis for each research question.

Research Question 1

Research Question 1: Is there a difference between the achievement of students who take AP Calculus AB in a 4x4 method of block scheduling when compared to the population of AP Calculus AB students as indicated by the scores on the 1995 AP Calculus AB examination?

The results of the Ztest indicated that the sample of students who took the course over one semester made lower scores on the 1995 AP Calculus AB test than the population of students who took the test. Both the effect size for the sample and the $\chi^2$ test supported this conclusion.

According to the Ztest, there was no evidence that the scores of students who took the course over two semesters of 90-minute classes differed from that of the population of students who took the test. However, the $\chi^2$ test did show a statistically significant difference in the distribution of these students' scores.

Research Question 2

Research question 2: Were special accommodations made for AP Calculus AB classes at schools using the 4x4 block-scheduling method?
No special provisions were made for the course in some schools where the 4x4 block-scheduling method was employed. At other locations, special accommodations were implemented. In those schools, plans made for the AP Calculus AB classes included review sessions scheduled outside of class time, classes held for one and one-half semesters instead of for one semester, classes scheduled for second and third nine weeks instead of the regular first or second semester days, elective follow-up courses, or traditional 55-minute classes. Some schools taught the course via satellite interactive television; others opted to have the students enroll in calculus at community colleges or universities. In one school system, funding was provided and students were required to take the AP exam in order to receive credit for the course.

**Research Question 3**

**Research question 3:** What prompted schools to make the scheduling change from traditional methods to 4x4 plans?

A variety of reasons prompted schools to make the scheduling change from traditional methods to 4x4 plans. The four reasons given most often in the survey results were: to offer students the chance to enroll in more elective courses; to provide teachers with the opportunity to utilize more diverse instructional strategies; to allow students greater opportunity for acceleration; and, to reduce the number of class changes during the day. Several schools also noted a fifth motivating factor, budgetary concerns. Fifteen additional interests were offered by respondents who selected the “other” category (see Table 7).
Research Question 4

Research question 4: In schools that changed, who made the decision to switch to the 4x4 method of scheduling?

The decision to switch to the 4x4 method of scheduling was made by a number of different persons or groups. School Planning Councils or Staff Advisory Committees were responsible for the decision most of the time. The next persons or groups in order of frequency were: building principals, superintendents or central office personnel, and entire faculties. In some cases, other persons or groups were the decision makers (see Table 8).

Research Question 5

Research question 5: At the sites where the change was made to the 4x4 method, who had input into the decision process?

At the sites where the change was made to the 4x4 method, faculty, parents, and students were noted as having the most input into the decision process. Community members, businesses, religious organizations, researchers and guest speakers also made notable contributions. In addition to these groups, respondents indicated that superintendents, school board members, principals, and site-based management committees were involved in the process, too. Three schools claimed that visits to other 4x4 school sites netted valuable information for the decision.

Research Question 6

Research question 6: What measures were taken to prepare the administration, faculty, staff, students, and community for the implementation of the 4x4 method?
Schools reported that staff development included numerous topics and was accomplished in a variety of ways. Time allotted for staff development varied from school to school and included activities scheduled for summer hours, inservice days, planning time, and after-school hours. Along with staff development activities, schools capitalized on other implementation schemes. These plans were as diverse as the staff development ones, although several schools used many of the same ideas.
Chapter V

Summary, Conclusions, and Recommendations

This study investigated the achievement of 4x4 block-scheduled AP Calculus AB students as indicated by their scores on the 1995 AP Calculus AB examination and sought information regarding the change from traditional scheduling. This chapter interprets the findings in the light of current research on block scheduling and makes recommendations for future research.

Research Questions

The investigation was driven by the following research questions which were concerned with student achievement and with the dynamics involved in the change process to the 4x4 method:

1. Is there a difference between the achievement of students who take AP Calculus AB in a 4x4 method of block scheduling when compared to the population of AP Calculus AB students as indicated by the scores on the 1995 AP Calculus AB examination?
2. Were special accommodations made for AP Calculus AB classes at schools using the 4x4 block-scheduling method?
3. What prompted schools to make the scheduling change from traditional methods to 4x4 plans?
4. In schools that changed, who made the decision to switch to the 4x4 method of scheduling?
5. At the sites where the change was made to the 4x4 method, who had input into the decision process?
5. At the sites where the change was made to the 4x4 method, who had input into the decision process?

6. What measures were taken to prepare the administration, faculty, staff, students, and community for the implementation of the 4x4 method?

Limitations of the Study

The conclusions, recommendations, and findings that follow need to be considered in the light of the following limitations:

1. The sample population was limited to schools in Virginia and North Carolina who were using a 4x4 form of block scheduling.

2. The study was limited to one year of data.

3. The questionnaire could have been completed by either the principal, an assistant principal, the AP coordinator, the guidance director, or the calculus teacher. Therefore, because of the personal biases or opinions of the respondent, the responses to some of the questions may not have been as accurate as possible. If another person in the same school had completed the survey, different data may have been collected, especially for the second page of survey questions.

4. No attempt was made to separate schools into samples according to whether the course was offered first or second semester. Since the AP test was given in May, the fact that first semester students may have had more instructional time than second semester students may have had consequences for the test scores.
Conclusions

Research Question 1

**Research Question 1**: Is there a difference between the achievement of students who take AP Calculus AB in a 4x4 method of block scheduling when compared to the population of AP Calculus AB students as indicated by the scores on the 1995 AP Calculus AB examination?

The results of the Z-test indicated that the sample of students who took the course over one semester achieved lower scores on the 1995 AP Calculus AB test than the population of students who took the test. Both the effect size for the sample and the $\chi^2$ test supported this conclusion.

According to the Z-test, there was no evidence that the scores of students who took the course over two semesters of 90-minute classes differed from that of the population of students who took the test. However, the $\chi^2$ test did show a statistically significant difference for this group’s distribution of scores.

Depending upon which test was used for measurement, different conclusions could be drawn about Sample 2. If only the Z-test was considered, the conclusion might have been that the 4x4 scheduling method did not impact the achievement of the students. However, if the $\chi^2$ methodology was the determinant, educators might conclude that achievement was impacted by the scheduling scheme.

Research Questions 2-6

Research questions two through six were intended to find out whether or not educators were consistent as they proceeded through the change process. In all the
questions, inconsistencies among the schools were revealed.

**Research Question 2**

**Research question 2:** Were special accommodations made for AP Calculus AB classes at schools using the 4x4 block-scheduling method?

No consistency was found regarding special accommodations among the 4x4 scheduled schools for the AP Calculus AB classes. While some schools made no accommodations, others did. In schools where plans included special provisions, a variety of options were found.

**Research Question 3**

**Research question 3:** What prompted schools to make the scheduling change from traditional methods to 4x4 plans?

No consistency was found regarding the rationale for changing from traditional methods to 4x4 scheduling plans. A variety of reasons prompted schools to make the scheduling change. While four reasons were indicated most often in the survey results (more elective courses, more diverse instructional strategies, greater opportunity for acceleration, reduction in the number of class changes during the day), several schools also noted other motivating factors.

**Research Question 4**

**Research question 4:** In schools that changed, who made the decision to switch to the 4x4 method of scheduling?
The study found no consistency among respondents when the query was made regarding who made the decision to switch to the 4x4 method of scheduling. Reportedly, the decision was made by a number of different persons or groups.

**Research Question 5**

**Research question 5:** At the sites where the change was made to the 4x4 method, who had input into the decision process?

No consistency was found by the study with respect to the topic of who participated in the decision process. At the sites where the change was made to the 4x4 method, faculty, parents, and students were noted as having the most input into the decision process, but numerous others also made contributions.

**Research Question 6**

**Research question 6:** What measures were taken to prepare the administration, faculty, staff, students, and community for the implementation of the 4x4 method?

As with the last four research questions, the sixth research question revealed no consistency among schools regarding preparations for the implementation of the 4x4 scheduling method. Schools reported that staff development included numerous topics and was accomplished in a variety of ways. Time allotted for staff development varied from school to school and included activities scheduled for summer hours, inservice days, planning time, and after-school hours. Other implementation schemes were found which were as diverse as the staff development ones, although several schools used many of the same ideas.
Discussion

Research Question 1

Research Question 1: Is there a difference between the achievement of students who take AP Calculus AB in a 4x4 method of block scheduling when compared to the population of AP Calculus AB students as indicated by the scores on the 1995 AP Calculus AB examination?

This research investigated whether 4x4 block scheduling had any effect on students' achievement in AP Calculus AB. The major assumption of this study was that the 4x4 method of block scheduling impacted the achievement of AP Calculus AB students. Of the two samples studied, at the .05 significance level Sample 1 showed a statistical difference in achievement according to both the Z test and the $\chi^2$ test. Students in courses of one semester duration had significantly lower achievement than the population. For Sample 2 there was a discrepancy at the .05 significance level between the two tests. According to the Z test, which compares central tendencies, the mean of Sample 2 was not significantly different from the population mean. By the $\chi^2$ test, which compares variability by investigating the distributions, the distribution of the scores of students who completed the course over two semesters with 90 minutes of instruction each day were significantly different from the distribution of scores in the population.

In Sample 1, the mean (2.03) was significantly lower than the population mean (2.79) and the distribution of scores was positively skewed. The number of students achieving a score of “1” or “2” in the sample was higher than expected, as evidenced by the residuals of 50.27 and 13.01, respectively (see Table 5). Likewise, the residuals for
the remaining scores indicated that the number of students achieving at these levels was lower than expected.

In Sample 2, the mean (2.91) was not significantly different from the population mean (2.79), but the distribution of scores was different. The number of students achieving a score of “1” or “5” in the sample was lower than expected, as evidenced by the residuals of −31.15 and −4.85, respectively (see Table 5). Likewise, the residuals for the remaining scores indicated that the number of students achieving at these levels was higher than expected. Fewer 1s and more 2s, 3s, and 4s may have been the result of having more instructional time than students in traditional schedules. The explanation for the decrease in the number of 5s is not obvious and indicates the need for further research.

**Effect size.** The effect size for Sample 1 was employed to aid in the interpretation of the results. An effect size is “a quantitative way of describing how well the *average* student who received the intervention performed relative to the *average* student who did not receive the intervention” (Borg & Gall, 1989, p. 7). An effect size of 1.0 would mean that the sample mean and the population mean would differ by one standard deviation. According to Borg and Gall, effect sizes larger than 0.33 are considered large enough to make a worthwhile difference in the outcome. In Sample 1 the effect size, 0.58, indicated that the students in this sample did less well than the average student in the population. The effect size of Sample 1 confirmed the outcomes of the Z and the $\chi^2$ tests and concluded that the sample mean was one-half of a standard deviation below the population mean. For such a dramatic drop in achievement, there must have been a reason
for the change. The difference in the number of hours in class, the methods employed for
instruction, the memory loss over time, the lack of review, a mismatch between the AP
curriculum and the one taught during the semester, or some other aspect of 4x4
scheduling may have served as the culprit.

**Number of students “passing” the test.** For Sample 1 both statistical tests held
that lower achievement had occurred. Although the discrepancy between the findings of
the Z and \( \chi^2 \) tests has been discussed previously, more information about Sample 2 was
warranted to more fully interpret the impact on the achievement of the two-semester
students. For that group, although the sample mean was not significantly different from
the population mean, the distribution of scores was. To aid in interpretation, another \( \chi^2 \)
test was done for both samples. Assuming that a score of “3” or better was considered a
“passing” grade, 77 students in Sample 1 and 224 students in Sample 2 achieved at an
acceptable level. The second \( \chi^2 \) test revealed whether or not there was a difference in the
distribution of “passing” scores for the samples (see Table 12).
Table 12. Results of $\chi^2$ tests for “passing” scores

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 or 2</td>
<td>161</td>
<td>97.82</td>
<td>63.18</td>
</tr>
<tr>
<td>3,4, or 5</td>
<td>77</td>
<td>140.18</td>
<td>-63.18</td>
</tr>
<tr>
<td>Total</td>
<td>238</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\chi^2 = 69.29^*$  
D.F. = 1  
Significance = .0000

* Significantly Different

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 or 2</td>
<td>131</td>
<td>145.90</td>
<td>-14.90</td>
</tr>
<tr>
<td>3,4, or 5</td>
<td>224</td>
<td>209.10</td>
<td>14.90</td>
</tr>
<tr>
<td>Total</td>
<td>355</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\chi^2 = 2.59$  
D.F. = 1  
Significance = .1079

Using one degree of freedom, a confidence level of .05, and a critical value of $\chi^2 = 3.84$ (Kiess, 1989, p. 627), a significant difference was found between Sample 1 and the population ($\chi^2 = 69.29$). In Sample 1, fewer students “passed” the test than expected, a result that mirrored the one found in the original $\chi^2$ test. The test results for Sample 2 did not indicate a significant difference ($\chi^2 = 2.59$) between the percentage of “passing” scores in the sample and those in the population. While the original $\chi^2$ test revealed a different distribution for the five categories of scores, the second one showed no difference in the number of students who achieved at an acceptable level. While a rise in
the number of students achieving scores other than a “1” or a “5” was found, there was no significant change in the number of students who “passed” the test. Achievement was improved somewhat in that 1s rose to the level of 2s or higher. However, there was a drop in the number of 5s, so achievement was not improved at that level. On a “pass/fail” basis, though, no gain was found.

**Other Comparisons.** In addition to comparing the samples to the population, other comparisons were done in an attempt to gain a better view of the meaning of the original data. For example, a comparison was made between the state populations and the overall population. When these populations were compared, a significant difference was found (see Table 13). Both the North Carolina and the Virginia means were significantly lower than the population mean. As would be expected, when the state populations were combined, the mean for that group also was significantly different from the population. Since the state populations were different from the overall population, some statistical tests were done to compare the samples and subgroups of the samples to the individual and combined state populations. The results of this testing may be found in Table 14.

When Sample 1 and Sample 2 were compared with the combined state populations of North Carolina and Virginia, significant differences were found for both samples with both statistical tests. Comparing the samples with a more similar population than the original population produced significant findings for both groups. Had the combined populations been utilized instead of the total population of test takers worldwide, the conclusion might have been drawn that one-semester courses hindered student
Table 13. Statistics for samples

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Population</th>
<th>NC State Population</th>
<th>VA State Population</th>
<th>NC &amp; VA Combined Populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \bar{x} )</td>
<td>2.79</td>
<td>2.46</td>
<td>2.63</td>
<td>2.54</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>1.31</td>
<td>1.31</td>
<td>1.27</td>
<td>1.30</td>
</tr>
<tr>
<td>( \sigma_x )</td>
<td>.004</td>
<td>.028</td>
<td>.022</td>
<td>.020</td>
</tr>
<tr>
<td>( Z_{obs} )</td>
<td>(-11.79^*)</td>
<td>(-7.73^*)</td>
<td>(-12.50^*)</td>
<td></td>
</tr>
<tr>
<td>( N )</td>
<td>103,032</td>
<td>3713</td>
<td>3213</td>
<td>6926</td>
</tr>
</tbody>
</table>

* Significant Difference
Table 14. Statistical results of other comparisons

<table>
<thead>
<tr>
<th></th>
<th>Population</th>
<th>NC</th>
<th>VA</th>
<th>NC+VA</th>
<th>Sample</th>
<th>Sample 2</th>
<th>NC1</th>
<th>NC2</th>
<th>VA1</th>
<th>VA2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pop.</td>
<td>Pop.</td>
<td>Pop.</td>
<td>Pop.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \bar{x} )</td>
<td>2.79</td>
<td>2.46</td>
<td>2.63</td>
<td>2.54</td>
<td>2.03</td>
<td>2.91</td>
<td>1.98</td>
<td>3.09</td>
<td>2.43</td>
<td>2.79</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>1.31</td>
<td>1.31</td>
<td>1.27</td>
<td>1.30</td>
<td>1.12</td>
<td>1.18</td>
<td>1.07</td>
<td>1.18</td>
<td>1.40</td>
<td>1.14</td>
</tr>
<tr>
<td>( \sigma_{\chi} )</td>
<td>0.04</td>
<td>0.028</td>
<td>0.022</td>
<td>0.020</td>
<td>0.072</td>
<td>0.063</td>
<td>0.074</td>
<td>0.081</td>
<td>0.264</td>
<td>0.096</td>
</tr>
<tr>
<td>( Z ) vs. d.f.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-10.45*</td>
<td>1.86</td>
<td>-10.99*</td>
<td>3.77*</td>
</tr>
<tr>
<td>( \chi^2 ) vs. d.f.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>84.87*</td>
<td>19.24*</td>
<td>84.21*</td>
<td>21.05*</td>
</tr>
<tr>
<td>( Z ) vs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-6.51*</td>
<td>7.85*</td>
<td>-0.71</td>
<td>-0.03</td>
</tr>
</tbody>
</table>

(Table continues)
<table>
<thead>
<tr>
<th></th>
<th>Population</th>
<th>NC</th>
<th>VA</th>
<th>NC+VA</th>
<th>Sample</th>
<th>Sample</th>
<th>NC1</th>
<th>NC2</th>
<th>VA1</th>
<th>VA2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pop.</td>
<td>Pop.</td>
<td>Pop.</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\chi^2$ vs.</td>
<td></td>
<td>29.15*</td>
<td>62.24*</td>
<td></td>
<td>7.32</td>
<td>31.99*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pop.</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Z$ vs.</td>
<td></td>
<td>-6.99*</td>
<td>5.84*</td>
<td>-7.59*</td>
<td>6.86*</td>
<td>-0.42</td>
<td>-0.91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC+VA</td>
<td></td>
<td>39.50*</td>
<td>44.11*</td>
<td>39.31*</td>
<td>47.67*</td>
<td>6.38</td>
<td>35.36*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pop.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$N$</td>
<td></td>
<td>103,032</td>
<td>3713</td>
<td>3213</td>
<td>6926</td>
<td>238</td>
<td>355</td>
<td>210</td>
<td>213</td>
<td>28</td>
</tr>
</tbody>
</table>

(Table continues)
<table>
<thead>
<tr>
<th></th>
<th>NC</th>
<th>VA</th>
<th>NC+VA</th>
<th>Sample</th>
<th>Sample</th>
<th>NC1</th>
<th>NC2</th>
<th>VA1</th>
<th>VA2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population</strong></td>
<td>Pop.</td>
<td>Pop.</td>
<td>Pop.</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\chi^2$ vs.</td>
<td>69.29*</td>
<td>2.58</td>
<td>63.22*</td>
<td>19.30*</td>
<td>6.22*</td>
<td>8.05*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pop.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\chi^2$ vs.</td>
<td></td>
<td></td>
<td></td>
<td>19.27*</td>
<td>59.59*</td>
<td>3.90*</td>
<td>2.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Pop.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\chi^2$ vs.</td>
<td>31.70*</td>
<td>22.19*</td>
<td>29.36*</td>
<td>45.51*</td>
<td>2.48</td>
<td>0.66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC+VA Pop.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significantly Different
achievement while two-semester ones improved it.

Four additional samples were identified: two from North Carolina and two from Virginia. The group of one-semester schools in North Carolina was labeled NC1 and the two-semester schools were NC2: one-semester schools in Virginia were VA1 while the two-semester ones were VA2. $Z$ and $\chi^2$ tests were conducted with these samples using a .05 level of confidence and critical values of ±1.96 and 9.49, respectively, except in the case of VA1 when 2.05 was the critical value used for the $Z$ because there were 27 degrees of freedom for that sample. Additional results of the $\chi^2$ testing may be seen in Tables 15-18.
<table>
<thead>
<tr>
<th>Score</th>
<th>AP Population</th>
<th>NC1 Frequency/Percent</th>
<th>NC1 Expected Frequency</th>
<th>NC1 Observed Cases</th>
<th>NC1 Residual</th>
<th>NC2 Expected Frequency</th>
<th>NC2 Observed Cases</th>
<th>NC2 Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23,305/22.6%</td>
<td>47.41</td>
<td>95</td>
<td>47.59</td>
<td>48.09</td>
<td>28</td>
<td>-20.09</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>19,019/18.5%</td>
<td>38.81</td>
<td>48</td>
<td>9.19</td>
<td>39.37</td>
<td>28</td>
<td>-11.37</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>28,904/28.1%</td>
<td>58.95</td>
<td>45</td>
<td>-13.95</td>
<td>59.79</td>
<td>79</td>
<td>19.21</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>19,632/19.1%</td>
<td>40.07</td>
<td>20</td>
<td>-20.07</td>
<td>40.64</td>
<td>52</td>
<td>11.36</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>12,172/11.8%</td>
<td>24.76</td>
<td>2</td>
<td>-22.76</td>
<td>25.11</td>
<td>26</td>
<td>.89</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>103,032</td>
<td>210</td>
<td>213</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 16. Population and sample frequencies for the Virginia samples

<table>
<thead>
<tr>
<th>AP</th>
<th>Population</th>
<th>VA1</th>
<th>VA1</th>
<th>VA2</th>
<th>VA2</th>
<th>VA2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Frequency</td>
<td>Expected</td>
<td>Observed</td>
<td>Residual</td>
<td>Expected</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>Frequency</td>
<td>Cases</td>
<td>Frequency</td>
<td>Cases</td>
<td>Frequency</td>
</tr>
<tr>
<td>----</td>
<td>---------</td>
<td>-----------</td>
<td>-------</td>
<td>-----------</td>
<td>-------</td>
<td>-----------</td>
</tr>
<tr>
<td>1</td>
<td>23,305/</td>
<td>6.32</td>
<td>9</td>
<td>2.68</td>
<td>32.06</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>22.6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>19,019/</td>
<td>5.17</td>
<td>9</td>
<td>3.83</td>
<td>26.24</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>18.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>28,904/</td>
<td>7.86</td>
<td>2</td>
<td>-5.86</td>
<td>39.86</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>28.1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>19,632/</td>
<td>5.34</td>
<td>5</td>
<td>-34</td>
<td>27.09</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>19.1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>12,172/</td>
<td>3.30</td>
<td>3</td>
<td>-30</td>
<td>16.74</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>11.8%</td>
<td></td>
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<td></td>
</tr>
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<td>Total</td>
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<td>28</td>
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<td>142</td>
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</table>
Table 17. State and sample frequencies for the North Carolina samples

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Frequency/Percent</th>
<th>Expected Frequency</th>
<th>Observed Cases</th>
<th>Residual</th>
<th>Expected Frequency</th>
<th>Observed Cases</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>123</td>
<td>69.72</td>
<td>95</td>
<td>25.28</td>
<td>70.72</td>
<td>28</td>
<td>-42.72</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>725</td>
<td>19.5%</td>
<td>48</td>
<td>7.05</td>
<td>41.53</td>
<td>28</td>
<td>-13.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>889</td>
<td>23.9%</td>
<td>45</td>
<td>-5.19</td>
<td>50.91</td>
<td>79</td>
<td>28.09</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>4</td>
<td>549</td>
<td>14.8%</td>
<td>20</td>
<td>-11.08</td>
<td>31.52</td>
<td>52</td>
<td>20.48</td>
</tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>319</td>
<td>8.6%</td>
<td>2</td>
<td>-16.06</td>
<td>18.32</td>
<td>26</td>
<td>7.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
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<td>213</td>
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<td></td>
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</table>

Table 18. State and sample frequencies for the Virginia samples

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Frequency/Percent</th>
<th>Expected Frequency</th>
<th>Observed Cases</th>
<th>Residual</th>
<th>Expected Frequency</th>
<th>Observed Cases</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>831</td>
<td>25.9%</td>
<td>7.25</td>
<td>9</td>
<td>1.75</td>
<td>36.78</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>636</td>
<td>19.8%</td>
<td>5.54</td>
<td>9</td>
<td>3.46</td>
<td>28.12</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>933</td>
<td>29.0%</td>
<td>8.12</td>
<td>2</td>
<td>-6.12</td>
<td>41.18</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>522</td>
<td>16.2%</td>
<td>4.54</td>
<td>5</td>
<td>.46</td>
<td>23.00</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>291</td>
<td>9.1%</td>
<td>2.55</td>
<td>3</td>
<td>.45</td>
<td>12.92</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3213</td>
<td>28</td>
<td>142</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Z scores found when comparing NC1 with the overall population (−10.99) and with the population of the state of North Carolina (−6.51) showed a statistically significant difference between the means of the groups. Students in this sample had lower achievement than other test takers in both the state and the overall population. Likewise, the $\chi^2$ results for NC1 indicated a significant difference in the distribution of scores when compared with both the state and the overall population. In both cases, the data were skewed positively, meaning more scores were at the lower end of the scale.

The Z scores for NC2 and the overall population (3.77) and for NC2 and the population of the state of North Carolina (7.85) showed a statistically significant difference between the means of the groups. Students in this sample had higher achievement than other test takers in both the state and the overall population. Also, the $\chi^2$ results for NC2 indicated a significant difference in the distribution of scores when compared with both the state and the overall population. In both cases, the data were skewed negatively, meaning more scores were at the upper end of the scale.

The Z scores for VA1 and the overall population (−1.37) and for VA1 and the population of the state of Virginia (−.76) showed no statistically significant difference between the means of the groups. The achievement of the students in this sample was not different from that of other test takers in both the state and the overall population. Likewise, the $\chi^2$ results for VA1 indicated no significant difference in the distribution of scores when compared with both the state and the overall population.
The Z-scores for VA2 and the overall population (−1.71) and for VA2 and the
state of Virginia (−.03) showed no statistically significant difference between the means
of the groups. Students in this sample did not have different levels of achievement than
other test takers in both the state and the overall population. However, the $\chi^2$ results for
VA2 indicated a significant difference in the distribution of scores when compared with
both the overall population ($\chi^2 = 37.10$) and the state ($\chi^2 = 31.99$). When the residuals for
these tests were investigated, the two-semester sample had lower numbers of 1s, 3s, 4s,
and 5s and more 2s than expected when compared with both the population and the state.
As before, a check was done to see if the different distribution resulted in more "passing"
scores.

**Number of students “passing” the test.** Again assuming that a score of "3" or
better was considered a “passing” grade, 67 students in NC1, 157 students in NC2, 10
students in VA1, and 67 students in VA2 achieved at an acceptable level. A $\chi^2$ test
revealed whether or not there was a difference in the distribution of “passing” scores for
the samples when compared with both the overall population and the population of the
particular state. (See Tables 19 and 20 for the results.)

Using one degree of freedom, a confidence level of .05, and a critical value of
$\chi^2 = 3.84$, a significant difference was found between the samples NC1 ($\chi^2 = 63.22$) and
NC2 ($\chi^2 = 19.30$) and both the population and the state. In NC1, fewer students “passed”
the test than expected, which meant that the AP scores for those students were lower than
expected. The results indicated that more students “passed” the test in NC2 than
expected, implying that those students achieved higher than expected. The test results for
VA1 did not indicate a significant difference between the percentage of "passing" scores in the sample and those in either the population or the state. Similarly, no significant difference was found between VA2 and the state. However, a significant difference was noted between VA2 and the population ($\chi^2 = 8.05$). Fewer "passing" scores were achieved than expected, implying that students in this group did less well than expected.

At this juncture, a word about the Virginia samples seems to be in order. The one-semester group consisted of five schools and 28 students, which represented an average of 5.6 students per school. The Virginia two-semester sample was composed of eight schools and 142 students, an average of 17.8 students per school. However, one Virginia school accounted for 40% of the students in the two-semester sample. The small numbers in VA1 and the unequal influence of the scores from one school in VA2 could have been the reason for the results found when these samples were tested. If the Virginia samples had been similar in size regarding the number of students and the number of schools, results more in line with those found with the North Carolina samples might have been discovered.

In summary, the additional testing revealed that Sample 1 and NC1 had significant differences no matter how they were compared. In all cases for these two samples, lower student achievement was evident. While the VA1 sample did not offer much in the way of significant differences, the sample itself may not have been large enough to have
Table 19. Results of $\chi^2$ tests for “passing” scores for the four samples and the population

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Percent</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
<th>$\chi^2$</th>
<th>D.F.</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 or 2</td>
<td>42,324</td>
<td>41.1</td>
<td>143</td>
<td>86.31</td>
<td>56.69</td>
<td>63.22</td>
<td>1</td>
<td>.0000</td>
</tr>
<tr>
<td>3,4, or 5</td>
<td>60,708</td>
<td>58.9</td>
<td>67</td>
<td>123.69</td>
<td>-56.69</td>
<td>19.30</td>
<td>1</td>
<td>.0000</td>
</tr>
<tr>
<td>Total</td>
<td>103,032</td>
<td></td>
<td>210</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NC1
<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
<th>$\chi^2$</th>
<th>D.F.</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or 2</td>
<td>143</td>
<td>86.31</td>
<td>56.69</td>
<td>63.22</td>
<td>1</td>
<td>.0000</td>
</tr>
<tr>
<td>3,4, or 5</td>
<td>67</td>
<td>123.69</td>
<td>-56.69</td>
<td>19.30</td>
<td>1</td>
<td>.0000</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NC2
<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
<th>$\chi^2$</th>
<th>D.F.</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or 2</td>
<td>56</td>
<td>87.54</td>
<td>-31.54</td>
<td>19.30</td>
<td>1</td>
<td>.0000</td>
</tr>
<tr>
<td>3,4, or 5</td>
<td>157</td>
<td>125.46</td>
<td>31.54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>213</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VA1
<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
<th>$\chi^2$</th>
<th>D.F.</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or 2</td>
<td>18</td>
<td>11.51</td>
<td>6.49</td>
<td>6.22</td>
<td>1</td>
<td>.0126</td>
</tr>
<tr>
<td>3,4, or 5</td>
<td>10</td>
<td>16.49</td>
<td>-6.49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VA2
<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
<th>$\chi^2$</th>
<th>D.F.</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or 2</td>
<td>75</td>
<td>58.36</td>
<td>16.64</td>
<td>8.05</td>
<td>1</td>
<td>.0045</td>
</tr>
<tr>
<td>3,4, or 5</td>
<td>67</td>
<td>83.64</td>
<td>-16.64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>142</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 20. Results of $\chi^2$ tests for “passing” scores for the four samples and the states

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Percent</th>
<th>Expected</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Carolina</td>
<td>1 or 2</td>
<td>1956</td>
<td>52.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,4, or 5</td>
<td>1757</td>
<td>47.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3713</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td>1 or 2</td>
<td>1467</td>
<td>45.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,4, or 5</td>
<td>1746</td>
<td>54.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3213</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC1</td>
<td>1 or 2</td>
<td>143</td>
<td>110.67</td>
</tr>
<tr>
<td></td>
<td>3,4, or 5</td>
<td>67</td>
<td>99.33</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>210</td>
<td></td>
</tr>
</tbody>
</table>

$\chi^2 = 19.97$  D.F. = 1  Significance = .0000

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC2</td>
<td>1 or 2</td>
<td>56</td>
<td>112.25</td>
</tr>
<tr>
<td></td>
<td>3,4, or 5</td>
<td>157</td>
<td>100.75</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>213</td>
<td></td>
</tr>
</tbody>
</table>

$\chi^2 = 59.59$  D.F. = 1  Significance = .0000

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA1</td>
<td>1 or 2</td>
<td>18</td>
<td>12.80</td>
</tr>
<tr>
<td></td>
<td>3,4, or 5</td>
<td>10</td>
<td>15.20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>

$\chi^2 = 3.90$  D.F. = 1  Significance = .0484

<table>
<thead>
<tr>
<th>AP Score</th>
<th>Cases Observed</th>
<th>Expected</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA2</td>
<td>1 or 2</td>
<td>75</td>
<td>64.89</td>
</tr>
<tr>
<td></td>
<td>3,4, or 5</td>
<td>67</td>
<td>77.11</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>142</td>
<td></td>
</tr>
</tbody>
</table>

$\chi^2 = 2.90$  D.F. = 1  Significance = .0887

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provided an accurate accounting of the true measure of the impact of 4x4 block scheduling in Virginia.

Sample 2 displayed significant differences in four of the six tests completed. Two tests, the Z test comparing Sample 2 and the overall population and the $\chi^2$ test for the distribution of "passing" scores when Sample 2 was compared with the overall population, revealed non-significant statistics. When the population of the combined states was held as the standard for contrast with Sample 2, the indications were that achievement was higher for those students. NC2 showed significant gains for achievement in all instances where tests were run. VA2 gave conflicting results, which may have been because of the make-up of the sample, as was discussed previously. However, when considered together, the three two-semester samples revealed that students performed at the same or higher levels as the students in the groups to which they were compared.

These results should serve as a signal for educators to make allowances for AP Calculus AB classes when scheduling courses in a 4x4 framework. The implication of this study seems to be that teaching AP Calculus AB for only one semester in a 4x4 schedule may not be the most advantageous way for students to be successful on the national AP test. Scheduling the course as a singleton which meets for 60 minutes daily, as a two-semester course that meets for 90 minutes daily, or as a two-semester course paired with another AP course each of which meets for 90 minutes on alternate days might be better alternatives. Because statistics similar to those revealed by this study might be found if the scores of AP courses in other disciplines were investigated,
administrators should reconsider the manner in which those classes are scheduled as well. As an extension of this work, further study with other AP courses in all disciplines is recommended.

Additionally, the number of semesters the course was taught may have been only one spoke in the wheel. Another spoke may have been the manner in which the schools handled the change process. The evidence provided by research questions three through six did not reveal consistent, if any, adherence to the advice of change experts such as Fullan and Hackmann. This topic will be discussed later in this work.

Other spokes in the wheel may have included the experience and training of instructors, the use of technology, the number of classes missed for various reasons, the sizes of the classes, the ability and readiness levels of the students, the availability of resources, the variations in 4x4 implementation strategies, etc. Further investigation of the impact of these topics also would aid in administrative decision-making.

**Traditional vs. 4x4 block clock hours in class.** In a traditional schedule, each class is approximately one hour long. With a school year of 180 days, this typically amounts to 180 hours of class time. In a 4x4 scheduled school, each class is one and one-half hours long. With a course duration of 90 days, students typically would be in class only 135 hours. If the course is scheduled as a two semester one under the 4x4 plan, typically there would be 270 hours of class time.

It would seem that the larger number of class hours provided under the two semester, 90-minutes per day option would produce higher achievement because, according to many researchers, increased time for instruction leads to improved learning.
Bloom (1980) maintained that time was a central factor in learning, and the NCTM declared that learning was “a product of both the time engaged in a learning task and the quality of that engagement” (1980, p. 11). In order to accommodate student learning, the National Science Board Commission on Precollege Education in Mathematics, Science and Technology (1983) recommended that time for teaching mathematics be increased. Also, Walberg (1988) asserted that raising time allocations was likely to help learning. In an effort to enhance student learning, the National Research Council (1989) recommended that teachers use less directive instructional strategies, although these strategies can require more time than the traditional period allows. In addition, Ryan (1991) maintained that once a policy to reschedule time-on-task was activated, achievement would be affected.

In two-semester samples students would have received more class time than students in a traditional setting, even considering that they would have been in class for less than the 270 hours allowed by the 4x4 schedule because of the May administration of the AP test. According to the prior research as cited above, because of the increased number of class hours, improved achievement should have resulted. When Sample 2 was investigated, however, the study was not conclusive regarding the difference between the achievement of students who had daily 90-minute classes for two semesters and the population of students who took the test. In Sample 2, the sample mean, 2.91, was larger than the population mean, 2.79. For these means, the \( \chi^2 \) test indicated a significant difference at the .05 level of confidence, but the Z test did not. Depending upon the test considered, the study might or might not have indicated improved learning by these
students. Further testing against different populations did reveal some evidence that student achievement had been altered positively. Further studies might provide additional insight into this issue.

In Sample 1 and in the other one-semester samples tested, the achievement of students was significantly lower than the population. If the course was scheduled for the second semester, students would have been in class for much less than 135 hours because the AP test was given in the first part of May. In the schools where the course was completed during the first semester of school, students received 135 hours of class time, assuming no days were lost due to weather, assemblies, or some other reason. If these students had studied AP Calculus AB for forty-five additional hours of class time, making their total clock hours equivalent to the traditionally scheduled daily 55-minute classes, their AP scores may have been different.

While it was not the intent of this study to compare one semester 90-minute courses with two semester 90-minute ones, the results of the study showed a disparity between the two groups. The one semester students had significantly lower scores than the population, while the two semester students scored as well as or better than the population, depending upon the statistical test used.

**Large blocks for instructional time.** Carroll contended that schedules that utilized large blocks for instructional time “establish a flexible, productive instructional environment that allows effective mastery learning as well as other practices recommended by research” (1989, p. 15). The achievement of students in schools where AP Calculus AB was scheduled for 90 minutes each day for two semesters neither
supported nor disputed what Carroll believed, since the study was not conclusive regarding this group. However, the statistical difference found with the data from Sample 1 indicated that, while such an environment as Carroll described may have been established, those students may not have been well-served with regards to the AP test. Whether this was due to the lapse of time between instruction and the testing, the fewer number of instructional days prior to the test, or to some other cause, the data revealed that those students had lower scores on the test.

Although the question of how much time is needed for learning cannot be answered in absolute terms because learning depends on many variables, Walberg maintained that “raising time allocations and engaging students for a greater fractions [sic] of allocated time are likely to help learning” (1988, p. 85). The study neither supported nor disputed what Walberg claimed, since the study was not conclusive regarding the difference in the achievement of students in schools where the course was scheduled for 90 minutes each day for two semesters.

Edwards (1995) maintained that Advanced Placement students appeared to be major beneficiaries of a 4x4 schedule. His data considered one school system in which all Advanced Placement classes were converted into two-credit, year-long courses. According to his work, student scores on the 1994 AP exams skewed to the upper end of the grading scale. However, the results of the data from Sample 2 did not support Edwards’ claim. The study was not conclusive regarding the difference between the achievement of students who had daily 90-minute AP Calculus AB classes for two semesters and the population of students who took the test.
Retention of learning. Concerning the issue of retention of learning, the results of this research seemed to be at odds with the conclusions reached by Kadel (1994) and Canady and Rettig (1995). After reviewing existing research, Kadel determined that students learn at least as well in block scheduling and retain this learning over time. Canady and Rettig concurred and stated that there was “very little difference between the retention of students who had just recently completed a prerequisite course and other students with greater time lapses between courses” (1995a, p. 86). The study showed that AP test scores of students who received instruction for only one semester were statistically lower than those of the population of students who took the test. In the cases where students completed the course by the end of first semester, at least three months had elapsed between the end of the course and the May testing date. Although Canady and Rettig reported that high school students could be expected to “retain slightly more than 85 percent of their original learning after a three-month summer vacation” (1995a, p. 86), the break in instruction may have created enough memory loss to have contributed to the difference in the scores for those students. Another consideration was that students who took the AP course in a class taught from March to June might not have covered all of the necessary material before taking the test (Kadel, 1994).

Curriculum. O’Neil (1995b) was concerned about whether as much of the curriculum was covered in block schedules as the traditional schedule allowed. Depending upon the semester in which a school scheduled the course, there might be a decline in the total number of minutes or days devoted to AP Calculus AB instruction. As a result of his research, he declared that “ultimately, however, the important issue is
how much students have learned, and students in block schedules are not scoring any lower on achievement tests, say educators using block schedules” (p. 14-15). Even though O’Neil claimed that “in general, research has found that students do at least as well on measures of academic achievement” (p. 15), this was not validated by the data from Sample 1. According to the results of this study, the achievement of these students was lower than that of their peers when measured by the AP Calculus AB test.

With a 4x4 method of scheduling, the number of instructional minutes allocated per course may be fewer than the number provided with a six- or seven-period schedule, unless the school day is lengthened. Therefore, some teachers have deemed it “necessary to re-examine their curricula, reduce review, and eliminate less important objectives” (Canady & Rettig, 1995a, p. 89). Because the curriculum is specified as a national one for AP courses, none of the objectives can be eliminated. Each one is likely to be represented on the AP test and should be mastered by students prior to the May testing. For the students in 4x4 schools where the course was scheduled for only one semester, this investigation revealed a difference in scores which may have been the result of omitted or quickly presented objectives.

Another occurrence that may have impacted on the curriculum taught was the report by some of the respondents that classes were canceled due to inclement weather. These days might not have been rescheduled during the same semester in which they were lost. The actual number of instructional days varied in some schools and could have limited the number of objectives completed or the length of time devoted to each objective, especially in the one-semester course.
Research Question 2

Research question 2: Were special accommodations made for AP Calculus AB classes at schools using the 4x4 block-scheduling method?

According to Canady and Rettig (1995a), schools on the 4x4 scheduling plan have various strategies for addressing the issue of AP courses. This statement was supported by the study, although no consistency was found regarding special accommodations for the AP Calculus AB classes. The schools in Sample 2 selected the option of scheduling AP courses for both semesters and, in some instances, offering two credits. Many schools chose to provide review sessions in the spring in preparation for the May exam. Another option was to continue the course as year-long in a single period. This alternative was selected by three of the organizations originally included in the research, but whose scores were not included due to this decision.

Canady and Rettig (1995a) further commented that some schools handled the issue by establishing a nine-week elective course to precede or follow 27 weeks of AP instruction. One school that opted to participate in the study altered this plan and scheduled the course for the first 27 weeks of school with an elective course planned for the remainder of the second semester.

The study revealed other options as well, including offering dual enrollment at area colleges, presenting the curriculum via satellite or interactive video, or teaching the course during the second and third nine weeks of school. Although different strategies were followed, the study showed that schools on the 4x4 scheduling plan did employ various strategies for addressing the issue of AP courses.
Research Question 3

Research question 3: What prompted schools to make the scheduling change from traditional methods to 4x4 plans?

A second purpose of the study was to describe some of the dynamics that created the shift from traditional scheduling to the 4x4 plans. Research questions three through six sought the background that lead to the registration of students into 4x4 classes. The third question revealed reasons for the change.

The National Education Commission on Time and Learning (1994b) found that over the past several years, a few states had abolished time requirements. These states tended “to adopt strategies of specifying desired results and giving schools and districts the responsibility of devising plans to achieve those results” (p. 18). Virginia and North Carolina are two states which have allowed school divisions to experiment with alternative scheduling practices in order to improve educational outcomes in their schools. As a result, schools in these states have opted to change their traditional schedules to take advantage of the numerous strengths of the 4x4 schedules.

Many advantages of the 4x4 scheduling method have been enumerated by proponents of the plan (Canady & Rettig, 1995; Carroll, 1987, 1989). According to Canady & Rettig (1995), a “well-crafted schedule” could be helpful in several ways: more effective use of time, space, and resources; improved instructional climate; solutions for problems related to the delivery of instruction; and the establishment of desired programs and instructional practices. In their opinions, providing quality time and creating a school climate were issues that redesigning the school schedule could help address. The reasons
for the shift to 4x4 that were provided by participants supported the opinions of Canady & Rettig and paralleled their list of advantages for the practice.

Improved student performance was labeled by Cawelti (1994a) as the central goal of restructuring. Newmann and Wehlage (1995) also placed significance on student learning by making it the center for the circles of support. The first and fourth most frequently selected choices of the survey participants who answered the third research question indicated a focus on student learning through the opportunity for students to enroll in more elective courses and through the chance for acceleration.

Research Question 4

Research question 4: In schools that changed, who made the decision to switch to the 4x4 method of scheduling?

The fourth research question disclosed the persons or groups who made the decision to switch scheduling formats. As has been mentioned previously in this work, the decision to switch to the 4x4 method of scheduling was made by a number of different persons or groups. The fact that School Planning Councils or Staff Advisory Committees were responsible for the decision most of the time pointed to the possibility that most schools who risked the change to 4x4 were operating under some form of site-based management, though site-based management was not a focus of this study.

Research Question 5

Research question 5: At the sites where the change was made to the 4x4 method, who had input into the decision process?
The fifth research question unveiled the persons or groups who had input into the decision to move to a 4x4 scheduling scheme. The conclusion that a number of different persons or groups (in addition to the most prominent three: faculty, parents, and students) were involved also hinted at the possibility that most schools investigated were operating under some form of site-based management. Again, site-based management was not a focus of this study.

**Research Question 6.**

**Research question 6:** What measures were taken to prepare the administration, faculty, staff, students, and community for the implementation of the 4x4 method?

The last question the study addressed dealt with the measures taken to prepare for the implementation of the 4x4 method. Staff development was designed to prepare staffs for dealing with the new design, while other implementation practices were aimed at informing and preparing all stakeholders.

O'Neil (1995b) asserted that the challenges for educators who instituted a block scheduling plan included ensuring that the instruction offered in block classes was appropriate for the longer format and offering staff development on instructional techniques and curriculum development. The responses provided 16 different topics related to instruction. While not all schools were addressing all of the topics, many schools included one or more of them for consideration during staff development.

The NCTM (1980) declared that instructional time was a "precious commodity" that should be used wisely and that teachers must employ the most effective and efficient techniques at their command. Because of this position, the NCTM recommended that
school administrators and parents support the teacher’s efforts to engage students more effectively in learning tasks and that teachers select diverse instructional strategies, materials, and resources. The findings of the study indicated that schools using 4x4 scheduling practices were attempting to meet these recommendations.

There was further evidence that many schools followed the advice of researchers who had defined effective staff development practices. As Cawelti (1994b) suggested, many schools established teams, visited other sites, and embarked upon strategic planning. In some cases, schools followed Elmore’s (1993) advice and used staff development to assist teachers with applying effective teaching research (examples included learning styles, authentic assessment, cooperative groups, integration techniques, etc.). Some instances existed where entire staffs were in continuous and coordinated programs, as was recommended by Newmann and Wehlage (1995). Several of the ideas suggested by Sparks (1995) were in evidence, too, although the most frequent references were to the recommendations regarding keeping the focus on student learning and providing content-specific staff development activities.

**Comments**

Research questions two through six revealed inconsistencies in the manner in which restructuring schools managed the change process. In several schools, there appeared to be a lack of cohesiveness, continuity, and commitment. Few respondents outlined procedures that followed Gorton’s (1987) formula for the change process. Little indication was observed that needs assessments were conducted or that formative and summative evaluations were underway. Gorton stressed decision-making, planning,
organizing, diagnosing, and evaluating, but these five processes did not appear to exist as an integral collection in the implementation strategies of the schools in the study. However, two stages of Gorton's formula did appear to have been attempted in nearly all schools: orient the target group to the proposed change and plan a program of implementation. The latter of these, though, seems to have been haphazardly accomplished and, in some cases, built upon little emphasis from the teachings of research.

The instructions of Fullan (1991) also seem to have been disregarded by some restructuring organizations. He maintained that collaboration and close interaction among those persons essential to carrying out the change process were key to the successful implementation of innovations. While both of these were evident in many schools, there was not consistency across the spectrum of sites.

North Carolina school systems appear to be adopting the 4x4 block scheduling method more rapidly than Virginia school systems. Because of the widespread use of the plan throughout the state, perhaps a more consistent, thoughtful, research-based plan of action would be beneficial. Attending to every “consequential” aspect of a school (Sizer, 1993), focusing on “the teacher-as-learner” to link classroom and school improvement, providing opportunities for people to work together instead of independently (Fullan, Bennett, & Rolheiser-Bennett, 1990), and applying the guidelines for implementing block scheduling (Hackmann, 1995) would serve as a framework for building such a plan. Perhaps it was not the fact that students were in 4x4 block scheduling that made the noted
differences in achievement in the organizations included in the study, but rather the manner in which the innovation was put into practice that was the source of the results.

**Implications for Practice**

The relationship between the method of scheduling and the achievement of AP Calculus AB students has implications for effectiveness of instruction, for student success in the next college-level mathematics course, for staff development, and for administrative decision-making. Knowledge gained from this research should be considered by school leaders in order to form a more comprehensive picture of the manner in which scheduling changes effect all students and programs. The following appear to be in order:

1. While the 4x4 scheduling method might be more beneficial for the educational process where some students, topics, and problems are concerned, this study has shown that it is not beneficial to at least one group of students, those who took AP Calculus AB in one semester. For these students, scheduling the course in a 4x4 setting for only one semester was not the best option. If AP Calculus AB courses are part of the academic offerings in 4x4 schools, they should be scheduled within a time frame that will best suit the curriculum. One interpretation of this study could be that these courses should be required to meet daily for two semesters instead of following the standard 4x4 plan of meeting daily for one semester. Alternatives such as scheduling the course as a singleton which meets for 60 minutes daily, as a two-semester course that meets for 90 minutes daily, or as a two-semester course paired with another AP course each of which meets for 90 minutes on alternate days might help to improve student achievement.
The possibility also exists that 4x4 scheduling practices might not be beneficial for other AP students as well. Statistics similar to those revealed by this study might be found if the scores of AP courses in other disciplines were investigated. Student achievement in other disciplines such as foreign language might be impacted in ways similar to those found in this study. While no one scheduling plan may exist that adequately meets the needs of every group, it should be the mission of every educator to make adjustments to whatever plan is adopted so that the opportunity for student success in all courses is optimized.

2. In one-semester AP Calculus AB classes, instruction may not have been as effective as it was in traditional classes. One reason for this might have been that teachers still may not be prepared to provide instruction in longer class periods. Teachers may not have changed their plans or presentations to adequately accommodate the longer classes or received enough training to comfortably and successfully do so even if they desired to alter their instructional techniques. Administrators should use common sense and informed practice to schedule staff development opportunities which will be consistent, continuous, pertinent, and informative. Supervision by administrators, observations of and by colleagues, and other strategies could be utilized to focus on this area of concern.

3. Research questions two through six provided evidence that schools were doing diverse practices regarding both AP Calculus AB classes and the change process. The variety of accommodations made for the course may have been the reason for the differences between the samples and the population. Also, although some schools did follow similar patterns, the implementation plans for the 4x4 method varied from school
to school. Because no consistent practices were followed, student learning may have been impacted, thus creating the differences in achievement as reflected by the AP test scores.

4. According to this study, there are several other possible factors that administrators should consider. One factor concerns whether the objectives in the AP Calculus AB course outline that are included on the AP test are compatible with school-wide goals. If they are not, then it may be better for calculus not to be offered as advanced placement, but as a continuation of the regular mathematical sequencing for students.

5. Yet another possibility to consider is whether the course is being taught according to the AP syllabus. Have teachers been trained at Advanced Placement seminars and institutes? Are they using graphing calculators, for example, during course instruction? Is there sufficient time for students to master the objectives?

6. Finally, the AP tests are used by colleges to predict students' success in the next college-level mathematics course. High school administrators also should heed the warning given by the results of this study and schedule AP Calculus AB classes in a time frame that serves to best enhance students' opportunities for success in future math courses.

**Recommendations for Future Research**

The following recommendations are made for future research which concern the limitations of this study and some of the questions raised by this study:

1. Study the extent to which AP Calculus AB teachers in 4x4 schools incorporated diverse teaching strategies into their daily plans.
2. Study achievement using the 1995, 1996 and 1997 AP Calculus AB scores of all Virginia and North Carolina schools that taught the course in a 4x4 setting.

3. Study achievement using data from all 4x4 scheduled schools in which the AP Calculus AB course is offered.

4. Compare the data from the study to the population from the states involved in the research instead of to the total population of students who took the test.

5. Determine if AP teachers re-examined their curricula, reduced review time, or eliminated some important objectives. Because the curriculum is specified as a national one for AP courses, none of the objectives can be eliminated since each is subject to testing.

6. Study two-semester 4x4 block-scheduled AP Calculus AB classes to see if there is a repetition of the reduction of 5s that occurred when the distribution of scores in Sample 2 was compared to that of the population.

7. Study other AP courses that were taught in 4x4 schools to see if the AP test results showed statistical differences in achievement.
Appendix A

Questionnaire: 4x4 Block Scheduling

1. Did your school use the 4x4 method of block scheduling in 1994-95?
   Yes ___  No ___

2. Did your school offer an AP Calculus AB course in 1994-95?
   Yes ___  No ___

3. According to Canady and Rettig (1995), schools on the 4x4 scheduling plan have various strategies for addressing the issue of AP courses. For example, AP courses might be scheduled for both semesters and offer two credits. Another possibility might be to provide review sessions in the spring in preparation for the May exam or to keep AP courses on a 180-day schedule. How was the AP Calculus AB course scheduled in your school? Were special accommodations made for the course at your school? (If additional space is needed, please attach a separate page.)

4. Using your school’s 1995 AP Calculus AB test results, please complete the following:
   Number of 5’s ______
   Number of 4’s ______
   Number of 3’s ______
   Number of 2’s ______
   Number of 1’s ______
   Total Number of Scores ______

5. Was your school using traditional scheduling before implementing the 4x4 block method?
   Yes ____  No ____ (If not scheduled traditionally, how was your school scheduled?)

School Code:
6. When did the change to the 4x4 block method occur? _____________________

7. Why was the scheduling change made? (Please check all that apply.)
   ____ To allow students greater opportunity for acceleration
   ____ To offer students the chance to enroll in more elective courses
   ____ To provide teachers with the opportunity to utilize more diverse, but possibly more time-consuming, instructional strategies
   ____ To reduce the number of class changes during the day
   ____ To help with budgetary concerns (fewer books, staff, materials, etc.)
   ____ Other: ________________________________

8. Who made the decision to switch to the 4x4 method of scheduling?
   ____ Superintendent/Central Office
   ____ Building Principal
   ____ School Planning Council/Staff Advisory Committee
   ____ Other: ________________________________

9. Who had input into the decision process? (Please check all that apply.)
   ____ Faculty
   ____ Students
   ____ Parents
   ____ Community members/Businesses/Religious organizations
   ____ Researchers/Guest speakers
   ____ Other: ________________________________

10. What measures were taken to prepare for the implementation of the 4x4 method?
    (How were students and parents notified? What staff development activities occurred?) __________________________________________________________
    ____________________________________________________________
    ____________________________________________________________

11. Comments or suggestions: __________________________________________
    ____________________________________________________________
    ____________________________________________________________

12. Would you like a copy of the results of this research? Yes ____ No ____

   Please return this questionnaire in the stamped, self-addressed return envelope.

   Thank you for your time and assistance with this study!!

School Code:
Appendix B

Cover Letter

April 2, 1996

«Title» «FirstName» «LastName», Principal  
«Company» High School  
«Address1»  
«City», «State» «PostalCode»

Dear «Title» «LastName»:

Our purpose in contacting you is to ask for your participation in a study concerning a critical area of interest to many educators, the 4x4 block method of school scheduling. Carolyn is a doctoral candidate at The College of William and Mary and is conducting a study regarding the difference in achievement between students who study AP Calculus AB in the 4x4 method and those who do so in a traditional schedule. Also, she teaches AP Calculus at Green Run High School in the Virginia Beach City Public Schools. The Green Run administration and faculty are considering making the shift from a traditional approach to one of various alternatives, including the 4x4 block scheduling method. Any information that can be gathered regarding this issue would inform their decision-making.

In addition, your input is important as it will add to the data base, thus making the research more helpful to all educational decision makers as they restructure their schools. The enclosed questionnaire takes minimal time to complete and requires that either you, the guidance director, the AP coordinator, or the AP Calculus AB instructor record AP Calculus AB test scores from the 1994-95 school year. The results may be found at the bottom of The College Board Candidate Grade Roster mailed in July to each participating school. Once completed, the questionnaire should be returned to Carolyn in the enclosed, self-addressed envelope by April 30, 1996.

Information is being gathered from schools throughout Virginia and North Carolina that use the 4x4 method of block scheduling. The anonymity of the school divisions and individuals will be protected. Every school division and high school in the study will be
assigned a code number, and the researcher will be the only individual with access to the
code list. Only the total number of 5's, 4's, 3's, 2's, and 1's for the 1995 test is being
sought; there is no need for the names of students or teachers to be provided.

This research is being conducted under the supervision of Dr. Robert J. Hanny of the
School of Education at The College of William and Mary in Williamsburg, Virginia. He
may be contacted at 804-221-2334. Carolyn's phone number is 804-721-2673. If you
would like a copy of the results of the study, one will be furnished to you at no cost.
Simply check the appropriate space on the questionnaire. Please accept our sincere
thanks in advance for your assistance with this important project.

Sincerely,

Carolyn M. Keen
Doctoral Candidate, School of Education

Robert J. Hanny, Ph.D.
Professor, School of Education

Enclosures: 2
Appendix C

Follow-up Letter

May 10, 1996

«Title» «FirstName» «LastName», Principal
«Company» High School
«Address1»
«City>, «State» «PostalCode»

Dear «Title» «LastName»:

We are contacting you again to extend to you another opportunity to participate in a study concerning a critical area of interest to many educators, the 4x4 block method of school scheduling. Carolyn is a doctoral candidate at The College of William and Mary and is conducting a study regarding the difference in achievement between students who study AP Calculus AB in the 4x4 method and those who do so in a traditional schedule. When our first packet was mailed, it arrived just before or during spring break for many schools. Consequently, there may not have been sufficient time for you to return the questionnaire before the requested date. Many schools have returned their questionnaires, and information from your school would be appreciated.

In addition, your input is important as it will add to the data base, thus making the research more helpful to all educational decision makers as they restructure their schools. The enclosed questionnaire takes minimal time to complete and requires that either you, the guidance director, the AP coordinator, or the AP Calculus AB instructor record AP Calculus AB test scores from the 1994-95 school year. The results may be found at the bottom of The College Board Candidate Grade Roster mailed in July to each participating school. Once completed, the questionnaire should be returned to Carolyn in the enclosed, self-addressed envelope by May 27, 1996.

Information is being gathered from schools throughout Virginia and North Carolina that use the 4x4 method of block scheduling. The anonymity of the school divisions and individuals will be protected. Every school division and high school in the study will be assigned a code number, and the researcher will be the only individual with access to the code list. Only the total number of 5’s, 4’s, 3’s, 2’s, and 1’s for the 1995 test is being sought; there is no need for the names of students or teachers to be provided.

This research is being conducted under the supervision of Dr. Robert J. Hanny of the School of Education at The College of William and Mary in Williamsburg, Virginia. He
may be contacted at 804-221-2334. Carolyn’s phone number is 804-721-2673. If you would like a copy of the results of the study, one will be furnished to you at no cost. Simply check the appropriate space on the questionnaire. Please accept our sincere thanks in advance for your assistance with this important project.

Sincerely,

Carolyn M. Keen
Doctoral Candidate, School of Education

Robert J. Hanny, Ph.D.
Professor, School of Education

Enclosures: 2
Appendix D

Comments or Suggestions from Survey Respondents

• The key to making this work is to allow faculty to visit schools where this is being used and to freely interview teachers and students in those schools. Faculty must be involved in extensive staff development. Pacing guides need to be developed. Some suggestions for staff development: 4-MAT, Cooperative Learning, Seminar Teaching.

• We seemed to sprint into the 4x4. I feel that AP Calculus should be a two semester course of some sort. If this is impossible, then the spring semester is the best time to do it.

• This has been an excellent organization for us.

Our best (AP) students go ADDITIONAL time (2 semesters). Others who need more time to absorb math had to learn Algebra, Geometry, etc. in 30 hours per semester LESS time. Suggestion: Why not teach BC Calculus in a whole year?

• We love the 4x4—would not go back to traditional schedule.

• Visit schools who have been on blocks, both 4x4, A/B and combination. Use schools with experience to help re-plan pacing of courses and sequencing—Be sure teachers realize they must be ready to change teaching styles and methods.

• No longer on 4x4. County decided to place all schools on 7 A/B schedule despite endorsement of 4x4 by superintendent and high school principals.

• A supportive, innovative central instructional center and school board are essential—this is a risk for them.

• 4x4 is a great schedule change. The benefits are far greater than most folks realize.
• We have been very happy with the change to 4x4.

• AP classes are the only ones we teach all year long (both terms).

• We offer AP Government and English Dual Enrollment: 6 credits composition, 6 credits literature (for college credit) 6 credits US History, 6 credits college math, 8 credits Biology (96-97).

• One block would not be enough time—former students are coming back saying they were prepared for college by their AP Calculus class.

• Need to have parents involved in the initial process.

• One year is not enough time to evaluate its [sic] effect on the AP courses.
References


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