Student Engaged Time in the Mathematics Classroom: A Comparison
between Coeducational and Single Sex Classrooms

by

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Dedication

This dedicated to my wife, Stacey, a teacher, scientist, mother and friend and to my daughters, Samantha and Jessica; free to be anything they want to be.
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Abstract

This quasi-experimental study examined student engaged time as a function of the gender composition of the classroom. Three levels of single sex and coeducational mathematics classes were compared. An analysis of variance found that class environment (single sex or coeducational), and class level (Algebra 1/2, Geometry 3/4, or Algebra 5/6) were significant factors. A significant interaction effect was also found. Algebra and Geometry students were more engaged in a coeducational environment and female Algebra 5/6 students were more engaged in a single sex environment.
Chapter 1

The Problem

Introduction

Visualize a classroom in a modern school today and the image is almost certainly one that includes girls and boys working and learning together. As natural as it seems, it has not always been this way and in recent years there is growing body of evidence that suggests some young women might benefit from spending time in school separated from young men. This evidence has been collected over the years by examining private single sex schools such as preparatory or parochial schools and more recently from a few experimental single sex classes within coeducational schools, both public and private.

In the past, the rationale for separating the sexes was largely based on the idea men and women had different educational needs. For women, the purpose of school was to prepare them to fulfil their roles in society (Shmurak 1998). Such roles left them powerless, and isolated. The system also served to maintain the social status quo, which kept women in these
roles. Why then would there be any interest in segregating the sexes again?

This introduction will take a brief look at the history of women in schools and the research that led to the questions posed by this study.

Allowing women to go to school is actually a rather recent concept. Before the nineteenth century women had few opportunities for education outside of home schooling and private tutors. The lucky few who were educated were generally of high social class and their field of study limited to that which was thought of at the time as suitable for women, largely music and the arts. During the early nineteenth century in this country, educational reformers argued that in a democratic country women should have the same social and moral rights as men and as such have access to the same education (Tyrack and Hansot 1990). The paradox was that though most agreed women needed to be better educated and thus more empowered, they also needed to be constrained to their traditional societal roles. In the late nineteenth century, as compulsory education became the norm, the number of schools exploded. At this point in time the purpose of education for women was largely seen as to prepare them to be wives and mothers while men were to be prepared for trades and professions (Stock 1978). An exception to this was teaching, one
of the few professions open to young women. This provided a reason for educating at least some women beyond what was considered necessary and proper at the time.

Given the very different expected outcomes for boys and girls, separate schools seemed logical. However, most school districts, being public and in rural areas, could not afford separate schools. The exceptions were in large cities where parochial and private independent schools could find sufficient numbers of students to operate. The former separated the sexes based on religious and moral justifications and the later made separations based on social class.

By the early twentieth century coeducation was the norm in public schools in the United States (Riordan 1990). Single sex schools were left to either parochial or other private schools. The separation of church and state in this country did not allow public single sex schools based on religion, and likewise the egalitarian image of American schools, made it equally difficult to justify public single sex schools based on social status. Coeducation continued as the norm in this country and, for the most part, the rest of the
world. However, there have been some rumblings in the past that are the precursors of today's interest in single sex education.

This interest can likely be traced to the feminist movement of the 1960's and 70's. Women questioned their traditional roles in society; roles that tended to exclude them from careers such as scientists, engineers and doctors as well as many other technical professions. Even when women found jobs in these areas, they were likely paid less than their male counterparts. The diving force of this movement was equality, both in the workplace and in society in general (Stock 1978).

Women were and still are underrepresented in science, mathematics and engineering (Olson 1999). The lack of women in technical fields begs the question, why? Some argue that women can not do mathematics and science as well as men; that their brains are not "wired" for it or that there is a "math" gene that is sex linked (Benbow and Lubinski 1997). This was one idea used to explain a "gender gap" in mathematics achievement test scores that was discovered in the early 1980's (Benbow and Stanley 1980).
Researchers operating from a framework of equality used this "gender gap" as evidence that the tests were biased against women and pushed for reform in standardized testing (Williams 1989). Those working from this framework argued that the differences seen in society between men and women would disappear if they were all treated the same. This implied that the same curriculum should be provided for boys and girls. The apex of this equality movement was the passage of Title IX in 1972. This law banned any school receiving federal funds from discriminating on the basis of sex.

Much of the work to explain the "gender gap" lost its relevance in the late 1980's when it was argued that it was the result of "differential course selection" (Smith and Walker 1988). This meant that the girls did worse on the mathematics sections of tests like the SAT, because they tended to take fewer and less challenging mathematics courses. When this effect was factored out, the "gap" seemed to disappear. One question answered, but another created. Why were young women opting out of mathematics and science classes? Research at this point moved away from psychological and physiological reasons and started looking more at the sociology of schools and gender.
It was clear that young women were already mentally opting out of mathematics and science in the middle school years (Streitmatter 1994). Girls, who were academically ahead of boys going into the middle school years, were coming out of middle school academically behind the boys (AAUW 1992). Social relationships become more important than academics for many eighth grade girls and they do not see it as socially acceptable to appear smart. Boys don’t like girls smarter than they are and it is important to be liked. In addition, girls see themselves as mothers, nurses or teachers and as such have little need for mathematics and science (Fennema & Meyer 1989).

Educators were themselves guilty of developing much of this attitude in young women. Within the classroom, teachers called on boys more frequently and asked them more challenging questions (Streitmatter 1994). In situations involving the use of manipulatives or lab materials, boys took control. Textbooks were often written from a viewpoint that favored boys, whether it was by the use of male models in problems and images or in the selection of problem situations that would interest boys (Streitmatter 1994).
It seemed that mathematics and science classrooms were meant for boys. All the more reason to treat everyone the same. In this vein there came several programs such as GESA, aimed at helping teachers create more gender neutral classrooms (Grayson 1987). This approach was consistent with Title IX. It also seemed a logical extension of educational policies driven by the racial integration of schools since the 1960’s.

The problem was that equality in principal did not mean equality in reality. To this day, too few teachers are even aware of the inequities that occur every day within their own classrooms. This was given great public attention with the publishing of the AAUW report, "How Schools Shortchange Girls" in 1990 and a similar book by Sadker and Sadker, "Failing at Fairness" (1995). Given then that boys tend to dominate coeducational classrooms, what is the alternative? The answer seemed obvious, take the boys out of the classrooms. There were two ways to do this, one was to form all girl schools, and the other was to form all girl classes within coeducational schools in those subjects where girls were losing ground to boys. The idea of all girl schools was not new, though fewer in numbers, they were still around and the idea of all girl classes within coeducational schools was also not new,
classes such as home economics, shop and health have a long history of separation by gender. Such classes perpetuated stereotypical gender roles. Even the idea of separating the sexes to improve the academics of one over the other was not original. At the turn of the century, it was clear that girls were better than boys in many academic areas and that they were more likely to stay in school and graduate (Tyrack and Hansot 1990). During this Progressive Era, reformers argued that if girls had an edge over boys and different interests, would it not make sense to segregate the sexes in academic subjects? Thus, all boy reading classes were created with books selected on the basis of what they would like to read. At the same time girls took mathematics and science classes geared towards domestics. The end of such classes was brought about by the fact that in small schools they were not practical and the fact that Americans in general were committed to coeducation (Tyrack and Hansot 1990).

Nearly one hundred years later, interest in single sex classes has been revived. This time though, the focus is on all girl mathematics and science classes within coeducational schools. Despite the similarity of the situations, the motivations are quite different. All boys classes were created as a
reaction to the fear that men would lose power and authority relative to women if too few of them finished school. Recent all girls classes have been formed to empower young women and help them break stereotypes of women as inferior students of mathematics and science.

Experimental classes started to appear in the late 1980's and 90's. The theory was that if girls were in separate mathematics and science classes, they would not have to compete with the boys for materials or the nurturing attention of the teacher. In addition, it would be acceptable to be seen as good at mathematics or science. There would not be any boys watching, ridiculing or distracting the girls. Thus, girls would be more successful in their mathematics and science classes and more likely to take additional courses in these areas. The end result would be more young women entering college better prepared to take classes in science and engineering and more willing to consider these as careers.

Such classes were created largely based on individual teacher initiative. They saw the need and got support from parents, administrators and students. In almost all cases these classes were welcomed and accepted.
Unfortunately, the same Title IX that was a boon to women rights since its inception became an obstacle to single sex classes. This was because few administrators were willing to risk losing Federal funding for the sake of single sex classes. Few complaints about single sex classes have actually been filed (Streitmatter 1999), but when they are, the end result is usually the elimination of the single sex class. Title IX does not strictly forbid the creation of single sex classes, but such classes require strong justification.

The idea of segregation in any form seems hypocritical in a country based on equality. Some women's groups such as NOW see these classes as a step backward, that they imply and reinforce the idea that women are somehow inferior to men (Connors 1997). Still others argue that if the problem is the way boys behave in classrooms, then we shouldn't segregate the classes, we should teach the boys to change their behavior (Sanders 1994).

As was done almost one hundred year earlier, there are those who remind us that boys underperform girls in reading and writing and are more at risk for dropping out than girls (Epstein, Elwood, Hey & Maw 1998). Thus, the logic used to justify all girl classes could just as easily be used to once again
create all boy classes. Is that the direction schools should go, coeducational schools, segregated into single sex academic classes based upon perceived gender differences in academic abilities? Yet, the research, as reviewed later in this study, indicates that some students are finding benefits in such classes. Are we to ignore those findings? The research is far from conclusive and as such many groups such as the AAUW are advocating a go-slow approach and more careful research (AAUW 1998).

Purpose of the Study

The purpose of this study was to provide quantitative evidence for differences between the environments of coeducational and single sex mathematics classes. Studies have shown a perception by girls in single sex classes that they pay more attention, get more work done and in a more timely fashion (Streimatter 1998, 1999 & Rosser 1990). Anecdotal evidence from girls in single sex classes at the observed school also indicated they think they pay more attention they and are less often distracted if there aren't any boys in the class. This study attempted to verify that assertion.
Research Questions

The following questions provided the direction for the research:

1. Was there a difference between student engaged time for male students and female students?
2. Was there a difference between student engaged time for students in a coeducational mathematics class and a single sex mathematics class?
3. Was there a difference between student engaged time for female students in a coeducational mathematics class and a single sex mathematics class?
4. Was there a difference between student engaged time for students in a coeducational mathematics class and a single sex mathematics class when grouped by class level?
5. Was there a difference between student engaged time for female students in a coeducational mathematics class and a single sex mathematics class when grouped by class level?

Significance of the Study

Much of the research on single sex education has been quantitative in nature and focused on academic and affective results such as student achievement and attitudes toward classes. This study examined the environment itself and
how it might affect a student’s engaged time. This variable has been strongly and positively correlated with achievement (Cobb 1972). If single sex classes improve a student’s engaged time, it would seem reasonable to expect that such an environment would lead to improved achievement. In particular, if young women benefit from single sex classes to the point that their achievement and future participation in higher level mathematics courses improves and leads to larger numbers of women in mathematically intensive careers, then the value of such classes would be clear.

Assumptions

For the purposes of this study, the following assumptions were made:

1. The sample of students used in the study are representative of secondary students for the three levels of mathematics classes examined.

2. The dependent variable used in the study, engaged time, can be measured consistently and reliably from student to student and from class to class.

3. The distribution of means for student engaged time is normal.

4. Teacher behaviors and expectations for student behavior were the same for experimental and control groups at the same class level.
5. Coeducational classes in the study were evenly balanced between genders.

6. Mistakes in measuring a student’s engaged time are evenly distributed across classroom environments and levels.

Limitations

The study was conducted with the following limitations:

1. The study was restricted to an urban secondary school in the Southwest United States.

2. Assignment to the control and experimental groups was by self-selection and not at random.

3. Cell sizes in the research design were not balanced.

4. Only female single sex classes were used in the experimental group.

5. Only three levels of mathematics classes were used in the study.

6. More than one teacher was observed during this study.

Definition of Terms

Single sex. Refers to those classes that have only students of one gender. In this study, all such classes were female.
Engaged time. Refers to the time students appear to be paying attention to materials or presentations that have instructional goals.

Coeducational. Refers to classes that have both male and female students in approximately equal proportions.

Classroom environment. Refers to the gender composition of the class, single sex or coeducational.

Summary

This chapter treated the beginnings of the problem from a socio-historical perspective. The need for finding ways to increase the number of women in mathematically intensive fields motivated the examination of alternative classroom environments. The assumptions and limitations of the study were listed. Terms specific to the study were defined. The next chapter will examine relevant literature on the topics of single sex education and student engaged time.
Chapter 2
A Brief Review of Relevant Research

Introduction
This chapter examines the literature related to this study. It is divided into four sections. The first two sections examine learner variables and environmental variables in relation to gender differences in mathematics. The third section examines single sex education, both as schools and as individual classes within coeducational schools. The final section looks at the research on engaged time.

Psychological Differences
Learner Variables
Learner variables in relation to gender differences in mathematics are often subdivided into cognitive development and belief categories. In the area of cognitive development, the most frequently cited gender difference is that of visual and spatial skills. There is research that shows boys have higher spatial skills (Rowe 1982, Fruchter 1954), but there is little that actually supports the idea that this is the reason boys do better on mathematics tests. The argument is that since much of mathematics involves abstractions and
geometric forms, those with better visual and spatial skills should do better in mathematics. Testing these abilities generally involves asking the subject to mentally rotate or move three-dimensional objects and indicate how they have changed. The question that has yet to be answered is whether girls are inherently less capable in this area or have just not had the same opportunities to develop these skills. Stereotypically, young boys play with building toys, video games, and play active outside sports, all of which help to develop these spatial skills. In the early grades, they are often encouraged to do so and dominate the use of these materials. Perhaps if young girls did not need to compete for items such as these and were similarly encouraged their spatial skills would improve. This may be all the more important because there is some evidence that indicates spatial skill level is more related to mathematics performance for females than males (Tartre 1990).

Psychological differences by gender are also divided into student beliefs. This area has been further subdivided into four categories, confidence, usefulness of mathematics, sex-role congruency and attributional style. Confidence in their ability to do mathematics has been found an important affective variable in determining a student’s internal belief system (Reyes
In general, girls express less confidence in their mathematical ability than boys. The more confidence they have in their ability to do mathematics, the better their performance on tests (Fennema & Sherman 1977, 1978). In addition, confidence has been correlated with participation in mathematics; the more confidence they expressed, the more mathematics classes they took (Sherman 1982).

How females perceive the usefulness of mathematics, both in the present and the future, is an important variable when examining female student mathematics achievement and participation. This variable was shown to be the most important reason for both sexes deciding to take more mathematics classes (Armstrong & Price 1982). If mathematics was associated with real world situations and, in particular, social applications, girls felt more confident and performed better (Leder 1992). This implies that girls might perform better in mathematics if the curriculum better reflected their own interests.

Sex role congruency in mathematics refers to whether or not females see the study of mathematics as a sex-role appropriate activity. A girl who thinks
success in mathematics is inappropriate for girls might fail to achieve as much as she is capable of in order that she can fulfill her sex role. She might also perceive teachers and peers of having lower expectations in mathematics because she is a girl. Another view might be that any success in mathematics means she is less feminine. All of these perceptions can lead to an attitude that there is a price to be paid for doing well in mathematics when you are female. Single-sex classes might well help with these perceptions by providing positive role models in the form of teachers and other female students who are successful in mathematics without sacrificing any of their femininity.

The final learner variable of note is that of attributional style. This refers to how someone explains his or her success or failure. The reasons generally fall into four categories: ability, effort, task difficulty and luck (Weiner 1974). What a person attributes their success or failure to is an important predictor of their expectations of performance on similar tasks in the future. If a person attributes their failure to ability then there is little reason to expect better performance in the future as you can’t change your ability. On the other hand, if you attribute that same failure to lack of effort, there is the
possibility that if you try harder in the future, you will be successful. Boys tend to attribute their success in mathematics to their ability, while girls tend to attribute their success to personal effort (Wollet, Pedro, Becker, Fennema 1980). This implies that if a girl does well in mathematics, she is not likely to credit it to ability and use the experience to improve her confidence and thus may not choose to take more mathematics courses.

Three of the variables discussed above are part of what Fennema and Peterson call the Autonomous Learning Behaviors Model (Fennema and Peterson 1985). This model suggests that because of societal influences (of which teachers and classrooms form the greatest part) and personal belief systems (lower confidence, attributional style, and belief in usefulness) females do not participate in mathematical learning activities that will help them to become independent learners of mathematics.

Environmental Variables

Environmental variables that show gender differences can be grouped into society, home and school. Of these, only those variables affecting the school environment were considered. Within this group, the variables examined
were textbooks, teacher-student interactions, and teacher beliefs. While some of these variables continue to show significant gender differences, other do not. An example of this is classroom textbooks. Early research showed a strong gender bias in favor of boys in textbooks (Kepner and Koehn 1977). Boys were the active subjects and leaders in stories, while girls were portrayed as passive observers. History books omitted the contributions of women and mathematics books focused on traditionally male applications. More recent studies show little gender bias in textbooks (Stockdale and Mangro 1986). In this case, it is clear awareness of gender equity has made a difference.

A more important area of research that has found differences related to gender is that of teacher-student interactions within the classroom. Some of the findings include: teachers give boys more frequent and longer attention, both positive and negative than girls (Meyer and Thompson 1956; Good, Sikes and Brophy 1973), boys initiate more interactions with their teachers, leading to more teacher attention (Irvin 1986), and boys seen as high achieving get more academic related interactions with the teacher than similar female students (Dweck et al. 1978). When working with students,
teachers tend to help male students learn the task at hand while doing the task for female students (Dweck and Gilliard 1975) and boys in class are more often asked higher order thinking questions than girls (Good, Sikes and Brophy 1973). In short, when boys and girls are together in the classroom, boys get more attention and get better attention from the teacher than girls. These differences were also found in England (Galdon, Simm, Croll 1980) and Australia (Lider 1987).

The differences noted between teachers and students may well be a result of teacher beliefs. Most important of these is teacher expectancy. Studies have shown that teacher expectancies can be correlated with student learning (Dusek 1985), but the research does not identify a clear difference by gender.

Several of the beliefs discussed in relation to the student, usefulness of mathematics, sex-role congruency and attribution of success or failure are also important teacher variables. It would seem reasonable to think that if teachers don’t think mathematics is as important for females as males then this belief will have an effect on how they teach their students. A study of
primary grade students by Greib and Easley (1984) found that boys had an advantage over girls of similar mathematical creativity in that they were not expected to necessarily follow rules for neatness and procedure as girls were. Thus, girls tended to learn mathematics by rote procedures and were recognized for the quality of the presentation of their work. Meanwhile boys became more independent learners as they practice non-routine procedures that led to deeper understandings of mathematics. Was this a result of teacher expectations that girls did not or could not learn mathematics like boys?

What teachers believe causes the success or failure of their students is the most important belief they have about their students (Clark and Peterson 1986). If they attribute student success or failure to themselves then they are likely to do something about student failure. On the other hand, if they attribute student success or failure to the student, they are less likely to feel responsibility for dealing with failure. Dweck, Davidson, Nelson and Enna (1978) found gender differences in teacher attribution of student success and failure. Teachers were more likely to attribute the failure of boys to lack of effort reinforcing their sense of confidence. Clark and Peterson (1986) did
not find these differences, so it is not clear they exist.

Teachers' views towards sex-role congruency indicate that they tend to believe that certain subjects are more appropriate for males than females (Dusek and Joseph 1985). In particular, mathematics is frequently seen as a masculine activity. This stereotyping influences teacher-student interactions within the classrooms and thus plays a significant role in the development of gender differences in mathematics.

Clearly students' attitudes are affected by what they experience in the classroom. If the expressed lack of confidence and ability in mathematics by girls is related to these experiences, it would seem reasonable to look for an alternative environment.

**Single Sex Education**

In reviewing the research on single sex education, it is important to keep in mind that the reasons for creating single sex schools and single sex classes within coeducational schools differ. Single sex schools have a long history rooted in tradition and the idea that women have educational needs different
from men. They were not created to help women become more equal. If anything, they were created to help women fulfill stereotypical roles in society. Over time this has changed. Such schools now teach the same curriculum as other coeducational schools, but they still operate from a viewpoint that providing their students a separate education better prepares them for life.

Recent single sex classes are based on the idea that women learn differently than men, and that coeducational classes do not provide them with equal access to learning. The classes teach the same curriculum, but attempt to provide an environment that will foster improved student participation, achievement and attitude (Streitmatter 1999). The goal of single sex classes is equity. This means that rather than treating both sexes exactly the same and thus maintaining the under-representation of women in mathematics and science, women are treated differently in the hope that the representation will be equal in the future.

The vast majority of studies done on single sex education in this country or elsewhere has been done with single sex schools. In this country, Title IX
has made it difficult for such schools to exist, except as parochial or independent schools (Streitmatter 1999). A much smaller body of research has been done on single sex classes within a coeducational school. Both of these formats will be examined.

**Single Sex Schools**

All girl Catholic schools have been extensively examined by Cornelius Riordan. Using data from the study, *High School and Beyond*, he found that females in the single sex schools out performed their counterparts in coeducational schools in the areas of vocabulary, reading, and mathematics (Riordan 1985). Even after removing effects of initial ability and family background, he found the females from the single sex schools still out performed the girls in the coeducational schools on four curriculum specific tests, most notably, science (Riordan 1990). However, fourteen years after high school, there were no significant differences between the girls from the single sex schools and those from the coeducational school.

Other researchers using the same data found similar results. Valerie Lee found significant differences between single sex and coeducational Catholic
schools in favor of single sex schools. The girls in the single sex schools were more positive about academics in general, more interested in mathematics, made greater gains in achievement in the area of science and had higher educational aspirations than the girls in coeducational schools (Lee and Bryk 1986).

Other researchers have challenged these positive results. One study found no difference in academic achievement, educational aspirations or self-esteem between all girls and coeducational Catholic schools (Le Pore and Warren, 1997). Another found coeducational schools more effective in establishing women in nontraditional fields. Even Riordan found no difference in educational (Riordan 1985) or occupational attainment (Riordan 1990) between coeducational and single sex Catholic schools.

Similar results were found in the United Kingdom and Australia. Science enrollments were better, and the girls received more adult encouragement in the all girl schools in Australia (Carpenter and Hayden 1987). In Northern Ireland, the academic self-concept of the female students was also better in the single sex environment than the coeducational (Cairns 1990). All of this
was countered by studies in Australia that indicated there was no difference in science enrollments (Carpenter and Hayden 1987, Daly et al. 1996) and no difference in attitude toward school or math (Gill 1996). Similar results were found in Northern Ireland, no difference in science enrollments, science achievement, mathematics achievement or English achievement (Daly 1995, 1996). Beyond these studies were some that showed coeducational schools in the United Kingdom were more effective than single sex schools in the areas of attitude toward school (Stables 1990), and science achievement (Harvey 1985). Canadian research also showed coeducational schools better than single sex schools in attitude toward school (Schneider 1982) and academic self-concept (Schneider 1988).

**Single Sex Classes**

The research on single sex classes examines many of the same variables as single sex schools, most notably achievement and attitude. The results are just as mixed.

Two urban school studies looked at single sex fifth, sixth and seventh grade mathematics classes. In the fifth grade classes, grades were significantly
higher in the single sex class as compared to the coeducational class, but standardized test results showed no difference (Singh, Vaught & Mitchell 1998). In the middle school, the classes were separated by gender. The classes showed no significant difference in achievement. The girls class did, however, show a more positive attitude towards mathematics (Seitsinger, Barboza, & Hird 1998).

Three studies looked at single-sex physics classes. The first found increased participation, better satisfaction, and a positive influence on interest in physics related careers (Stowe 1991). In the second, the students reported the class as friendlier; they got more work done and did not have to vie with boys to get the teacher's attention (Streitmatter 1998). Another was a three year longitudinal study that found increased confidence, achievement and likelihood of taking subsequent physics classes (Gillibrand, Robinson, Brawn & Osborn 1999)

Other studies that showed achievement differences favoring single-sex classes include one that gathered considerable media attention. A single sex Algebra class in Presque Isle, Maine was profiled on ABC's Nightline. The
school documented a decrease in the difference by gender of the mathematics portion of Maine Educational Assessment from seventy-two to sixteen points (Durost 1996). Another study found that ninth grade Algebra students assigned to a single-sex class made greater gains in mathematics scores from grade eight to eleven (Wood and Brown 1997). Countering these results was a Canadian study of grades 10-13 that found improved attitudes, but no achievement differences (Macfarlane & Crawford 1985).

A study of a single-sex middle school Algebra class examined attitude as others have done, but it also looked at risk-taking behavior in the form of asking and answering questions. It found that, in addition to better attitude, the girls were more willing to ask and answer questions in the single-sex environment than in the coeducational one (Streitmatter 1997). It also noted that, as the other studies found, the girls preferred the single-sex environment.

Much of the initial research on single-sex classes originated in Australia where the country was under direction by the courts to address gender inequities within the school system. One such study found no significant
difference in confidence or achievement between single-sex and mixed sex classes (Rowe 1988). It did, however, indicate that there was an intervention effect that showed girls in the single-sex class were significantly more likely to take more mathematics classes. A study in Australia by Leder (1994) looked at both short and longer term effects of single sex classes on attitudes and performance in the tenth grade (Leder & Forgasz 1994). It found no difference in performance during the year or in choices for subjects the following year. There was, however, a significant gender difference in anticipated mathematics courses for grade twelve.

The overall results indicate that girls perceive all girl classes as better than coeducational classes for a variety of reasons. They also made some improvements in confidence and in many cases, achievement gains were found.

**Engaged Time**

Although instructional time may seem like a simple, common sense concept, it is actually a complicated, multifaceted concept of which engaged time is but one aspect. Research on instructional time has been limited by several
different viewpoints. One view is that it states the obvious (Jackson 1985; Philips 1985), those who study more learn more and so the concept is not worthy of research. Another view is that, despite initial ideas of its simplicity it is in reality too complex to study (Karweit 1985) and even when it can be measured accurately, it is not a particularly powerful variable (Karweit 1983). A number of researchers see instructional time as a poor way of getting at the information that is really of interest, that is, what is going on inside the student's head (Peterson, Swing, Braverman, & Buss 1982). Despite these views, instructional time has its place in educational research as in Berliner's words it "allows for understanding, prediction and control" (Berliner 1990).

Instructional time can be subdivided into allocated time, engaged time, time-on-task, academic learning time, transition time, waiting time, aptitude, perseverance, and pace. This study examined engaged time, which is defined as the time students appear to be paying attention to materials, or presentations that have instructional goals (Berliner 1990). This is closely associated to time-on-task. The difference between the two is that time-on-task is usually defined as engaged time on a specific learning task with some
outcome measure. Since the two concepts are closely related, we will consider research on both.

Many studies have examined time-on-task and achievement. In particular, mathematics achievement and engaged time as related to a specific task are positively correlated (Cobb 1972), as were attention and achievement (Lahaderne 1968). Many of these studies have been challenged based upon data collection issues. However, it has generally been accepted that observation periods of at least thirty minutes over periods of ten days or more as being sufficient (Karweit & Slavin 1982).

The purpose of many early instructional time studies was to find ways of evaluating teacher effectiveness. If time spent learning leads to achievement, then teachers who can engage students will be more successful at helping their students learn. Engaged time and time-on-task in these studies were treated as independent variables that were to predict achievement. In contrast, this study treats engaged time as a dependent variable and looks at the classroom environment as a source of differences between classes. No relevant research treating engaged time as a function of student or classroom variables has been conducted.
Summary

The review of the research literature shows that there are significant psychological differences between males and females with respect to spatial visualization skills, attitude, confidence, belief in the utility of mathematics and sex-role congruency. Females differ from males in attributional style and within the classroom; females get less and lower quality attention from the teacher.

Single sex schools have shown improved attitude and in some cases improved achievement for girls. Single sex classes have shown similar results. In addition, many of these studies show that girls perceive the single-sex as being better and prefer them to coeducational classes.

Engaged time can be accurately and reliably measured and it has been positively correlated with achievement. There has not been any research on gender differences in engaged time or how the classroom environment might affect engaged time.

Given then, that boys and girls differ when learning mathematics, and girls
are at a disadvantage in the classroom when it comes to the attention of the
teacher, it seems reasonable to think that single sex classes would provide a
better environment for girls to learn mathematics. Past research focused on
the end result of such classes, whether the girls’ achievement or attitude after
being in the class improved as compared to coeducational classes. This study
focused instead on what happened in the classes at the time; how the
engaged times differed by environment. If it were established that changing
the classroom environment from coeducational to single sex has an effect on
a variable such as engaged time, then it would be reasonable to expect to
find differences in terms of variables such as achievement. If no significant
difference in engaged time between single-sex and coeducational classes is
found, then the question is why the girls perceive them as being different.
This line of inquiry could include many of the other perceptions noted in this
review.
Chapter 3
Methodology

Introduction

The present study was designed to determine whether there was a difference between the engaged time of students in coeducational and single sex learning environments. The chapter is divided into the following sections: design of the study, setting, sample, instrument, procedure, variables, research questions and analysis of the data.

Design of the Study

The study was quasi-experimental in nature since assignment to control and experimental groups was not done randomly. Coeducational classes represented the control group and the single sex classes represented the experimental group. The type of design was factorial, using the classroom environment, class level, and gender as factors. To minimize confounding, each teacher in the study taught both the coeducational and single sex classes for a given level.
Setting

The secondary school examined in the study is a large (more than 2000 students) urban school in a major southwestern metropolitan area. The school is a part of the district’s attempt to meet Federal Desegregation requirements by allowing students that improve the ethnic balance of the school to attend even if they do not live within the school’s attendance area. The demographics of the school are 59% Hispanic, 30% Anglo, 6% African American, 2% Asian and 4% Native American. The school experimented with single sex mathematics classes for female students in each of the past five years. In the past year the program expanded from a single class to three classes at three different levels.

Sample

Students in the observed classes ranged in age from fourteen to eighteen (grades nine to twelve). Each class level was dominated by one or two grades. The Algebra class was largely ninth graders, Geometry, mostly ninth and tenth graders and Algebra 5/6, mostly eleventh graders. Assignment to the coeducational classes was by self-selection. The previous semester, students registered by picking the periods they wanted each subject. At that
time none of the students were aware of the fact that their class would serve as a control group for this study.

Assignment to the single sex classes was also by self-selection. Teachers, counselors and peers recommended students for the class. It was up to these students to select the class during registration if they wanted it and it would fit in their schedule. Counselors directed additional students to the class during meetings with the students following registration.

The lack of randomness in the selection of subjects for the single sex classes is an area of concern, but unavoidable. Title IX outlaws any discrimination based on gender so students could not be forced to take the single sex class. Any significant difference found between the coeducational and single sex classes would be in question due to this factor. The only way to verify the difference would be to observe the same female students in both single sex and coeducational environments. This might be accomplished if a single sex class was closed after one semester and the students moved into coeducational classes with the same teacher.
The three mathematics levels examined were, Algebra, Geometry and Algebra 5/6. Algebra is the entry-level mathematics course at this school and is required for graduation. The observed classes included a mix of students who have a past history of failing Algebra and were retaking the class for the second or more times along with students who were taking Algebra for the first time. Many of these students were also at risk for dropping out of school before they graduate.

Geometry is also required for graduation, however the observed classes at this level included students, the majority of which, are intending on going on to a four-year college. Due to recent state requirements, students in Geometry were not required to have passed Algebra before taking the class. In previous years they were so required. The Geometry classes were split between Honors and non-Honors classes. Two Honors Geometry classes were observed, but treated as one class to provide a larger sample. The single sex class was not an Honors class, but the coeducational classes were. The same teacher taught both single sex and coeducational classes at each level. No differences between the classes were observed in terms of teacher behaviors or expectations of student behaviors.
The Algebra 5/6 class is not required for graduation, but is required for entrance into any four-year college or university. All of these students are intending to go to college following their graduation. These students were required to have passed Geometry before taking the class.

It should be noted that the school used in this study follows what is commonly called a block schedule. This means classes meet for extended ninety-minute periods on alternating days and a shorter forty-five minute period once a week. Observations were made during both lengths of class periods.

The same teacher taught the Algebra and Algebra 5/6 classes. She has taught for approximately ten years and worked with single sex classes twice before. She has taught both courses several times. The Geometry teacher has taught for 25 years and has extensive experience teaching geometry. She has also taught single sex classes previously.

Instrument

Information on student task behavior in the classroom was collected using
the Student Record of Behavior (Marchant 1989). This instrument was
developed for collecting a great deal of data from a large number of students
in a short amount of time. It has been shown to be highly reliable by single
and multiple observers. It works best with traditional classes where students
are seated most of the time. The process involved noting the position of the
students to be observed on a grid and then sequentially observing each
student and coding one of eight categories of behavior. Each student would
be observed for approximately 10 seconds and their behavior coded until all
subjects were observed. The process would then be repeated ten times.
Assuming fifteen to thirty subjects in each class, it would take from twenty-
five to fifty minutes to collect a set of data. Coding the data followed this
format:

VA- Verbal Appropriate: The student was engaged with peers; either asking,
answering a question or making a comment about the topic presently being
discussed.

VAT- Verbal Appropriate with Teacher: The student was asking, answering
a question or making a comment directed towards the teacher.
VI- Verbal Inappropriate: The student was talking with peers about a topic not related to the classroom task.

VIT-Verbal Inappropriate with Teacher: The student was asking, answering a question or making a comment not related to the topic being discussed.

VU- Verbal Undefined: The student was talking to peers and it was not possible to determine whether the topic is related to the classroom task.

VUT-Verbal Undefined with Teacher: The student was talking to the teacher and it was not possible to determine whether the topic is related to the classroom task.

BA- Behavior Appropriate: The student exhibited a behavior that indicated they were on task. This included reading a text, working on a problem, taking notes or listening to the teacher or peers.

BI- Behavior Inappropriate: The student exhibited behavior that indicated
they were off task. This included reading anything other than the class text, working on assignments for other classes, doodling, sleeping, or listening to other students' talk about things not related to the class.

**BU - Behavior Undefined:** The student exhibited a behavior and it was not possible to determine whether it was related to the classroom task. This included cases when it was not clear whether a student was daydreaming or listening to the instructor.

Several of the above codes were combined to better address the questions examined by this study. Namely, VA, VAT and BA were combined and coded as just BA. In addition, VI, VIT and BI were combined and coded as just BI. The code BA was then an indication the student was engaged, while the code BI was an indication the student was not engaged. This was done because the research questions were not differentiated with respect to verbal/non-verbal behaviors or interactions with the teacher. In addition, the VU, BU and VUT codes were not used, as the author was able to make decisions about student behaviors in all cases. Although this may have meant some false positive (non-engaged coded as engaged) results were
noted, it was likely false negative (engaged coded as non-engaged) results were also noted. In either case, if one assumes these mistakes were equally distributed among the classes, then it would not affect comparisons of means across class levels or environments. The author collected all data for this study. As such, inter-rater reliability was not an issue.

Procedure

Data for the Algebra and Algebra 5/6 classes were collected weekly for a period of ten weeks beginning with the fourth week of classes. This time frame has been used in much of the early research on instructional time (Karweit & Slavin 1982). The author made classroom visits before collecting data so subjects in the study would become accustomed to his presence. Observations were scheduled so that the same activities and lessons occurred in both single sex and coeducational classes at each level. In addition, observations were made during both extended and short class periods.

Data for the Geometry classes was collected over five weeks during the first five weeks of the second semester using the StRoBe (Marchant 1989). The data was collected twice a week. Before data collection began, the observer
made visits to familiarize the class with his presence as was done with the other classes. The shortened time frame was not inconsistent with the earlier research cited as a total of ten observation periods were still used.

Variables

In this study, the dependent variable, engaged time, was measured as a function of student gender, classroom environment and class level. This continuous variable was measured in both coeducational and single sex classes at three levels of mathematics. A percent was calculated for each student by counting the number of BA codes on the StRoBe instrument and dividing by the number of observations for that student. In most cases, students were observed ten times during a classroom visit. If a student left the room for any reason, they would have fewer than ten observations and the percent would be appropriately adjusted. This percent was calculated for each student, in each class, for every classroom visit and entered into a statistical spreadsheet. Values for engaged time ranged from zero to one hundred percent.

Engaged time observations have an inherent problem, in that a student may
appear to be engaged, listening to the teacher, for instance, while they are actually thinking about something else. One cannot know what any student is thinking in class at any given moment. One can though, observe their behavior. A basic assumption in collecting this data was that, unless some behavior clearly indicates a student was not engaged, it was assumed that the student was engaged. There were likely times when a student was noted as being engaged when in fact he/she was not and likewise, students were probably sometimes noted as not engaged when in fact they were. It would seem reasonable to assume the two cases balance each other and did not affect the outcome of the study. Another reason this should not be considered a confounding variable, is that if non-engaged behavior was under reported as compared to engaged behavior, it is reasonable to assume the effect was constant in both coeducational and single sex classes and would not affect any comparison across the two groups. This would only not be true if one gender was more prone to show false engaged behavior than the other.

The teacher variable was not directly included in the study. Ideally, the same teacher should have taught all classes. Since this was not an option at the site
of the observations, the best that could be achieved was to have the same teacher teach both the control and experimental courses for two of the three levels. In the study the teacher variable was combined with the class level variable. Any difference detected by class level could partly be attributed to the teacher.

The independent variables in the study were:

1. Gender. This refers to the sex of the student: male or female.

2. Class level. This refers to the class the student was taking: Algebra, Geometry or Algebra 5/6.

3. Classroom environment. This refers to the gender composition of the class: Coeducational or single sex.

All three were treated as nominal, although class level could be considered as ordinal since there is an implicit understanding that Algebra, Geometry and Algebra 5/6 represent increasing order of complexity. The aspect of the class level variable that was of more interest was the fact that it generally represented the grade level of the student and thus implied an increasing sequence of age from 14-18 years. This would imply certain expectations about engaged time and class level; namely that older students are more
engaged then younger students. This implication was examined as a matter of accounting for the variance of each independent variable during the analysis of the data.

Research Questions

The study examined whether gender, classroom environment and class level were significant factors in determining student engaged time. More specifically, the following questions were to be answered:

Q (1) Was there a significant difference between the mean student engaged time for male students and female students?

Q (2) Was there a significant difference between the mean student engaged time for students in a coeducational mathematics class and a single sex mathematics class?

Q (3) Was there a significant difference between the mean student engaged time for female students in a coeducational mathematics class and a single sex mathematics class?

Q (4) Was there a significant difference between the mean student engaged time for students in a coeducational mathematics class and a single sex mathematics class when grouped by class level?
Q(5) Was there a significant difference between the mean student engaged time for female students in a coeducational mathematics class and a single sex mathematics class when grouped by class level?

Analysis of the Data

All four questions were examined under the null hypothesis that all means between groups were equal. Significance was accepted at the 0.05 level. In questions (1), (2) and (4), unequal cell sizes required the rejection of the assumption of equal variances. The first question was analyzed by using a two sample t-test for means. Questions (2) and (3) were first examined by creating interaction plots to see if there was any interaction between class level and classroom environment. A two-way analysis of variance was then performed with class level, classroom environment and their interaction as factors. Questions (4) and (5) were examined by a two sample t-tests.

All statistical analyses were done using a professional version of S-Plus 2000.
Chapter 4

Data Analysis

Introduction

This chapter formally analyzes the data that resulted from the current study. It is divided into four sections. The first section describes gender breakdown of the classes by level and gender composition. The second section describes the results from a two sample t-test used to compare the engaged time by gender. For this test all data for the coeducational classes were combined. The third section examines the analysis of variance (ANOVA) used to compare engaged time by class gender composition, class level and student gender. In the last section post hoc comparisons are done by class level to look for significant differences between mean engaged times for coeducational and single sex classes.

Description of the Sample

Class sizes shown in Table 1 represent the maximum number of students enrolled in each class by gender, and the gender composition of the class. Over the time period in which data was collected some students were
Table 1

Class sizes of observed classes by gender and gender composition of class.

<table>
<thead>
<tr>
<th></th>
<th>Coeducational Female/Male</th>
<th>Single sex Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>16/8</td>
<td>24</td>
</tr>
<tr>
<td>Geometry</td>
<td>32/28</td>
<td>24</td>
</tr>
<tr>
<td>Algebra 5/6</td>
<td>22/12</td>
<td>36</td>
</tr>
</tbody>
</table>
dropped and some added. In all the classes, the enrollment did not change more than one or two students. The number of students present in each class on any given observation day varied due to illness and other circumstances. The mean number of students by gender, and the gender composition of the class is presented in Table 2. The fact that not all students were present for all observations, was not of concern as the unit of study was the total classroom or a specific gender, not the individual students. Neither the Algebra nor Algebra 5/6 classes fit what might be considered coeducational. These classes had significantly less than half the students as males. Given that this study was based on how male students might distract female students, the small number of males present might inflate the measured results for engaged time in these classes. Specific ages and ethnicity of the students observed were not noted as they were not of interest in this study.

The lack of randomness in the selection of subjects in the coeducational and in particular, the single sex classes, needs to be addressed. The reasons students were placed in the single sex classes varied tremendously, but some general trends were clear. Students self selected or teachers recommended
Table 2

Mean number of students present in observed classes by gender and gender composition of class.

<table>
<thead>
<tr>
<th>Mean number of students present during observations</th>
<th>Coeducational Female/Male</th>
<th>Single sex Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>12.8/6.4</td>
<td>21.7</td>
</tr>
<tr>
<td>Geometry</td>
<td>25.6/22.7</td>
<td>19.7</td>
</tr>
<tr>
<td>Algebra 5/6</td>
<td>20.2/10.6</td>
<td>31.9</td>
</tr>
</tbody>
</table>
them for the single sex class because the teachers thought the students would
do better in terms of achievement in a single sex environment. This was
largely based on their own perception that they would be able to pay
attention better without the distraction of boys in the class. This opens the
possibility that the students in the single sex classes were either below
average achievers or below average in terms of their confidence to do
mathematics as compared to students in the coeducational classes. It might
be argued that having such preconceptions would lead to an overstatement of
the engaged time of students in the single sex class as higher student
expectations of engaged time lead to higher actual engaged times. On the
other hand, one might suggest that lower achieving students are less engaged
and so students in the single sex classes were predisposed to show lower
engaged times because of the make up of the class. Thus the engaged time of
single sex classes might well be understated. Ideally, the same students
should be observed in both environments. Baring that, in future studies, it
would be helpful to better describe the classes in terms of achievement and
confidence towards mathematics.
Table 3 shows the means for engaged time for students by gender, class level and classroom environment. The following sections examine the significance of the differences between several of the groups.

Comparison of engaged time for male and female students
A Welch Modified Two-Sample t-Test (assuming unequal variances) was performed after combining data for male and female students from all three class levels. The results are shown in Table 4. The fact that the difference between the two groups was not significant (p=0.2626) was not unexpected.

There is not any research that indicates males are more or less engaged than females in the classroom. If a difference is found between the engaged time for students in single sex and coeducational classes, then it cannot be attributed to the gender of the students themselves.

Comparison of engaged time for coeducational and single sex classrooms
A Welch Modified Two-Sample t-Test (assuming unequal variances) was performed after combining data for students from coeducational and single sex classes students from all three class levels. The results are shown in
Table 3

**Mean percent engaged time for students by gender, class level and gender composition.**

<table>
<thead>
<tr>
<th>Mean Percent engaged time</th>
<th>Coed Female</th>
<th>SD</th>
<th>Coed Male</th>
<th>SD</th>
<th>Single sex Female</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>82.87</td>
<td>21.96</td>
<td>79.22</td>
<td>25.09</td>
<td>65.34</td>
<td>28.54</td>
</tr>
<tr>
<td>Geometry</td>
<td>86.95</td>
<td>13.75</td>
<td>82.48</td>
<td>19.34</td>
<td>83.37</td>
<td>18.17</td>
</tr>
<tr>
<td>Algebra 5/6</td>
<td>77.77</td>
<td>26.89</td>
<td>80.84</td>
<td>23.66</td>
<td>83.01</td>
<td>22.05</td>
</tr>
</tbody>
</table>
Table 4

*Welch Modified Two-Sample t-Test for Mean engaged time by gender*

Female       Male
80.10462     81.51385

value of $t = -1.1212$

degrees of freedom = 698.64

$p$-value = 0.2626
Table 5. The fact that the difference between the two groups was significant (p=0.0001 <0.01) implies that the classroom environment does effect student engaged time and favors coeducational classes.

Before the two way analysis of variance was run it was necessary to see if there was any interaction effect between the classroom environment and the class level. The interaction plot is shown in Graph 1. The plots for the two environments cross in moving from the Algebra to the Algebra 5/6 classes. This indicates that there is an interaction and this factor needs to be included in the analysis. The results of the ANOVA are shown in Table 6.

One of the assumptions for using the ANOVA is that there are equal cell sizes. In this study that would mean the classes being compared were all of the same size. This was not the case. By running the ANOVA using two different models and comparing the results, we can decide if the different cell sizes made any difference in the results (Applebaum and Cramer 1974).

As seen in Table 6, reversing the parameters in the model, made a slight
Table 5

Welch Modified Two-Sample \( t \)-Test for

Mean engaged time by classroom environment

Coeducational    Single sex

82.33571    77.87585

value of \( t = 3.9242 \)

degrees of Freedom = 1445.245

p-value = 0.0001
Graph 1

Interaction Plot for Engaged time for Coeducational Vs Single sex classes
Table 6

ANOVA for Engaged time as function of class level and environment

Analysis of Variance Model 1

formula: Engaged Time ~ Class + Environment + Class:Environment

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>Sum of Sq</th>
<th>Mean Sq</th>
<th>F-value</th>
<th>P(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Level</td>
<td>2</td>
<td>33579.6</td>
<td>16789.81</td>
<td>34.30949</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Environment</td>
<td>1</td>
<td>3689.25</td>
<td>3689.25</td>
<td>7.53887</td>
<td>0.0061014</td>
</tr>
<tr>
<td>Interaction</td>
<td>2</td>
<td>26464.7</td>
<td>13232.34</td>
<td>27.03990</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Residuals</td>
<td>1710</td>
<td>836811.2</td>
<td>489.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis of Variance Model 2

formula: Engaged Time ~ Environment + Class + Environment:Class

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>Sum of Sq</th>
<th>Mean Sq</th>
<th>F-value</th>
<th>P(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>1</td>
<td>8351.8</td>
<td>8351.8</td>
<td>17.06672</td>
<td>0.0000378</td>
</tr>
<tr>
<td>Class</td>
<td>2</td>
<td>28917.0</td>
<td>14458.52</td>
<td>29.54557</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Interaction</td>
<td>2</td>
<td>26464.7</td>
<td>13232.34</td>
<td>27.03990</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Residuals</td>
<td>1710</td>
<td>853929.3</td>
<td>498.79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
difference in the F-values and their corresponding probabilities. This difference would not lead to any change in the decision to reject the null hypothesis. Clearly, class level (p=0) and environment (p = 0.0000378) are significant factors in engaged time and these factors have a significant interaction effect (p = 0). The table also makes it clear that class level is a stronger determinant than environment in predicting engaged time. Despite the significance of this result, the factors of class level, classroom environment and their interaction account for only 3.1% and 0.87% and 2.8% of the total variance respectively.

Comparison of engaged time for female students in coeducational and single sex classrooms

An analysis similar to the previous section was done to compare female students in coeducational and single sex classroom. A Welch Modified Two-Sample t-Test (assuming unequal variances) was performed after combining data for female students from coeducational and single sex classes from all three class levels. The results are shown in Table 7. The fact that the difference between the two groups was highly significant (p=0.0001 <0.01)
Table 7

**Welch Modified Two-Sample t-Test for**

**Mean Engaged Time For Female Students**

<table>
<thead>
<tr>
<th>Coeducational</th>
<th>Single Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>82.89249</td>
<td>77.87585</td>
</tr>
</tbody>
</table>

value of $t = 3.9682$

degrees of freedom = 1309.228

$p$-value = 0.0001
implies that the classroom environment does effect student engaged time for female students and favors the coeducational environment.

As was done in the previous section, an interaction plot was performed with class level and classroom environment as factors. The interaction plot is shown in Graph 2. The plots for the two environments cross in moving from the Geometry to the Algebra 5/6 classes. This indicates that there is an interaction and this factor needs to be included in the analysis. The results of the ANOVA are shown in Table 8. As before, two models were calculated to determine whether the different cell sizes had an effect on the decision to reject the null hypothesis.

As seen in Table 8, reversing the parameters in the model, made a slight difference in the F-values and their corresponding probabilities. This difference would not lead to any change in the decision to reject the null hypothesis. Clearly, class level (p=0) and environment (p = 0.0000501) and their interaction (p=0) are significant factors in engaged time. The table also makes it clear that class level is a stronger determinant than environment in predicting engaged time. Despite the significance of this result, the factors of
Graph 2

**Interaction Plot for Engaged time of female students for Coeducational Vs Single sex classes**

![Interaction Plot for Engaged time of female students for Coeducational Vs Single sex classes](image)
Table 8

**ANOVA for Engaged time for females as function of class level and environment**

Analysis of Variance Model 1

formula: Engaged Time ~ Class + Environment + Class:Environment

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>Sum of Sq</th>
<th>Mean Sq</th>
<th>F-value</th>
<th>P(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Level</td>
<td>2</td>
<td>36601.4</td>
<td>18360.70</td>
<td>36.95676</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Environment</td>
<td>1</td>
<td>4274.1</td>
<td>4274.07</td>
<td>8.63112</td>
<td>0.0033623</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>25288.5</td>
<td>12644.27</td>
<td>25.53406</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Residuals</td>
<td>1313</td>
<td>656087.5</td>
<td>495.19</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis of Variance Model 2

formula: Engaged Time ~ Environment + Class + Environment:Class

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>Sum of Sq</th>
<th>Mean Sq</th>
<th>F-value</th>
<th>P(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>1</td>
<td>8195.6</td>
<td>8195.63</td>
<td>16.55040</td>
<td>0.0000501</td>
</tr>
<tr>
<td>Class</td>
<td>2</td>
<td>32679.8</td>
<td>16339.92</td>
<td>32.99712</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Interaction</td>
<td>2</td>
<td>25288.5</td>
<td>12644.27</td>
<td>25.53406</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Residuals</td>
<td>1313</td>
<td>650187.5</td>
<td>495.19</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
class level, classroom environment and their interaction account for only 4.87% and 0.11% and 3.7% of the total variance respectively.

Post hoc analysis of comparisons between coeducational and single sex classes by class level

This last section examines comparisons between mean engaged time for coeducational and single sex classes by class level. This was done because the interaction plots and the table of means suggest that although overall the coeducational environment is best for engaged time, there are class levels where the single sex environment might be better. The means are summarized in Table 9.

A Welch Modified Two-Sample t-Test assuming unequal variances was used to compare the mean engaged time of coeducational and single sex classes by class level. The results are summarized in Table 10.

The same analysis was used to compare the engaged time of female students in the coeducational classes to those in single sex classes by class level. The results are listed in Tables 11 and 12. The results suggest that Algebra
Table 9

**Mean Engaged Time by Class Environment and Class Level**

<table>
<thead>
<tr>
<th>Class Level</th>
<th>Coeducational</th>
<th>SD</th>
<th>Single Sex</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>81.65</td>
<td>23.05</td>
<td>65.34</td>
<td>28.55</td>
</tr>
<tr>
<td>Geometry</td>
<td>84.85</td>
<td>16.74</td>
<td>83.37</td>
<td>18.17</td>
</tr>
<tr>
<td>Algebra 5/6</td>
<td>78.82</td>
<td>25.83</td>
<td>83.01</td>
<td>22.05</td>
</tr>
</tbody>
</table>
Table 10

Significance of Difference Between Mean Engaged Time of Coeducational and Single Sex Classes by Class Level

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>P(t)</th>
<th>Favors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>6.3857</td>
<td>403.716</td>
<td>0</td>
<td>Coeducational</td>
</tr>
<tr>
<td>Geometry</td>
<td>1.2898</td>
<td>393.306</td>
<td>.1979</td>
<td>Neither</td>
</tr>
<tr>
<td>Algebra 5/6</td>
<td>-2.18</td>
<td>602.849</td>
<td>0.0296</td>
<td>Single sex</td>
</tr>
</tbody>
</table>
Table 11

Mean Engaged Time for females by Class Environment and Class Level

<table>
<thead>
<tr>
<th></th>
<th>Coeducational</th>
<th>SD</th>
<th>Single Sex</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>82.86</td>
<td>21.96</td>
<td>65.34</td>
<td>28.55</td>
</tr>
<tr>
<td>Geometry</td>
<td>86.95</td>
<td>13.75</td>
<td>83.37</td>
<td>18.17</td>
</tr>
<tr>
<td>Algebra 5/6</td>
<td>77.77</td>
<td>26.89</td>
<td>83.01</td>
<td>22.05</td>
</tr>
</tbody>
</table>
Table 12

Significance of Difference Between Mean Engaged Time for females from Coeducational and Single Sex Classes by Class Level

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>P(t)</th>
<th>Favors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>6.389</td>
<td>319.61</td>
<td>0</td>
<td>Coeducational</td>
</tr>
<tr>
<td>Geometry</td>
<td>2.3065</td>
<td>353.859</td>
<td>0.0217</td>
<td>Coeducational</td>
</tr>
<tr>
<td>Algebra 5/6</td>
<td>-2.3216</td>
<td>366.54</td>
<td>0.0208</td>
<td>Single sex</td>
</tr>
</tbody>
</table>
students are more engaged in a coeducational environment, while Algebra 5/6 students are more engaged in a single sex environment. Female Geometry students were more engaged in a single sex environment.

Summary

This chapter presented the analysis of the data in the same order as the research questions were formulated in the previous chapters. The first section described the enrollment of the coeducational and single sex classes in terms of the class size and the number present during observations. In addition, the breakdown by gender for the coeducational classes was stated. It was noted that two coeducational classes did not have equal numbers of male and female students. The issue of selection bias was discussed in relation to the single sex classes.

The second section looked at the question of whether there was any difference between the engaged times of male and female students. This was done by a t-test. The test showed that there was no significant difference between the two groups.
The third section examined how the classroom environment and class level affected the engaged time of the class. In the process, an interaction effect was discovered. A two-way analysis of variance was performed for class level, classroom environment and their interaction. This analysis indicated that all three factors were significant at the 0.01 level. This analysis was also performed to compare female students in the coeducational classes to those in the single sex classes. The results were the same. It was also indicated that although the factors were all significant, they accounted for only a small part of the total variance.

The final section looked closer at the comparisons by classroom environment to see if there were any significant differences between classroom environments. Separate t-tests were used in these comparisons. The results indicated that Algebra students benefited from a coeducational environment and Algebra 5/6 students did better in a single sex environment. Female Geometry students did better in the coeducational environment.
Chapter 5
Conclusions

This last chapter is divided into four sections. The first section restates the original problem and its purposes. It also discusses and summarizes the theoretical framework, and research design. The next section discusses the findings. The last two sections discuss implications of the study and suggestions for further research.

Summary

Questions as to why women are under-represented in mathematics, science and engineering careers motivated research as to causes and ways to address the problem. In the process it was found that when compared to men, women learn mathematics in different ways, express different attitudes about mathematics and are treated differently in the classroom. Given these differences, it would seem reasonable to consider a single sex environment for women in order to provide them with a more equitable educational experience. The question then, was how single sex classes for women differ from coeducational classes.
Students in single sex classes expressed a preference for the format and a perception that the format allowed them to be more engaged in learning. The purpose of this study was to see if single sex and coeducational classes differed in terms of the student variable, engaged time. If such a difference was found and favored single sex classes, it would imply that female students should achieve more in single sex classes. Coupled with improvements in attitude already noted, this would hopefully lead to more women in more mathematics and science classes and eventually more women in science and mathematics related careers.

The study was quasi-experimental in nature with single sex classes acting as the treatment group and coeducational classes as the control. Five research questions related to student engaged time directed the study. The first was to determine whether engaged time differed by gender. A t-test found no significant differences.

The next question examined whether a single sex environment was better for engaged time than a coeducational environment. The same question was then addressed specifically to female students. An analysis of variance
showed that overall, engaged time was highest in coeducational environments, though it accounted for a very small part of the total variance. Female students were also better off in the coeducational environment. There was, however, a significant interaction effect that suggested that in some cases females were more engaged in single sex environments.

The final questions used ad hoc t-tests to look at this interaction effect. They found that female students at the highest mathematics level were better off in the single sex environment. The opposite was found to be true for students in the lowest mathematics level.

Discussion of findings

The first research question examined differences in engaged times by gender. The finding that engaged time did not differ by gender was expected. Despite the differences by gender that this study has pointed out in reference to student attitudes and beliefs, when you sit students down in class together they are, for the most part, just as likely to be engaged in learning. This also supported the idea that if a difference was found between
the engaged times of students in single sex and coeducational it was not due
to the gender of the students.

The next two questions compared single sex and coeducational
environments and female students in each of those environments. The
analysis of variance showed that classroom environment was indeed a
significant factor, though it favored coeducational classes. But class level
and its interaction with classroom environment were even more significant.
One would expect that as students take higher level classes, they are getting
older and more mature and thus probably better able and motivated to pay
attention in class. Comparing female students in single-sex classes to female
students in coeducational classes yielded similar results.

Despite the significance of these factors, they only accounted for a small
amount of the total variance. Far more of the variance was due to differences
between students. The nature of engaged time and how it was measured
might explain this. In observing students, they were for the most part either
engaged the whole observation period or not. This was indicated by the
rather large standard deviation for the classes. There was a certain degree of
momentum involved. Students who were engaged tended to stay engaged, those who were not, did not suddenly become engaged.

Another way to look at these differences is in terms of class time. The differences between the classes ranged from about one to seventeen percent. In the course of a fifty-minute class, this means a difference of less than a minute to about nine minutes. In the first case it would not make much difference, but give a teacher nine more minutes of the students' attention over the course of a year and it would make a tremendous difference.

The final two questions looked more closely at how the environments differed by class level. This ad hoc analysis provided some interesting results. Comparing the single sex classes to the coeducational classes indicated that girls at the Algebra 5/6 level were better off in the single sex classes and students at the Algebra and Geometry level were better off in the coeducational environment. The results might be due to another student variable, maturity. The Algebra students were the youngest and as such possibly the least able to focus their attention. At this age they may also relate better to peers of the same sex and thus be more distracted in a single
sex environment than a coeducational one. Older students might be able to pay attention for longer periods and better able to relate to students across gender lines so that a single sex environment is not such a distraction.

Other factors should be considered. One factor may have been the teacher. The highest engaged times were for the geometry classes and the same teacher taught these. Perhaps this teacher was better able to engage the students either because of experience or personality. Another factor might have been the achievement level of the students. Although Algebra 5/6 was the highest mathematics level, students in the Honors Geometry class were likely higher achievers across all subjects. They may have been better overall students and more inclined to be engaged.

This study does not clarify why the students were less engaged in one environment over another. The perception of students in single sex classes was that since there were not any boys to distract them, they should be more engaged. Why then were the girls in the single sex Algebra class less engaged? Are students wrong about their perceptions or is it a matter of honesty? Perhaps the perception is based more on stereotypes than reality.
Whatever the source of distraction was, it did not seem to be present in the single sex Algebra 5/6 class. Can other sources of variance be identified?

This points out the problem with using engaged time, it does not tell you what the student is thinking about when they are not engaged. The assumption that if girls are not engaged when they are in coeducational classes it is because they are thinking about the boys may be overly simplistic.

**Implications of this study**

This study has shown that there are female students who are more engaged in one type of environment over another. Since engaged time has been shown to be a predictor of achievement, it follows that some female students would benefit from placement in either single sex or coeducational environments. These students need to be identified and provided the opportunity to enroll in such classes. The fact that this study covered a wide range of mathematics classes and a variety of students at a rather average school, implies the result could be generalized to many schools.
It is also clear that teachers need to be aware of gender equity issues within their classrooms. If female preference for single sex classes is the result of disparate treatment in coeducational classes, then a change in teachers’ behaviors and beliefs could make a significant impact. Increases in engaged time in single sex classes may not be so much due to a lack of distractions from boys as a more positive attitude towards the class since the girls do not have to compete with the boys for the teacher’s attention.

Directions for future research

As is the case in most studies, more questions were raised than answered. As was stated earlier, this was a quasi-experimental study. Subjects were self-selected for the treatment group. Their reasons for doing so may well have had a significant impact on the results. Legally, students cannot be randomly assigned to single sex classes, but the students who select such classes could be evaluated for reasons they choose the class, achievement level or the factors that form Fennema and Peterson’s Autonomous Learning Behaviors Model. These are confidence, attributional style, and belief in usefulness of mathematics.
One way around this problem would be to see how the same students performed in different environments. This might happen in the case of a single sex class that was turned into a coeducational class. Such a scenario might be quite possible due to legal challenges to single sex classes or changing school enrollments.

Research on single sex classes should also include all boy classes. A powerful design would be to have single sex classes for both sexes combined after a semester. This may be problematic, as there is some evidence that teachers perceive all boy classes as difficult and undesirable to teach.

Work needs to examine more closely what variables affect engaged time. Some of these may be related classroom variables such as the teacher, textbooks or even time of day. Others may be related to learner variables such as attitude, motivation, or age/maturity. A better model of what affects student engaged time might make it possible to explain differences found between single sex and coeducational classes.
Qualitative studies could help better detail student perceptions of what makes single sex classes different from coeducational classes. They might also be able to answer the question of what students are thinking about when they’re not listening to the teacher. Such research could also follow students who participate in single sex classes for several years. Most of the present research examines students who are only in such classes for one year. The long-term benefit single sex classes is thus unknown.

With all these unanswered questions, the need for further research is clear. Since students have positive views of single sex classes, there is evidence that some students benefit from them and there does not appear to be any negative aspects to the existence of such classes there seems no reason not to continue them.
<table>
<thead>
<tr>
<th>Course</th>
<th>Date</th>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-sex</td>
<td>Coed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coding: VA-Verbal Appropriate</th>
<th>BA-Behavior Appropriate</th>
<th>VAT-Verbal Appropriate/Teacher</th>
</tr>
</thead>
<tbody>
<tr>
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<td>BI-Behavior Inappropriate</td>
<td>VIT-Verbal Inappropriate/Teacher</td>
</tr>
<tr>
<td>VU-Verbal Unidentified</td>
<td>BU-Behavior Unidentified</td>
<td>VUT-Verbal Unidentified/Teacher</td>
</tr>
</tbody>
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