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The Single-Sex Classroom and Math Self-Concept in Girls

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THE SINGLE-SEX CLASSROOM AND MATH SELF-CONCEPT IN GIRLS

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by

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THE SINGLE-SEX CLASSROOM, MATH SELF-CONCEPT,

AND MATH ACHIEVEMENT IN GIRLS

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The present research investigated the effect of single-sex or coed environments on girls' self-concept and math achievement. One hundred and thirty-eight students participated, 63 attended a private nondenominational Christian school where they were instructed in a single-sex math class and the remaining 75 students were enrolled in private Catholic schools where they attended coeducational math classes. Students were grouped by grade (i.e., 7/8, 9/10, and 11/12). Self-concept, as measured on the Self Description Questionnaire II (Marsh, 1989) significantly correlated with the Stanford Diagnostic Math Achievement Test: Fourth Edition (SDMT-4) between school-types. The SDMT-4 composite scores as a function of school type revealed a significant main effect of grade ($F(2,128)=3.407$, $p<.05$). Students' performance on the SDMT-4 Concept and Application subtest varied as a function of both the school-type and the grade group ($F(2,128)=5.081$, $p<.01$).

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TABLE OF CONTENTS

The Single-Sex Classroom, Math Self-Concept, and Math Achievement in Girls.

Introduction

Research shows girls' and boys' mathematics self-concept and achievement are comparable in elementary school; however as adolescence emerges, girls' scores fall below boys' (AAUW, 1992; Marsh, Parker & Barnes, 1985). In general self-concept in mathematics has been found to be highly correlated with mathematics achievement (Marsh et al., 1986, Shavelson & Bolus, 1982; Skaalvik & Rankin, 1990). Further, low self-concept is hypothesized to contribute to the decline of girls' mathematics performance. Educators question how girls and boys in the same learning environment are getting such different educational outcomes, particularly in mathematics. Research reveals the existence of classroom behavior in favor of boys in the areas of teacher-student attention, interaction, and feedback, particularly in the area of mathematics. Such a gender bias interferes with the maintenance of an optimal classroom learning environment for girls. (AAUW, 1992; Becker, 1986; Kelly, 1989; Leder & Forgasz, 1994; Sadker & Sadker, 1985, 1986) particularly in the area of mathematics. A survey of the coeducational classroom research suggests that when various environmental factors are analyzed, both genders in the same educational setting may, in fact, not be in the same educational environment. It could be assumed that in girls' single-sex classrooms the absence of males could foster higher academic achievement and self-concept in mathematics for girls. Thus, it is imperative that outcomes for girls in different school types be investigated.

Previous research, conducted primarily in Australia, on the single-sex classroom and its effects on mathematics achievement and self-concept for female students has been inconclusive and may not be generalized to an American sample. Therefore it is essential that research be conducted in the United States to study different school-types and their effects on mathematics achievement and self-concept with girls. The purpose of this study was to examine the math achievement and self-concept of girls in single-sex versus coeducational schools. Such an investigation results in beneficial information regarding the appropriateness of the American standard of the coeducational classroom. An understanding of self-concept and its relationship to self-esteem must first be established prior to investigating the academic experiences of students.

Literature Review

Self-Concept

Self-concept defined. Self-esteem has been defined as "... global feelings and beliefs students have about themselves as people" (Burnett, 1994, p 164) and has been used as a variable in research concerning students and education. Self-concept has been defined as a subcomponent of self-esteem, referring to an individual's self evaluation of specific characteristics and abilities (Whylie, 1961; Burnett, 1994). In the past, researchers have used self-esteem and self-concept interchangeably. The present study utilized Whylie's definition of self-concept when investigating girls' self-evaluation of their mathematic abilities because it is a more specific definition than Burnett's. Self-esteem as defined by Burnett does not refer to a detailed and descriptive self analysis of

an individual's abilities as found in Whylie's definition. Self-evaluation of a student's abilities in math is of concern in the purported study.

Several general measures of self-concept have been developed for research and clinical purposes (e.g., Fennema-Sherman Mathematics Attitude Scales, The Self-Esteem Inventory, and The Pierce-Harrison Children's Self-Concept Scale). The Self Descriptive Questionnaire (SDQ-I, II, and III), one of the more specific measures, was developed and used in Australia. The SDQ was designed to be a self-evaluative tool. Research on the SDQ showed that this more specific assessment of self-concept correlated with teacher perception of student self-concept (mean r=.60) and with corresponding academic measures (mean r=.59) (Marsh & O'Neill, 1984). Such information further supports the use of the Whylie's (1961) definition of self-concept in the proposed study. The SDQ will be discussed further in the Methods section.

Self-concept and achievement. When investigating self-concept and achievement, researchers have shown that both genders' academic self-concept is highest in grades 7, 11 and 12 and lowest in grade 9 (Marsh & O'Neill, 1984; Marsh et al., 1989, & AAUW, 1992). Furthermore, females demonstrated slightly lower self-concept score levels than their male counterparts, although the researchers did not give a reason why this occurred.

The AAUW (1992) examined students' general self esteem and more specific academic self-esteem. Their research revealed that 69% of elementary boys and 60% of elementary girls indicated having adequate or high general self- esteem. By high school the percentage of girls with high self-esteem dropped to 29% in contrast to the boys which dropped to 46%. Thus from elementary to high school the self-esteem gender gap

widened significantly from approximately 9% to 17%. The AAUW (1992) research also revealed that students' self-esteem was impacted directly by the influence of and interactions with adults, teachers and school. Further, research revealed that although girls demonstrated assertive and confident behaviors at ages 8 and 9, by the time they were approximately 11, they lost confidence in their ability to succeed.

The AAUW report suggested that a circular relationship existed between self-esteem levels and interest in mathematics. Specifically, girls who had higher general self-esteem enjoyed math and those who had a lower general self-esteem did not enjoy math. AAUW research investigating both girls and boys who enjoyed math in the beginning of their elementary schooling revealed that the girls' interest in math dropped 20 points by high school versus the boys' interest in math which dropped only 12 points within the same time frame. It seemed that girls lost interest in math as the classes became increasingly difficult. Sadker & Sadker (1986) found that in elementary school girls' scores on standardized tests were equal to or better than their male peers; however, by high school, boys were earning higher scores. More specifically, a meta-analysis by Hyde, Fennema and Lamon (1990) found that girls' computation and problem solving achievement scores were higher than boys' in elementary and middle school. Again, high school males out-performed females in the area of problem solving, although no differences were found between genders concerning computation. When girls obtained low grades in math, they saw it as a personal failure. In contrast, when obtaining low grades, boys saw math as simply not useful (Sadker & Sadker, 1986).

Academically based measures were found to significantly correlate with students' same area self-concept score. For example, mathematics self-concept scores were correlated significantly with mathematics achievement as measured by a standardized achievement test and grades but they were not significantly correlated with reading achievement (Marsh, 1986; Shavelson & Bolus, 1982; Skaalvik & Rankin, 1990).

Researchers have investigated the process of self-evaluation when individuals complete various self-concept measures. It has been suggested that individuals may conduct an internal, external, or combination comparison when reporting their academic self-concept. When asked questions concerning their mathematic self-concept individuals with an internal reference would compare their perceived math ability with their academic ability in another subject area such as English; however, individuals with an external reference will compare their perceived performance with the perceived performance of their peers (Marsh, 1986).

With an established relationship between math self-concept and math achievement, one must further investigate the coeducational environment in which the majority of the research was conducted. An important domain of concern is the differential treatment of girls versus boys in the classroom.

Differential Classroom Treatment of Girls

Teacher classroom behaviors

Differential instructional treatment of girls has been found in general education and in specific subjects. Research has revealed that differential instructional teacher-student contact was found when observing girls and boys in the classroom (Kelly, 1989). Kelly suggested that although girls participated equally in

math class, they were not given equal instructional contact compared to their male peers regardless of teacher gender. As stated by Sadker and Sadker (1986), "The most valuable resource in a classroom is the teacher's attention. If the teacher is giving more of that valuable resource to one group it should come as no surprise that that group shows greater educational gains" (p. 514). A meta-analysis of instructional contact revealed the largest gender differences were found in the areas of science, social studies, and math (Kelly, 1989). According to the study, girls were found to participate in math as much as in any other subjects; however, the amount of instructional contact was considerably less as compared to the boys in the class. Becker (1981) investigated the equality of interaction between the genders in high school math. Gender differences in the occurrence of direct questions (given by teacher to specific student), open questions (given by teacher and answered by calling on volunteers), call-outs (teacher asks a question and a student calls out an answer), and student-initiated interactions revealed that all except the student-initiated interactions occurred more often with males than with females. However, significant differences between genders were found only with call-outs and open ended questions.

Instructors were found to initiate 63% of their individual academic contact with males. The majority of the instruction was classified as direct questions, open questions, and call-outs . Each of these interactions occurred at least 55% of the time with the male students. When males gave a correct, partially correct, or incorrect answer they received 56% of all sustaining feedback, which was defined as times when the teacher and student

continued conversing and elaborating in further conversation brought on by the initial question. After an incorrect response, males received sustained contact 64% of the time versus 58% of the time for females. It should be noted that statistical significance was not stated in the study.

Gender differences in instructional contact were investigated Kelly's (1988) meta-analysis. The meta-analysis investigated 81 teacher-student interactions (preschool through high school) and revealed that, in a coeducational classroom, teachers averaged 44% of their time with girls and 56% of their time with boys despite the fact that girls volunteered slightly more often than boys. These percentages suggested that over the length of a child's school career each boy received 1,800 more hours of teacher-student interaction compared to a female peer. Researchers speculated that such quantitative differences could be due to boys' tendencies to call answers out loud without being called upon. Sadker and Sadker (1980, 1986) found that when a girl exhibited such "calling out" behavior to answer a question she was quickly reprimanded and told to raise her hand, whereas a boy exhibiting the same behavior received no such reprimand. The authors claimed boys were trained to be assertive and girls were trained to be passive. However, girls have been shown to exhibit more assertive behavior in single-sex mathematics classes. The researchers found that it was easier for girls to participate in classroom discussions and ask questions in the single-sex environment (Leder & Forgasz, 1994).

Researchers also investigated students grouped into categories of "desirable" students versus "less desirable" students, as characterized by teachers' perceptions of

preferred academic and classroom behavior. The girls in the more "desirable" student group still received less attention from their teachers than did the boys in the same student desirability group (Kelly, 1988). Researchers have also found that, in sex segregated classrooms, instructors were observed to physically gravitate toward the male segregated side (Sadker & Sadker, 1986). The possible implication of such differential treatment will likely result in the female students receiving less reinforcement and quality attention.

Teacher-student interactions. Studies have shown that teachers have a tendency to provide more positive feedback for on-task and appropriate classroom behavior to boys than for girls (Serbin, O'Leary, Kent, & Tonick, 1973; Irvine, 1986; Melnick & Rosenthal, 1986). Research in elementary schools revealed that boys received more verbal and nonverbal praise as well as instructional based contact than girls (Brophy & Good, 1974; Simpson & Erickson, 1983). Sadker and Sadker (1985) investigated teachers' reactions in fourth, sixth, and eighth grade classrooms by recording the amount of praise (i.e., "excellent job"), acceptance (affirming correct performance without praise such as, "O.K.", "uh-huh", "I see", or teacher silence), remediation (probing a child for a more correct answer), and criticism (i.e., "Answer 5 is wrong") received by each gender. The researchers found that female students received the most acceptance responses, a category which was viewed by the researchers as having the least educational value. Researchers stated that the acceptance response was at times a desirable and appropriate response; however, an abundance of acceptance response did not lead to the most optimal learning environment. In fact, according to Sadker and Sadker (1985) constructive criticism, contingent feedback, and praise have been proven to be essential to learning.

Too much acceptance and too little remediation, criticism, and praise may not foster academic growth. In contrast to girls, boys received more of the responses viewed as educationally valued: remediation, criticism, and praise.

Dweck, Davidson, Nelson and Enna (1978) found that 90% of the positive feedback boys received was directed at the intellectual quality (i.e., ability and the correctness of the response) of their performance; whereas, for girls, less than 80% of the positive feedback they received was directed at the intellectual quality of their performance. Thus, approximately 20% of positive evaluations girls received pertained to intellectually irrelevant aspects of their work (i.e., neatness and following instructions). Such a difference in the percentage of positive feedback girls and boys received pertaining to intellectual quality of their performance was found to be significant. Further, less than a third of the negative evaluations that boys received regarded issues relating to conduct and neatness (intellectually irrelevant aspects) whereas nearly two-thirds of girls' negative feedback was directed towards intellectually relevant aspects of their work.

With this information in mind, researchers Dweck, Davidson, Nelson and Enna (1978) conducted a second study in which they investigated the differential treatment given to girls by their teachers and its effects on attribution. It was hypothesized that the feedback girls had been observed to receive, labeled "girl-feedback", would lead students to view their failure as a lack of ability, whereas the feedback boys received, labeled "boy-feedback", would result in students viewing failure as a result of their own effort or the behavior of the evaluator. Results of Dweck, Davidson, Nelson, & Enna's (1978)

second study in which students were randomly exposed to one of the two types of feedback conditions revealed that 80% of the girls and 50% of the boys in the teacher-boy ("boy feedback") condition stated their failure was due to effort. In contrast, the teacher-girl ("girl feedback") condition resulted in only 20% of the girls and 30% of the boys attributing their failure to effort. Such results suggested that feedback given to students had a direct effect on their view of failure. It is especially important to note how academically detrimental it is for students to experience the "girl-feedback" condition since viewing failure as a lack of ability may be perceived as a unalterable condition. The results of the boy-feedback condition, in which students view failure as a result of their effort or the evaluators behavior, could in fact be modified to produce a more positive outcome in the future (Dweck et al., 1978).

Considering the previously reviewed research, one should examine the effects of gender bias in the classroom, self-concept and academic achievement in girls. Most research in these areas has been conducted in coeducational public schools. However, it is possible that differences in single-sex versus coeducational schools would produce different outcomes. General differences between the school types, and the implications of federal law will be discussed in the next section.

Single-Sex vs. Coed Schools

Legal differences.

In the United States researchers are often limited to the study of Catholic schools when investigating the single-sex classroom. Catholic schools do not have to abide by Title IX, the Education Amendment of 1972, which states that individuals cannot be barred from participating in federally financed education

(Alexander, 1992). Thus, unlike the federally funded public school, the private Catholic school can separate students into single-sex classrooms or schools. Furthermore, the only non-private schools that have single-sex classrooms to compare to coeducational classrooms are those found in countries such as Australia, where no such law exists. Thus in order to obtain comparable groups to study, researchers must either use private schools or conduct their research abroad.

Achievement. Researchers Lee and Bryk (1986) and Marsh (1991) have utilized High School and Beyond (HSB), a national survey data based on secondary schooling in the United States, to study the academic differences between single-sex versus coeducational schools. The information in the database consisted of a random sample of students from public and Catholic schools. The Catholic school sample consisted of single-sex and coeducational schools. Lee and Bryk (1986) and Marsh (1991) utilized samples of the data to analyze school related behavior, attitudes and achievement. Results indicated Catholic schools in general were more academically oriented than coeducational public schools. Students were enrolled in more academically oriented classes, selected more math and science courses, and were more likely to be enrolled in a college prepatory curriculum versus a vocational curriculum. Further research investigated the single-sex classes versus the coeducational classes within the Catholic school system and indicated that students in these single-sex schools had higher academic orientations and educational aspirations. Compared to coeducational students, both male and female students in single-sex classes were more likely to view education as an avenue to achievement status, and were more inner oriented in terms of locus of control. (Cairns,

1990; Schneider & Coutts, 1982; Lee & Byrk, 1986). When comparing the two school types, the following control factors were taken into consideration: family background (socioeconomic status, ethnic status, single parent status, religious orientation, number of years in Catholic school, retention, and financial sacrifice), curriculum track (course enrollment, educational aspirations), and school social composition (average social class and percentage of minority students). After controlling for these factors, there were no academic areas in the sophomore to senior years in which coeducational school students outperformed their grade counterparts in the single-sex school. In mathematics, only the boys' single-sex school outperformed the girls and boys in the coeducational school.

Lee and Byrk (1986) found both boys and girls in single-sex schools were more likely to enroll in math than their coeducational peers; however, only the boys' enrollment in math courses was measured to be statistically significant. Even though the girls attending single-sex school did not enroll in more general academic courses than the coeducational girls, they were still reported to have made significant general academic achievement gains. Furthermore, the girls attending the single-sex schools also exhibited fewer stereotyped sex role attitudes compared to the girls attending the coeducational school. Such stereotyping attitudes showed a significant decrease in the sophomore to senior years for both boys and girls in the single-sex school. Marsh (1989) criticized the Lee and Byrk (1986) study stating that, because measures were not collected prior to the start of the high school year, there was no basis for Lee and Byrk's inference that similarities existed between the students enrolled in single-sex and coeducational schools prior to that point. Marsh stated that using the High School and Beyond (HSB) database

allowed no way to test whether differences existed or not. Marsh further disagreed with Lee and Byrk's use of a one-tailed significance test because he believe that significant differences favoring either school-type were important to the future of academics. He stated that although the researchers reviewed literature which supported their hypothesis that single-sex schools would out-perform coeducational schools, the research itself was inconsistent in its findings and some of the studies did not control for adequate background variables. Such a critique reveals that research in this area is conflicting and inconclusive.

Attitudinal Measures. Leder and Forgasz (1994) conducted a study in Australia that examined the short and long-term effect of class type on students' attitudes and performance in a single-sex mathematics class in grade 10 in a coeducational school. Data were gathered three times during the study: early in the school year, seven months into the school year, and at the end of the school year, just prior to dismissal. The first and third data collection consisted of paper and pencil tests and self reports administered to tenth grade boys and girls in single-sex math classes. The second data collection involved interviews with students in the first part of the study and those who were not.

The self report measures were four likert scales which investigated: a) students' views on mathematics; b) attribution of success and failure in mathematics; c) self perception in mathematics; and d) perception of the mathematics classroom environment. The interview data investigated the students' view of single-sex classes, the effect it had on learning, the classroom environment, peer relations, perceptions of teachers and their attitudes in the single-sex classroom and the importance of the

existence of single-sex classes in future education. The study did not specify the degree of uniform methodology or the specific procedure that was involved in the interview portion of the study. Data were also collected in which teachers were asked to evaluate student's mathematics performance at the beginning, middle and end of the year. Results from the study of self-report measures revealed that 40% of the 29 girls versus 6% of the 25 boys sampled wanted to be in a single-sex math classroom the following year. Fifty-one percent of the boys would choose a coeducational classroom versus 16 percent of the girls. The remaining students either stated they would not mind a single-sex classroom the following year or were unsure of their preference. Girls stated that it was easier to ask questions without boys present in the classroom to tease and distract them. The boys preferred to have girls in the classroom because of their input and their productivity in small groups. The self-report data also revealed that girls in grade 10 stated they benefitted from the single-sex classroom. The single-sex classroom gave them more confidence and more effective work strategies. Fifty percent of the 29 girls sampled indicated their math performance had not changed in the single-sex school experience. In the remaining 50% all but two stated that their math performance had improved. Twelve percent of the boys indicated having greater difficulty in the single-sex environment whereas 56% stated they were doing better. All the boys based their reasoning on teacher performance and their own work ethic (Leder and Forgasz, 1994).

The teachers' measure of performance (based on a likert scale) was taken at the beginning, middle and end of the school year for all students in the study. Differences were not found for the independent variables of gender and class type. Although all of

the girls' math achievement scores exceeded males at each time of measurement, it was not a significant amount.

Bornholt (1988) investigated self-concept and single-sex schools with students in grades 7 through 10 in Australia. These researchers investigated the effects of gender and school type on the perception of achievement. Students completed a test of reading comprehension and math achievement. Following each test students were asked to evaluate and estimate their own level of performance. Results revealed there were no significant gender differences in actual test scores. Males did, however, make higher estimates of their achievement than females in the area of mathematics. Researchers did not find that gender differences were larger in a coeducational setting. A decline was found in over-estimation from grades 8 to 10. Males overestimated performance more than females in mathematics and English, although actual performance scores did not differ significantly between genders.

The effect of school-type on achievement and confidence. Rowe (1988) investigated the effects of single-sex and coeducational classes on student achievement and confidence. Student groups from an Australian coed school were randomly selected from grades seven and eight and placed in either single-sex classes of either gender or coed classes for the subject of mathematics only. The division of student groups resulted in 12 single-sex classes and four coed classes. Teachers were also randomly assigned to the various mathematics classes. Twice during the academic year the students were given subtests from the standardized achievement test, ACER Mathematics Profile Series of Operations, Space, Numbers and Measurement, and the Fennema-Sherman Mathematics

Attitude Scales. The Fennema-Sherman Mathematics Attitude Scales contains items pertaining to confidence in learning and using mathematics. The following year, when the students were in the end of their eighth and ninth year of school, they were again administered the achievement subtests and the attitude scale.

The original intention of the researchers was to have the two groups of students remain in their allocated class-type, single-sex or coeducational. However, due to the school's need to meet the students' curriculum needs (timetable constraints of students taking Music and French) 111 of the 398 students were reallocated to a different class-type one year after the beginning of the study. Analysis of the intact group, where no class-type shift occurred, revealed a nonsignificant gender effect for achievement and confidence scores. However , a significant class-type effect was found concerning the variables of achievement and confidence. Significant achievement and confidence score gains were found across the three test periods for all students except for boys in the intact coed mathematics classes. On the second and third test periods, both girls and boys in single-sex classes displayed significantly higher levels of math confidence than students in the coed classes. Only a weak correlation was found between confidence and achievement in the coeducation classes. Such results suggest students' confidence in their math ability was a significant predictor of achievement in the single-sex classroom but not in the coed classroom. Further data analysis revealed no class-type effect on students' achievement independent of confidence (Rowe, 1988).

Effects of transition between types of schools. Although Rowe (1988) did not anticipate the relocation of students to a different class-type during the first year of the

study he utilized this change to examine the data of the resulting shift group. The analysis revealed for those individuals who began the study in a single-sex classroom, except for girls' achievement, both their achievement and confidence scores significantly improved between test sessions one and two. Girls' achievement scores continued to improve when relocated to coed classes on testing period three, however scores of boys who relocated declined over the same period. Contrary to previously mentioned studies (Bornholt, 1988; Leder & Forgasz, 1994) the present study revealed the confidence scores for all students who moved from single-sex to coed schools declined. The decline was more significant for girls. Furthermore, achievement scores for those students relocated from coed to single-sex classes improved. This change was significant for the girls but not for the boys. Girls' confidence scores also improved across measurement periods. The analyses further revealed that a strong positive effect for confidence on achievement, where confidence was positively correlated with achievement regardless of class-type relocation.

Australian researchers also investigated student self-concept and achievement in transition from a boys high school (BS) and a girls high school (GS) which were reorganized and combined to form two coed schools (Marsh, Smith, Marsh & Owens, 1988; Marsh, Owens, Myers & Smith, 1989). The effects of transition involving single-sex versus coeducational schools on various self-concept areas and on mathematics achievement between genders and school type were analyzed.

In the first year of the study, the pretransition phase, data were collected on the BS and GS when they were individual schools. In year two, the transition phase, only

grades 7, 9, and 11 from both of the single-sex schools attended coed classes. In year 3 and 4, post-transition phase, all students in both single-sex school attended coed classes. At the end of each phase, the Self Description Questionnaire (SDQ) II was administered to a sample of the students in each grade. Achievement was measured based on School Certificate awards given in Math and English. These are standardized tests administered by the New South Wales State Department of Education (Marsh, Marsh, & Owens, 1988).

Researchers examined the students' self-concept scores in the pre and post-transition periods and found self-concept to be significantly higher in the post-transition phase, when students attended coeducational school, rather than in the pretransition phase. Self-concept was found to decrease between grades seven and eight for both genders and then begin to increase around grade nine to grade eleven. The investigation further revealed that boys had a slightly higher self-concept score than girls in all areas measured on the SDQ-II, regardless of class-type. Within subject areas, differences between the genders were also revealed. Boys had higher self-concept scores in math than girls. However, the transition year analysis revealed that total self-concept scores were higher in single-sex classes than in coed classes. The longitudinal pre-post comparison, taken at the beginning and end of the entire study, revealed the coeducational classroom had higher self-concept scores in contrast to the pre and post transition. The pre and post transition, taken immediately before and after the transition between school-types, indicated higher self-concept scores for students in the single-sex classes. Researchers stated that the reason the coeducational classroom had lower self-concept

post transition scores was due to a slight initial negative effect of the transition phase. Self-concept scores in the transition phase consistently increased the following year.

Researchers classified each group of students within each phase of research into three groups. Self-concept went up when students who attended single-sex classes in year one and two moved to coed classes in years three and four. Self-concept scores did not differ significantly rise in those individuals who attended single-sex classes in year one and coed classes in year two, three, and four. In the last two years of attending a coeducational school, their self-concept scores were higher in comparison to the first year when they attended the single-sex classes. Self-concept scores went up when students were in single-sex classes in year one and two and in coed classes in year three. Again, self-concept scores were higher in these students when in coed schools versus single-sex schools. Students' achievement scores were shown to be stable across the four years of the study. Girls performed better in English compared to boys; whereas girls performed worse in mathematics compared to their male counterparts. However, no transition effects were found on achievement scores (Marsh et al., 1988).

Specific limitations of the study must be noted. In Australia, the distribution of grades in high school was dependent on that school's performance on the reference test taken by all grade ten students in the state for that year. During the study this measurement of mathematics achievement was hindered by a change in the procedure in which School Certificate grades were awarded. Previously, grades of one through five were awarded to individuals for mathematics performance. However, the second year of the study a multilevel mathematics curriculum was implemented. The policy change

called for students to take one of three examinations based on their mathematics ability: advanced, intermediate, or general. Students in the advanced level earned one of three grades, the intermediate level students were awarded one of two grades. Schools were also allowed to continue with the old system during years two and three of the study. In the final year both schools used the new method. The analysis revealed no gender differences. It is important to note that different streams (advanced, intermediate, or general) were given different tests; thus the grades were not easily compared and results should be interpreted with caution. There existed a lack of a suitable controls for comparison and a lack of consideration for differing background variables. Furthermore, the decrease in self-concept scores during the transitional phase was not adequately explained.

A later study of single-sex to coeducational school transition supported the Marsh (1988, 1989) findings. In a United States Catholic high school, Kysor (1993) investigated such a transition with grades nine through twelve. The study covered four years and included pretransition, transition, and post transition results utilizing the previously mentioned Australian measure the Self Description Questionnaire II. Overall, as students moved from a single-sex to a coeducation school, males had a significantly higher total self-concept then females. General self-concept improved over time in both males and females. Freshmen, sophomores, and juniors, however, had higher mathematics self-concept scores than their senior counterparts. In general, results revealed that significant differences existed between males and females overall, and specifically in mathematics self-concept scores, in which males scored higher.

Summary and Conclusion

Educators question how girls and boys in the same learning environment are getting different educational outcomes, particularly in mathematics. Research reveals the existence of classroom behavior in favor of boys in the areas of teacher-student attention, interaction, and feedback, particularly in the area of mathematics. Such a gender bias interferes with the maintenance of an optimal classroom learning environment for girls. (AAUW, 1992; Becker, 1986; Kelly, 1989; Leder & Forgasz, 1994; Sadker & Sadker, 1985, 1986), particularly in the area of mathematics. Some researchers have implied that the experience of being a female student can foster learned helplessness (Dweck et at., 1978). Self-concept in math has been found to be highly correlated with math achievement (Marsh, 1986, Shavelson & Bolus, 1982; Skaalvik & Rankin, 1990). Investigations of whether a single-sex classroom affects the mathematics achievement and self-concept scores for the female student have been conducted (Bornholt, 1988; Rowe, 1988; Marsh et al., 1988, 1989; Kysor, 1993, Leder & Forgasz, 1994). Research in this area is inconclusive.

There are many limitations in the past investigations of single-sex classes and math self-concept in girls. The results of Leder and Forgasz (1994) revealed that the single-sex mathematics classes gave the female students more confidence and, of the 50% of those questioned, all but two stated their math performance had improved. According to the teachers' measure of student performance, no significant gender differences were found concerning gender and class type. The results of this study must be questioned.

The self-report and teacher-report measurement tools utilized in the study lacked proof of validity and reliability. Further, comparisons to a control group did not occur.

Rowe's (1988) study with the rare experimental control of randomly allocated students and teachers to class-type adds validity to the results which revealed individuals in single-sex mathematics classes exhibited significantly higher math confidence than their coed class peers. However, Marsh and colleagues' (1988, 1989) investigations of the effects of transition involving single-sex versus coeducational schools on mathematics self-concept and achievement revealed opposite effects in which self-concept scores were higher in coed schools versus single-sex schools. Such results are limited when one considers the change in the math achievement measure, the lack of suitable controls, and the inattention to various background variables.

Furthermore, many of the studies that have investigated the issue of girls' self-concept in single versus coeducation schools have been conducted in Australia where Title IX does not encumber the existence of single-sex classes. Because of cultural variations, such studies may not be generalizable to a United States sample. Due to the restriction of Title IX, a study needs to be conducted in a private school system in the United States.

Current Study

This study was conducted in the private school system. A sample of students was be taken from a single-sex classroom environment and compared to their coeducational peers. Research is not available to show if high/low mathematics achievement causes high/low mathematics self-concept, or vise versa. Studies have shown that a positive

correlation exist between the two variables. When one of these variables is high, the other is high. One possible relationship that could exist would be individuals with higher mathematic achievement scores will experience lower mathematic frustration, thus resulting in higher mathematic self-concept scores. Therefore, the present study hypothesized that a positive correlation exists between participants achievement and self-concept scores in both the single-sex and coeducational classroom.

Since, in the girls single-sex classroom the absence of male students would result in the absence of differential treatment, it is possible that this could foster higher academic achievement and self-concept in mathematics. Thus, it was hypothesized that girls in single-sex classrooms will have higher academic achievement and self-concept scores.

Research has also shown that self-concept is highest in grades 7, 11, and 12 and lowest in grade 9, thus was it was hypothesized that mathematics self-concept scores will be lowest in the 9/10 group and highest in the 11/12 group in both schools.

Method

Participants and Setting

Two types of schools were utilized in the present study: a school where girls and boys were taught academics separately (single-sex school) and two schools where girls and boys were taught together (coeducational schools). The single-sex school's total population consisted 229 students; 68 seventh graders, 63 eighth graders, 29 ninth graders, 26 tenth graders, 29 eleventh graders, and 24 twelfth graders. The coeducational schools (one elementary and one secondary) total population consisted of 799 students;

45 seventh graders, 49 eighth graders, 193 ninth graders, 173 tenth graders, 176 eleventh graders, and 163 twelfth graders. One hundred and thirty-eight students completed all components of the study. For the purpose of this study, participants were divided into three groups according to grade, 7/8, 9/10, and 11/12 (see Table 1). There was an attempt to obtain approximately 30 students in each group. An attempt was also made to divide them equally by grade and school. For varying reasons, there were less than 30 students in each research group. The breakdown of participant numbers by research group in the school with the single-sex classrooms were as follows: 7/8 - twenty students, 9/10- twenty-five students, and 11/12- sixteen students. The coeducational schools, despite having a higher total student population, resulted in somewhat similar participant involvement: 7/8- twenty-five students, 9/10 -thirty-one students, and 11/12- nineteen students. Sixty-three of the students attended a private nondenominational Christian school where they were instructed in a single-sex math class. The remaining 75 students were enrolled in private Catholic schools where they attended coeducational math classes. The number of participants from the single-sex sample equates to 26% of the single-sex total population whereas the number of participants from the coed sample equates to 9 % of the total coed population. The age of participants on average were within the normal range expected for each investigated grade level. The participants in the corresponding groups of the study were similar in age (see Table 2). Both groups of schools had the same average age for grades 7, 8, and 12; ages 13, 14, and 17, respectively. The average ages for grades 9 through 11 in the coeducational sample were 14, 16, and 17 whereas in the matched school they were ages 15, 15, and 16.

Attempts were made to match for socio-economic status based on average family income, average financial assistance, and tuition cost. Demographic information was collected from the administration and each participant (See Appendix A1, A2, and B). There were only one school in the area that separated girls and boys during instruction. That school consisted of grades 7 through 12. Although there were many parochial schools in the surrounding area of the school with the single-sex classrooms, the researcher chose the coeducational schools that were closest in proximity to better control for socio-economic status. The elementary coeducational school was within a mile of the single-sex research population and was a feeder school to the coeducational high school that was also used in the study. The high school was approximately five miles from the single-sex population. The examination of the demographic data led the examiner to believe that the schools were similar enough in comparison for the present study.

Similarities Between Schools

Examination of the demographic school data revealed that the schools in the present study were similar in the following ways: financial assistance, number of days and hours in school, average year in attendance at current school, and number of female and male math teachers. Average family income could not be obtained from all participating schools. Both types of schools charge tuition; however, they differed in price due to the fact that the Catholic Diocese contributed financially to their schools, thus lessening the tuition cost for students in coeducational school. One coeducation school charged $1,675 for parishoners and $2,750 for nonparishoners (including book fees) per year. In the coeducational high school, the tuition cost was $2,904 for

parishoners and $3,529 per year for nonparishoners (not including book fees). In the single-sex school the tuition was reported to be $4,550 for grades seven through eight and $4,800 for grades nine through twelve (book fees not included). Financial assistance for the coeducation population was equal to approximately 15 percent, and 16 approximately percent for the single sex classroom population.

The school year for all participants lasted 180 days, with a 7 hour school day. The average number of years that the students had attended the coeducation schools was approximately five years, whereas the students in the single sex classroom school had attended, on average, approximately four years. None of the students from the coeducational school had ever attended an all girl school or a school that taught the gender separately for academic subjects. On average, the students from the single-sex classroom population had attended a coeducational school from grades Kindergarten through sixth grade. In both types of schools there were five male and two female teachers teaching math in the grades seven through twelve.

Instruments

The Self-Description Questionnaire I, II and III (SDQ II and III).

The Self-Description Questionnaire I, II and III (SDQ I, II, and III) are pencil and paper self-concept tests that can be individually or group administered to participants. The version of the SDQ administered was based on the age of the participant. The SDQ II, designed for students in grades 7 through 12, was utilized in this study. Responses were recorded on a 6-point scale. The SDQ II was designed to measure 11 factors of self-concept and consisted of 102 items; however, only the math self-concept factor were

administered to the participants. The SDQ-II raw scores are transformed into T-scores using the mean and standard deviation of the normative group resulting in a mean of 50 and a standard deviation of 10. The math self-concept consisted of 10 items, which were equally divided into negatively and positively worded sentences. Research on the SDQ II scale revealed that math self-concept scores significantly correlated with descriptive self ($\underline{r}$ = .95), peer, parent, and teacher appraisals ($\underline{r}$ = .77) of a given individual's math self-concept (Marsh, 1988). Furthermore, research on the SDQ II revealed that math achievement substantially correlated with math ability and math self-concept ($\underline{r}$ =.80) versus a nonrelated comparison of verbal ability and math self-concept ($\underline{r}$ =.06) (Marsh, 1986, Marsh & O'Neill, 1984; Marsh, 1990). The factors the SDQ were designed to measure were distinctly identified by factor analyses and assessed differential components of self-concept. Each factor has been found to be internally consistent and stable over time (Marsh, 1986). Specifically, the math self-concept scale on the SDQ II has been found to have an internal consistency coefficient of .90 and a Test-Retest Reliability coefficient over a seven week interval of .88. As reported in the SDQ-II manual, the SDQ II was constructed from earlier research utilizing the SDQ I and III. Since the SDQ-II contains items from the other SDQ measures, that have already proved to be valid, such validity is inferred to the SDQ-II. One hundred and thirty-eight students completed all components of the study.

Wechsler Intelligence Scales. The WISC-III and the WAIS-III are two individually administered cognitive assessment measures that were utilized to control for IQ. In general the WISC-III is designed to assess the intelligence for ages 6 through

16-11 whereas the WIAS assesses ages 17 through adult. Both tests are based on the same underlying conception of intelligence. They also have similar scale structure, domains, and subtest measures. Only the Vocabulary and Block Design subtests were administered, because the Vocabulary subtest loads the highest on the Verbal section of the WISC-III, and the Block Design loads the highest on the Performance section of the WISC-III (Wechsler, 1991). These subtests load the highest on their respective Split-half reliability coefficients for the WISC-III subtests. Idealistically the examiner would have preferred to have administered the entire IQ test to the participants; however, the resources to perform such a task were not available. IQ scales and factor-based scales for ages 11 through 16 ranged from .88 to .91 for the Vocabulary subtest and .84 to .92 for the Block Design subtest. Stability coefficient for test-retest reliability for the 11-16 age group ranged from .88 to .89 on the Vocabulary subtest and .75 to .77 on the Block Design subtest. The correlation coefficient between the Vocabulary and Block Design subtests on the WISC-III and WAIS-III are .83 and .80 respectively (Wechsler, 1990; Wechsler, 1997). The WISC-III has a correlation coefficient with the Stanford Binet -IV of .83.

The Stanford Diagnostic Mathematics Achievement Test: Fourth Edition

The Stanford Diagnostic Mathematics Achievement Test Fourth Edition (SDMT-4) is a group administered pencil and paper mathematics achievement test. The multiple choice section of the test was group administered. It consisted of a Concepts and Applications and Computation sections. The Concepts and Applications section was divided into the following areas: numeration, probability and statistics, graphs and tables, problem

solving, and geometry and measurement. Reliability coefficients for the Concepts and Applications section ranged from grades 7 to 12 were reported to be from .83 to .88. The Computation section consisted of the following areas: addition and subtraction of whole numbers, multiplication and division of whole numbers, operations with fractions and mixed numbers, operations with decimals and percents, and equations. Reliability coefficients for the Computation section from grades 7 to 12 were reported to range from .77 to .87. SDMT-4 reliability coefficient for the Multiple Choice section from grade 7 to 12 were reported to range from .89 to .92. Alternate form reliability for the grades to be measured were reported to be no less then .85. As recommended in the SDMT-4 manual to establish validity, mathematic department heads from the schools in the study have conducted an informal investigation of the test content and have found it to represent the instructional objectives of their schools' mathematics program. The SDMT-4 was chosen as a measure in this study because it has good reliability, corresponds with the curriculum in the projected schools to be studied, and is group administered. Normed means on the SDMT-4 vary by grade, (see Table Table 3).

Procedures

Letters requesting volunteers for this research on mathematics were accompanied by permission forms and sent to parents via school newsletters. Two such attempts were made for all schools. School staff as well as the examiner went to classrooms in the coeducational school and spoke to the entire female population at the single-sex school in order to encourage participation in the present study. The seventh and eighth grade

coeducational population were given candy bars for the return of a completed consent form.

The staff of the secondary coeducational school as well as the examiner felt that candy bars for consent forms would not be reinforcing at that age level. The staff at the single-sex school informed the examiner that their students would not be reinforced by the candy bars. Furthermore, they stated that the students should volunteer for the study because of the experience and the sake of learning thus the candy bars were not utilized for any grades in the single-sex population. Any encouragement, outside of verbal reinforcement, for participation was discouraged in the single-sex school. School staff felt that the students would be "offended" at the attempt to encouraged participation. One could argue that a different sample would volunteer with reinforcement versus without; however, in general the encouragement from staff was equal. It is hoped that a candy bar for a consent form may cue a student to turn in the form but would not be the basis for their participation in the study. Thus it is assumed by the examiner that the nonuniform use of reinforcers was not detrimental to the study.

The group-administered portion of the study was given to one of the coeducational groups during the last period of a school day. Individual participants completed the WISC-III portion of the study on subsequent school days. The participants in the coeducational ninth through twelfth grade sample were encouraged to participate in the study with a chance to win up to $100 based on the number of students who returned a consent form and completed the group portion of the study. This sample stayed after school on a half day to complete the group portion of the study. Approximately one to

two weeks, later individual participants were pulled from class to complete either the WISC-III or the WAIS-III portion of the study in no preferred order.

The girls in the single-sex population were spoken to about the research by the examiner a total of three times during the early morning sessions in which all the girls in the school come together for prayer and announcements. The girls were also told that, depending on the number of students who participated, they could win up to $100. Forty-three girls from grades 7 through 12 participated in the first group-administered portion of the study. Approximately 2 weeks later the girls were administered the I.Q. portion of the study before and after school. Because only 43 girls participated in the study, the researcher again asked for volunteers for the study. This time, to better accommodate the students schedules, two additional dates to administer the group portion of the study were made available after school. The I.Q. portion of the study was again administered before and after school.

During the group administration of the study, each participant was assigned a subject number and given a file folder containing the following information: consent form, assent form, demographics sheet, SDQ II, SDMT-4. They were first asked to read and sign the assent form, and then to complete the demographics sheet. Upon completing the demographics sheet, the participants were read the instructions for the SDQ II and asked to complete the form (administration time 10 minutes). The SDQ II was purposely administered prior to the SDMT-4 to avoid the participants' perceived performance on the SDMT-4 affecting their responses on the SDQ II. Finally, the instructions for the SDMT-4 were read and the students were given one hour to complete the test. The

average time of completion for the SDMT-4 was approximately 45 minutes for all participants.

For all groups, The SDQ II was administered prior to the SDMT-4. The order effects of the Wechsler Intelligence Scales and the SDMT-4 were not a concern to the researcher. It was not thought that the students' perceived performance on either measure would affect the performance on the subsequent test positively or negatively. In regards to the aforementioned intelligence scales, participants were individually administered the Block Design and Vocabulary subtests from either the Wechsler Intelligence Scale for Children Third Edition (Wechsler, 1991) or the Wechsler Adult Intelligence Scales Third Edition (Wechsler, 1997). Participants ages 11 through 16 were administered the WISC-III whereas participants 17 through 18 were administered the WAIS-III. Both tests were given to participants on an individual basis by a professional trained to administer intelligence tests. Administration took approximately 15 minutes.

Results

Descriptive Statistics

Independent variables in the present study were school-type (i.e., coed or single-sex) and grade (i.e., 7/8, 9/10, 11/12). Dependent variables included academic achievement and self-concept scores. Academic achievement measured by the SDMT-4 resulted in the following three scaled scores, as found in the test manual: Concepts and Applications (story problems), Computation (pencil and paper test), and a total composite score. The SDQ II self-concept measure resulted in one final T-score. Four covariates were utilized: Vocabulary and Block Design scaled scores from the

WISC-III, age, and the number of years they attended their current school-type (see Table 4).

Hypothesis 1: Relationship between math achievement and math self-concept

It was hypothesized that a positive correlation would exist between participant's math achievement and math self-concept in both the single-sex and coeducational classrooms. A Pearson Product Correlation revealed a significant correlation in the investigation within the entire participant sample as well as in an independent investigation of the single-sex sample (see Tables 5 and 6). No such results were found in the coed population. The total composite score on the SDMT-4 and the SDQ-II, when both types of schools were combined, were significantly correlated (r=.226, p <.01). Also found were significant correlations between the SDQ-II and both the Computation and Concept and Application subtests of the SDMT-4 (r=.290, p<.01; r=.194, p<.05). Additional analysis found that in the single-sex sample a significant correlation also existed between the Computation portion as well as the Concepts and Application portion of the SDMT-4 with the SDQ-II (r=.310, p<.05; r=.433, p<.01). An independent investigation of the coed sample did not reveal any such correlations between the individual subtests of the SDMT-4 and the SDQ-II (r=.170, p>.05; r=.099, p>.01) (see Table 7).

Hypotheses 2 and 3: Differences in school types

The hypothesis that students from a single-sex classroom environment will have higher academic achievement and self concept than students in the coed classrooms was examined by conducting an ANCOVA on the student's math achievement and self concept scores. The Verbal and Block Design scaled scores, age, and the number of years students attended their current school-type were utilized as covariates. Type of school (i.e., single-sex or coed) and grade groups (i.e., 7/8, 9/10, 11/12) were used as independent variables.

Originally, an ANOVA was proposed as the main analysis of the study. An ANOVA is more appropriate to use when dependent variables are conceptually independent, whereas, MANOVA should be utilized when the dependent variables are conceptually related and assess similar underlying constructs (Cone & Foster, 1993). The ANCOVA is a more powerful test than the ANOVA. It is more sensitive to differences, and is less likely to result in statistical error (Maxwell & DeLaney, 1990) Thus, ANCOVAs were conducted for hypothesis 2 and 3, which investigated whether math achievement as an effect of class-type and grade group and investigating self-concept as an effect of class-type and grade group. Math achievement performance was analyzed in two different ways: first, the combined scores (i.e., a composite of the Computation and Concepts and Applications subtest scores) were analyzed, then the same analyses were repeated separately for each of the subscales (i.e., Computation and Concepts and Applications). All ANCOVAs included the covariates of the Block Design, and Vocabulary subtests from the WISC-III, as well as age, and years at the school. The

researcher wanted to control for these variables, in case there were any significant differences among the two samples. Here they are all held constant and can not interfere as confounding variables.

Performance on Math Achievement Test

An ANCOVA utilizing the math achievement composite scores as a function of school type revealed a significant main effect of grade ($F(2,128)=3.407$, $p<.05$). Neither the status main effect ($F(1,128)= .038$, $p>.05$) nor the interaction between status and grade were significant ($F(2, 128)= 2.421$, $p > .05$). Therefore, math performance achievement varied as a function of grade.

Pairwise marginal mean (see Table 8) comparisons of grade group were conducted by using an independent samples t-test. Students in grade 7/8 ($M=716.377$, $SE=9.01$) had the lowest performance on the math achievement test, which was significantly different than performance on math achievement in grade 9/10 ($M=744.434$, $SE = 5.68$) and in grades 11/12 ($M=757.774$, $SE = 9.60$). There was no significant difference between groups 9/10 and 11/12.

When students' performance on only the computation subtest was analyzed, the grade main effect was nonsignificant ($F(2,128)=1.856$, $p>.05$). Neither the status main effect ($F(1,128)= .073$, $p>.05$) nor the interaction between status and grade ($F(2,128) = 1.163$, $p>.05$) was significant. Therefore, students' performance on the Computation subtest scores did not vary as a function of school or grade when controlling for the Block Design and Vocabulary Subtests as well as age and years at the students' particular school-type (see Table 9).

An ANCOVA utilizing the Concepts and Application subtest as a function of school type and grade group revealed a significant grade main effect ($F(2,128)=5.081$, $p<.01$). The status main effect was nonsignificant ($F(1,128)= .025$, $p>.05$). The interaction between the grade group and status was significant ($F(2,128)=3.726$, $p<.05$). Therefore, students' performance on the Concepts and Application subtest varied as a function of both the students' type of school (i.e., single-sex and coed) and the grade group[1] (see Figure 1).

Because the interaction was significant ($F(2,128)=3.726$, $p<.05$), Tukey's alpha correction method (with the critical adjustment of 5.64 for 3 and 132 degrees of freedom) was used to conduct pairwise simple cell mean comparisons of grade (with three levels: 7/8, 9/10, 11/12) and status (with two levels: single-sex and coed) (see Table 10). On the Concept and Application subtest in the single-sex classrooms children in the 9/10 grade group outperformed children in the seventh and eight grades ($M_{9/10\ single}=752.037$, $SD=35.68$; $M_{7/8\ single}=719.55$, $SD=29.027$; $F(1,132)=10.70$ compared to Tukey's critical adjustment of 5.64). Such results were not found in coed classrooms ($M_{9/10\ coed}=731.806$, $SD=29.707$; $M_{7/8\ coed}=718.12$, $SD=39.135$; $F(1,132)=2.19$ compared to Tukey's critical adjustment of 5.64). In the coed classroom, a significant difference was found between the 9/10 and 11/12 grade groups, thus the 11/12 grade group had significantly higher Concepts and Application scores than the younger coeducation 9/10 group 9/10 ($M_{9/10coed}=731.806$, $SD=29.707$; $M_{11/12coed}=776.947$, $SD=31.089$;

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Because the interaction is significant, the research will not interpret the main effect for grade because students' performance on the Concepts and Application subtest varied as a function of both independent variables..

F(1,132)=21.46 compared to Tukey's critical adjustment of 5.64). These significant differences between grade groups 9/10 and 11/12 within the coed sample was not found within the single-sex sample ($M_{9/10single}$=752.037, SD=35.68; $M_{11/12single}$=760.625, SD=39.366; F(1,132)=.58 compared to Tukey's critical adjustment of 5.64). In both school-types a significant difference was revealed on students' Concept and Application performance between the grade groups of 7/8 and 11/12 (F_{single} (1,132)=12.85; F_{coed}(1,132)=32.71). Thus, students in the 11/12 grade group in the single-sex and coed schools earned significantly higher Concept and Application scores than the 7/8 grade group from their school-type (i.e., single-sex and coed).

Pairwise simple cell mean comparisons also revealed that students' Concept and Application performance in coed and single-sex classrooms was not significantly different from each other, within each grade level ($M_{7/8\ single}$=719.55, SD=29.027; $M_{7/8\ coed}$ =718.12, SD=39.135; F(1,132)=.40 within the seventh and eighth grade level; $M_{9/10\ single}$=752.037, SD=35.68; $M_{9/10\ coed}$=731.806, SD=29.707; F(1,132)=5.06 within ninth and tenth grade level; $M_{11/12\ single}$=760.625, SD=39.366; $M_{11/12\ coed}$=776.947, SD=31.089; F(1,132)=.58 within eleventh and twelveth grade level all compared to Tukey's critical adjustment of 5.64). The difference between the two types of schools at the 9/10 grade group was almost significant. A significant difference would likely have been found between single-sex and coed students' performance on the Concept and Application subtest, had Tukey's critical test not been utilized as a method of adjusting the alpha level for the number of comparisons.

Self-concept

The ANCOVA performed on math self-concept scores as a function of school type and grade-group revealed a nonsignificant grade main effect ($F(2,128)=.208$, $p>.05$) and nonsignificant status main effect ($F(1,128)= .006$, $p>.05$). The interaction between status and grade was also nonsignificant ($F(2, 128)= .487$, $p > .05$). Therefore, students' self-concept scores in the area of math did not change as a function of grade-group and school- type when controlling for the Block Design and Vocabulary subtests scores, age, and years at their current school-type (see Table 11).

Discussion

Past research results investigating self-concept in mathematics has revealed that self-concept is correlated with mathematic achievement (Marsh et al., 1986, Shavelson & Bolus, 1982; Skaalvik & Rankin, 1990). Also, a previous survey of the coeducational classroom suggested that when various environmental factors are analyzed, both genders in the same educational setting may, in fact, not be in the same educational environment (AAUW, 1992; Becker, 1986; Kelly, 1989; Leder & Forgasz, 1994; Sadker & Sadker, 1985, 1986). An assumption could be made that the exclusion of male students in girls' single-sex classrooms would result in the absence of the reported differential treatment. The absence of such differential treatment could be thought to foster higher academic achievement and self-concept in mathematics for girls. Thus, it was imperative that outcomes for girls in different school types be investigated. The present research investigated the effect of single-sex or coed environments on students' self-concept and math achievement.

Hypotheses for the present study included the following: a) a positive correlation would exist between participants' achievement and self-concept scores in both the single-sex and coeducational classroom; b) girls in single-sex classrooms would have higher academic achievement and self-concept scores than girls in coed classrooms; and c) mathematics self-concept scores would be lowest in the 9/10 group and highest in the 11/12 group in both schools. The Concept and Application (i.e., math story problems), Computation (i.e., numerical computation problems) and an overall math composite score from the SDMT-4 were utilized in the analysis.

General Findings

Regarding the first hypothesis, where overall math achievement scores were analyzed across single-sex and coed samples, a significant relationship between math achievement and self-concept was found. Such results are consistent with research indicating self-concept in math is correlated with math achievement (Marsh, 1986, Rowe, 1988, Shavelson & Bolus, 1982; Skaalvik & Rankin, 1990). It should be noted that the correlation between math self-concept and math academic achievement in previous studies ranged from .55 to .68; however, the strongest correlation in the present study was .38.

Analyses from past research regarding the relationship between math self-concept and math achievement utilized only one composite math performance score from different achievement measures. For example, one study utilized the School Certificate awards administered by the New South Wales State Department of Education as a math achievement measure (Marsh, Marsh, & Owens, 1988). In the present study, when the

two subscales were analyzed separately, it was found that in the single-sex sample a significant correlation also existed between the Computation portion as well as the Concepts and Application portion of the SDMT-4 with the SDQ-II. Only in the sample as a whole and the single-sex sample could one conclude that a positive relationship existed between math performance and math self-concept. A significant relationship was not found in the coed sample. This is inconsistent with previous research.

The second hypothesis that girls in a single-sex classroom would have higher academic achievement and self-concept scores than girls in coed classrooms was not supported. This finding is consistent with a previous study involving a shift from two individual single-sex boy and girl schools also revealed a nonsignificant math performance difference (Marsh, Smith, Marsh & Owens, 1988; Marsh, Owens, Myers & Smith, 1989). For example, Rowe's (1988) study of seventh and eighth grade students randomly placed in single-sex versus coed classroom and then administered three math measures throughout two years of school revealed that the type of school the participants attended did not affect their math performance on any of the measured variables. In the present study, composite math achievement varied only as a function of grade group in both samples, not as a function of class-type. In general, students in grade groups 7/8 had significantly lower performance on math achievement compared to the other two grade groups. Obviously, the younger the student, the less math skills one would expect to have mastered; however, since the SDMT-4 subtest and composite scores are standardized, this finding shows that the 7/8 students knew less than expected math mastery.

As mentioned above, additional analysis was also conducted on the subtests of the overall math performance, Computation and Concept and Application subtests. Analysis on the Computation subtest revealed that students' performance on this subtest did not vary as a function of school-type, grade group, or as an interaction of those two factors. Students' performance on the Concept and Application subtest varied as a function of both the type of school (i.e., single-sex and coed) and the grade group (i.e., a significant interaction between type of school and grade group was found). Therefore, both factors were related to student performance on the Concepts and Application subtest. Such results suggest that within the single-sex sample, grade 9/10 earned significantly higher Concept and Application scores than the 7/8 grade group, whereas in the coed sample the 11/12 grade group earned significantly higher scores than the 9/10 grade group. In both samples, grade 11/12 earned higher scores than the 7/8 grade group. No differences were found on the Math Concept and Application subtest across school-types.

Regarding the third hypothesis, analyses involving math self-concept did not reveal significant results. No significant differences were found between school-type and math self-concept. Past research findings in this area have been inconsistent. Rowe's (1988) study with the rare experimental control of randomly allocated students and teachers to class-type revealed individuals in single-sex mathematics classes exhibited significantly higher math confidence than their coed class peers. However, Marsh and colleagues' (1989) investigations of the effects of transition involving single-sex versus coeducational schools on mathematics self-concept and achievement revealed

self-concept scores were higher in coed schools compared to single-sex schools. Furthermore, the present study did not support past research which found that academic self-concept is highest in grades 7, 11 and 12 and lowest in grade 9 (Marsh & O'Neill, 1984; Marsh et al., 1989, & AAUW, 1992). No significant differences in self-concept was found in either school-type at any grade group.

General Interpretations and Limitation

The results of the present study offer a different approach into the investigation of the single-sex and coed classrooms regarding math self-concept and achievement, due to the use of the SDMT-4's math achievement subtests in addition to the overall math composite score. Results of the correlation between the SDQ-II and the SDMT-4 and its subtests offer interesting results. Although, the correlation between the SDMT-4 composite, and the SDQ-II is commensurate with past research, the correlation was weaker. When investigating the school-types independently, only the measured self-concept of the single-sex school was correlated with the SDMT-4 subtests. The weak correlation appears to be the result of the lack of relationship found between self-concept and the math achievement measures in the coed sample. Both of the samples' means on the SDQ-II are positively skewed. Such results suggest that the type of person that volunteered for the study had higher math self-concept. Furthermore, a person who was willing to give up their time to be administered various measures for little, if any, extrinsic reinforcement might be expected to have higher than average math self-concept. An individual with low self-concept would natural be less likely to volunteer for a study that exacerbated their negative self-concept. Self-concept self-concept could be

perceived differently by the different schools. Also, most of the students' performance on the SDMT-4 were higher than average which may indicate that the test was too easy. If the test was too easy then not all of the sample's math skills may have been investigated. When examining the individual school-type composite scores, it was found that 18% of the students in each school-type earned all the points on the math achievement test. None of the students took the suggested time, as stated in the SDMT-4 administration book, to complete either the subtests and the measure as a whole. All students were finished with the SDMT-4 well before the allotted time. If the achievement test was truly not difficult enough than the interpretation of the students' actual skills is limited. Although, the researcher presented the test to the appropriate staff at each school in order to verify that the problems were taught in their curriculum, the researcher did not investigate if there were other more advanced math problem solving that was not covered on the test.

If the SDQ-II and the SDMT-4 are highly reliable and valid then the lack of nonsignificance in the coed sample could be due to the small sample from which the single-sex population was derived (n= 239), compared to the coed pool that came from a larger total school population (n= 799). Such results suggest that the coed sample represented only 9% of its total population whereas the single-sex sample represented 26% of its total population. Due to the larger percent sampling, the single-sex participants may have been a more representative sample of the total single-sex school. It is likely that the smaller percent of participants from the coed school do not represent the typical coed student from the pool of which they participants volunteered. More coed participants may have resulted in higher statistical power, thus more significant findings.

The second and third hypothesis investigated whether math achievement and self-concept were different between the two school-types and between grade groups. Except for those previously mentioned, the results of the present study did not reveal significant findings regarding self-concept. Again, it appears that the limited number of coed participants may have greatly affected the validity of the coed self-concept scores. Although the suggested age appropriate SDQ-II version was utilized, it still may not be sensitive enough to detect these differences among ages. The measure may have needed more detailed items to again separate the students who have moderately positive math self-concept from those that have a extremely poor math self-concept. The SDQ-II, which contained 10 math self-concept questions may have been too limited in scope to have appropriately assessed self-concept. When dealing with such a construct one must also wonder whether it can be defined universally among students' in grades 7 through 12. Bonholt et al., (1988) found that males made higher estimates of their achievement than females; thus it could be that females also may have reported more depressed or middle ground scores with regards to self-concept. Such a report may seem more socially appropriate to girls. Thus, despite instructions, the students in the present study may not have been responding from their own perspective; the students may have responded with a "faking good" response in order to convey an appropriate response that fit an expectation that they perceived. Another reason why the self-concept variable did not have any significant results could be related to the findings of Marsh (1986). His research suggested that individuals may conduct an internal, external, or combination comparison when reporting their academic self-concept.

The investigation of SDMT-4 subtests revealed that on the SDMT-4 math performance in the 7/8 grade group was significantly different than that of grade group 9/10, and 11/12. Investigations of the subtests and school-type revealed students' performance on the Concepts and Application subtest varied as a function of both the student's type of school and the grade group. Specifically, the single-sex sample had significantly lower performance scores in grades 7/8 as compared to 9/10, the coed sample had significantly lower performance scores from grade 9/10 as compared to grade group 11/12. Both samples had significantly lower performance scores in 7/8 as compared to 11/12.

Even though statistically significant differences in math achievement as a function of school-type were not found, qualitative differences were observed. Worth noting that in the school where the single-sex classroom population exists the teachers regularly display themselves as students. Each year as a staff, they chose a topic that all of the members are expected to investigate and share information; thus they learn together. The staff also attends a staff required retreat. It lasts approximately two weeks. During this time period the staff studies various topics daily. For example, they may study calculus from 8 am to 9 am and then study Shakespeare, etc. The staff could be assumed to exude the notion that learning is a love and not a drudgery. Such an attitude over time could be received by students and adopted. Thus, over time the students learn by modeling that learning is an adventure that can be accomplished by all. Students from the single-sex sample often commented on the intensity of the school demands. They were very verbal about the need to study and the hours they studied. There appeared to be more

competition in this school. Since the coed school was so small, it would be more difficult to hide ones successes and failures with ones peers. Students freely stated that they enjoyed the school and some students conveyed a serious interest or career goal (i.e., playing the harp in a symphony). It appeared that the students' interests were validated, thus expounded upon, which may be easier in such a small school. Such individual interests were not seen in the coed population or that population did not so freely share such interests. Interpretations of these findings suggest that in the sample investigated there appeared to be different peaks in math mastery. Although, there is not a significant difference between the school-types, the differences within each sample is worth discussing. Again, such results could be due to the obtainment of only 9% of the coed total sample, and the fact that the math test was probably too easy. The more difficult the math test the greater the distribution of measured sample performance. The interaction and the significant differences within each sample may indicate that those concepts that are assessed on the Concept and Application subtest may have been taught at different grades. For example, in the coed population in which grade 11/12 has significantly higher performance than grade group 9/10 there may be a class within their curriculum that teaches concepts relative to the Concept and Application subtest. Collecting information on the number and type of math classes a students had taken and then controlling for that variable may have altered the present results. Also, there also may be some instructional differences within the grade groups where higher performance was found. Such instructional differences may assist students with specific types of strategies that assisted them in earning higher Concept and Application scores. Not only are math

classes relevant, but so may be other classes that teach incidental concepts that strengthen those skills necessary in the Concepts and Application subtest.

Suggestions for Future Research and for Educators

Due to the noncommensurate findings with previous research, the additional investigation utilizing math, and the noted limitation of the present study further research is needed regarding girls' self-concept and math achievement in single-sex and coed schools. The present study could be replicated with the following recommended changes: larger sample size for both schools, utilization of a more difficult math achievement test (possibly even an individually administered achievement test), and a more comprehensive measure of self-concept. Additional studies should include math achievement tests' subscale scores in order to thoroughly investigate math skills. Other methodological issues should be investigated (i.e., using multiple schools). Intervention studies could be implemented by teaching a group of students purported strategies that increase math self-concept. Those student could then be compared to a control group. Future studies could also include boys in the sample. Another study could include comparing boys' and girls' self-concept and achievement in both school-types.

Due to the inconsistent outcomes in the studies regarding girls' self-concept and math achievement little can be generalized beyond the scope of this study and thus implications for the educator are somewhat limited. Although the correlation between self-concept and achievement in the present study was found to be weaker than past studies, it still suggests that self-concept and math achievement are related. Self-concept measures may be an asset to psycho-educational evaluations. Teachers may also want to

monitor their students' math-self concept since it is related to math achievement. Although limitations in the measurement of math achievement were found in the present study, significant differences in math knowledge at different grade levels were found. The results may reinforce the importance of curriculum development with grades at all schools.

Summary

Results of the study suggest that the way individuals perceive their math ability is related to their actual math performance. Results also suggest that within the school-types, using a normed and standardized achievement measure with subtests suggested that at different grades students knew significantly more math in the area of Concept and Application (story problems). Due to a restrictive sample (particulary in the coed school), a perceived limited distribution of math achievement scores, and positively skewed self-concept scores the present study had limited results. Further research is still needed to investigate girls' math self-concept and math achievement.

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Appendix A1

(To be given to coed students)

Please complete the following questionnaire as accurately as possible:

Subject Number:

Date of Birth:

Age:

Grade:

1. What grade did you begin attending your present school?

2. Have you ever attended an all girl school?

If yes, state in grades how long you attended that school.

Appendix A2

(To be given to students in single-sex classroom)

Please complete the following questionnaire as accurately as possible:

Subject Number:

Date of Birth:

Age:

Grade:

1. What grade did you begin attending your present school?

2. Have you ever attended a school where boys and girls were not taught in separate classrooms?

If yes, state in grades how long you attended that school.

Appendix B

Please complete the following form as accurately as possible.

1. In grades 7 through 12, how many students are enrolled in each grade level?
2. In grades 7 through 12, how many male and female teachers do you have teaching math? Male____ Female_____
3. What is the average family income of your school?
4. What is the number of students receiving financial assistance at your school?
5. What are the requirements to be enrolled in your school?
6. What is the average number of years students attend your school?
7. What percent of your students come from the following types of schools prior to attending your school:

   Private____ Public____
8. How many hours are there in the school day?
9. How many days are there in the school year?
10. What special programs does your school offer (e.g. Title I)?

Table 1

Mean Grade of Participants Based on School-Type and Grade Group

	M	SD	n
7/8 Grades			
Single-Sex	7.70	.47	20
Coed	7.48	.51	25
9/10 Grades			
Single-Sex	9.52	.51	27
Coed	9.19	.40	31
11/12 Grades			
Single-Sex	11.38	.50	16
Coed	11.21	.42.	19

Table 2

Mean Age of Participants Based on School-Type and Grade Group

	M	SD	n	Range
7/8 Grades				
Single-Sex	13.87	.72	20	12.00-14.80
Coed	13.47	.61	25	12.11-14.40
9/10 Grades				
Single-Sex	15.75	.80	27	13.80 - 17.20
Coed	15.10	.62	31	14.10 - 16.10
11/12 Grades				
Single-Sex	16.95	1.28	16	13.00 - 18.60
Coed	17.30	.59	19	16.10 - 18.40

Table 3

SDMT-4 Normed Average Scaled Scores

	C&A	Comp.	Total
Grades			
7	680	693	683
8	693	707	695
9	701	709	704
10	704	711	707
11	712	718	712
12	716	725	719

Table 4

Entire Participant Sample Descriptives on all Administered

	M	SD	n	Range
Block Design	11.96	3.07	138	6.00 - 19.00
Vocabulary	11.96	2.19	138	8.00 - 18.00
SDQ-II	56.64	5.87	138	35.00 - 68.00
C & A	741.07	39.33	138	645.00 - 819.00
Computation	723.42	37.98	138	618.00 - 775.00
SDMT-4	738.46	40.75	138	637.00 - 828.00

Note. Block Design= the nonverbal subtest on the Wechsler Intelligence Scale for Children - Third Edition (WISC-III), Vocabulary = the verbal subtest of the WISC-III, SDQ-II= Self Description Questionnaire is the self-concept measure used in the study, C & A= the Concept Application or story problem portion of the Stanford Diagnostic Math Test Fourth Edition (SDMT-4), Computation= the computation portion of the SDMT-4.

Table 5

Intercorrelations Among Variables within the Entire Sample

	Age	Grade grp	Years At	SDQ	C&A	Comp	SDMT
Age							
Grade grp	.860**						
Years At	-.134	-.165	-				
SDQ	-.127	-.060	-.111				
C&A	.456**	.488**	.029	.194*			
Comp	.310**	.352**	-029	.290*	.620**		
SDMT	.406**	.438**	.062	.226**	.943**	.802**	.073**

Note: Grade grp = the 7/8, 9/10, and 11/12 grade grouping of students; Years At= the years at their present school; BD=Block Design subtest of the WISC-III; Voc= the Vocabulary subtest on the WISC-III; C&A=the Concept and Application portion of the SDMT-4; Comp.= the Computation portion of the SDMT-4; SDMT=SDMT-4; School=the type of school the student attends.

* correlation is significant at the .05 level (2-tailed)

**correlation is significant at the .01 level (2-tailed)

Table 6

Intercorrelations Among Variables within the Single-Sex Sample.

	Age	Grade grp	Years At	SDQ	C&A	Comp	SDMT
Age	-						
Grade grp	.788**	-					
Years At	.742**	.831**					
SDQ	-.202	-.140	-.072				
C&A	.318*	.420**	.333**	.310*			
Comp	.155	.310*	.231	.433**	.568**	-	
SDMT	.263*	.403**	.313*	.380**	. 939**	.777**	

Note: Grade grp. = the 7/8, 9/10, and 11/12 grade grouping of students; Years At= the years at their present school; BD=Block Design subtest of the WISC-III; Voc= the Vocabulary subtest on the WISC-III; C&A=the Concept and Application portion of the SDMT-4; Comp.= the Computation portion of the SDMT-4; SDMT=SDMT-4; School=the type of school the student attends.

* correlation is significant at the .05 level (2-tailed)

**correlation is significant at the .01 level (2-tailed)

Table 7

Intercorrelations Among Variables within the Coed Sample

	Age	Grade grp	Years At	SDQ	C&A	Comp	SDMT
Age	-						
Grade grp	.922**	-					
Years At	-.498**	-624*					
SDQ	-.068	-.009	- .138	-			
C&A	.552**	.542**	- .087	.099			
Comp	.418**	.388**	- .126	.170	.658**		
SDMT	.506**	.467**	- .029	.098	.945**	.820**	-

Note: Grade grp = the 7/8, 9/10, and 11/12 grade grouping of students; Years At= the years at their present school; BD=Block Design subtest of the WISC-III; Voc= the Vocabulary subtest on the WISC-III; C&A=the Concept and Application portion of the SDMT-4; Comp.= the Computation portion of the SDMT-4; SDMT=SDMT-4; School=the type of school the student attends.

* correlation is significant at the .05 level (2-tailed)

**correlation is significant at the .01 level (2-tailed)

Table 8

SDMT-4 by School-Type and Grade Group: Composite

	M	SD	n	Range
7/8 Grades				
Single-Sex	718.75	30.50	20	637.00-762.00
Coed	719.75	42.23	25	644.00-812.00
9/10 Grades				
Single-Sex	747.74	37.87	27	679.00-828.00
Coed	726.52	31.05	31	679.00 - 805.00
11/12 Grades				
Single-Sex	760.19	41.95	16	693.00 - 828.00
Coed	772.26	34.56	19	730.00 -828.00

Table 9

SDMT-4 Computation by School-Type and Grade Group

	M	SD	n	Range
7/8 Grades				
Single-Sex	711.05	35.73	20	626.00-747.00
Coed	706.28	39.86	25	618.00-747.00
9/10 Grades				
Single-Sex	732.37	38.25	27	671.00-775.00
Coed	714.32	35.57	31	654.00 - 7775.00
11/12 Grades				
Single-Sex	741.44	34.25	16	681.00 - 775.00
Coed	745.95	25.48	16	681.00 -775.00

Table 10

SDMT-4 Concept and Application by School-Type and Grade Group

	M	SD	n	Range
7/8 Grades				
Single-Sex	719.55	29.03	20	645.00-754.00
Coed	718.12	39.13	25	661.00-805.00
9/10 Grades				
Single-Sex	752.04	35.68	27	683.00 - 819.00
Coed	731.81	29.71	31	668.00 - 796.00
11/12 Grades				
Single-Sex	760.63	39.37	16	699.00 -819.00
Coed	776.95	31.09	19	733.00 - 819.00

Table 11

SDQ-II Scores by School-Type and Grade Group

	M	SD	n	Range
7/8 Grades				
Single-Sex	58.15	7.17	20	43.00-68.00
Coed	55.88	6.18	25	35.00-64.00
9/10 Grades				
Single-Sex	55.89	5.20	27	47.00 - 64.00
Coed	57.77	4.93	31	48.00 - 66.00
11/12 Grades				
Single-Sex	56.06	5.66	16	47.00 - 65.00
Coed	55.79	6.56	19	44.00 - 67.00

Figure Caption

Figure 1. SDMT-4 Mean scores on the Concept and Application subtest for grade groups in both single-sex and coed class-types.