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Gender-Based Achievement, Self-Confidence, and Enrollment Gaps: Mathematics at Trinity College

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GENDER-BASED ACHIEVEMENT, SELF-CONFIDENCE AND ENROLLMENT GAPS: MATHEMATICS AT TRINITY COLLEGE

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INTRODUCTION

Do gendered achievement, enrollment, and confidence gaps math exist on the college level? If so, are the differences significant? What factors explain the differences and why are the gaps important? Studies show that gender differences in math achievement measures are declining; however gender gaps in math scores continue to exist (AAUW, 1999). Previous studies disproportionately examine sex-based achievement gaps and attitudes towards math in elementary and middle school and suggest hidden curriculums teachers employ in their classrooms disadvantage female students. Research also suggests a significant gap in levels of male and female self-confidence in math ability. Much of the research on this topic is outdated and more data into the into sex-based achievement, enrollment, and self-confidence gaps in mathematics on the college level is needed to further our understanding of why these gaps continue to exist or why they cease to exist and how this may significantly disadvantage one gender from full participation in a technologically advanced society.

Historically, researchers have held differential socialization responsible for gender inequities in mathematics, on every academic level- elementary through college (Campbell & Beaudry, 1998). Data suggests that as students grow older gender differences in math

tend to be more pronounced. In elementary school, gender-based achievement gaps are small or nonexistent. As students approach middle and high school, greater gaps are found in math achievement measures, math participation, and in attitudes towards math in general. In high school more males than females enroll in upper level math classes, significantly increasing the chances that sex-based gaps in math enrollment will continue to exist in college (Campbell & Beaudry, 1998).

REVIEW OF THE LITERATURE

Achievement

Historically, most of the research in this field suggests that the math achievement gap is positively correlated to, and heavily dependent on age. Researchers have also argued that gender differences in mathematic achievement and self-confidence gaps are less pronounced in elementary school than in high school. According to the 2002 Connecticut State Department of Education and No Child Left Behind (NCLB) data, the gender gap in mathematic achievement increases as students get older. Overall, males are more likely to score higher than females in the math sections of the Connecticut Mastery Test (CMT) and Connecticut Academic Performance Test (CAPT). However, male and female CMT math scores (tested in grades four, six, and eight) are more similar than CAPT math scores, (tested in grade ten) suggesting that the achievement gap continues to increase with age.

Enrollment

According to the AAUW Report (1999) there are significant gender-based enrollment gaps in math classes. Data suggests that math participation gaps are shrinking. Female enrollment has rapidly increased in algebra, geometry, precalculus, trigonometry and calculus. According to the AAUW (1999) data, between 1987 and 1997 college-bound female participation in geometry and Algebra II increased at a greater rate than participation for college bound males'.

Although enrollment gaps are shrinking, currently the research suggests that the gaps still exist. College-bound female high school students are disproportionately more likely than college-bound males to cease their mathematics career upon completing Algebra II. AAUW researchers (1999) maintain, "Stopping a math education at this level can close the door on future studies, scholarships, and careers" (AAUW, 1999).

Self-Confidence/Attitudes

Gender-based achievement gaps in mathematics can be explained by teacher-student interactions in the classroom and the lack of self-confidence female students have in their math skills. Research suggests that gender biased instructional techniques in math classrooms serve to systematically disadvantage female math students and their confidence in their math skills (Jewett, 1996). According to the 1992 AAUW Education Foundation, interactions between teachers and students unintentionally convey the message to females that males are better in math and that their questions, comments, and answers are not important (Jewett, 1996). Subtle gender bias in the classroom silence female students by discouraging their participation. "Teachers call on males more than females; ask more complex, cognitively demanding questions; and give males more positive feedback more

often" (Jewett, 1996). Teachers tend to expect less from their female math students and discourage important autonomous learning behaviors in female math students (Fennema & Peterson, 1985). As a result, female students are more likely to doubt their mathematic abilities and score lower on math achievement measures than males (AAUW, 1992; Fennema & Peterson, 1985).

Differential socialization in and outside the classroom encourages autonomous learning behaviors in males and dependent learning behaviors in females (Fennema & Peterson, 1985). Male students are disproportionately provided with lower levels of help than their female peers in the classroom and at home (Campbell & Beaudry, 1998) which tends to encourage self-imposed pressure and persistence in males. Female students are socialized to be more dependent on others for academic help, which serves to negatively affect their self-confidence in their math skills. By the time male and female students reach high school, female self confidence in their math abilities tend to fall significantly below males', creating a confidence gap that tends to persist through high school and into college (Campbell & Beaudry, 1998; Eccles, 1983).

In a technologically advanced society, the sex-based achievement, enrollment and self-confidence gaps in mathematics leaves many American females at a significant disadvantage. To solve this significant social dilemma, educators and law makers have attempted to increase female participation in math by emphasizing preventative instructional techniques and single-sex education.

Instructional Techniques

Casey, Nuttal and Pezaris (2001) suggest that biological factors interact with spatial experiences to account for the gender-based math achievement gap. Various studies focus gender differences in strategies students employ to solve math problems. This study found that males tend to depend on visual-spatial strategies when solving math problems, whereas females tend to use verbal-analytical strategies when solving math problems. This suggests that because females experience fewer opportunities to exercise their spatial abilities outside of school, their potential to possess strong spatial skills is limited unless spatial thinking is specifically targeted within the math curriculum in school. Because curriculums usually emphasize verbal skills (the area in which males tend to need the most help in), spatial skills (the area in which female need the most help in) receive less emphasis. Thus, employing more activities designed to strengthen spatial skills could potentially close gender differences in math performance (Casey, Nuttal, & Pezaris, 2001).

Single-Sex Education

Due to differential socialization within the math classroom, researchers, educators and law makers have lobbied for the potential effectiveness of single-sex education in combating gender-based gaps in math achievement, enrollment and self-confidence.

First passed in 1965, the Elementary and Secondary Education Act (ESEA) is a federal law designed for pre-collegiate education. Amended in 2002 by the Bush Administration, today the ESEA is commonly known as the *No Child Left Behind Act* (NCLB) and plays a critical role in contemporary educational policy. The NCLB act aims to improve schooling for all children by placing rigorous educational standards on every public school in the United States. While the most controversial aspect of NCLB lies in its

stringent and uniform accountability mandates, less consideration is given to a provision in the law which allows local education agencies to use federal funds to institute same-sex schools and classrooms.

Recently, a significant amount of research has focused on the effects of single-sex education on the gender-based achievement and persistence gaps in mathematics (Shapka & Keating, 2003). Shapka and Keating (2003) suggest that there is mixed evidence on whether educating females in single-sex math classrooms has been successful in closing the gaps. Researchers point to the lack of cross-sex socialization and instruction as hindering the development of math skills and argue that single-sex classrooms create a social setting that cannot realistically prepare either male or female students for mixed-gender life outside of the classroom (Shapka & Keating, 2001). In addition, single-sex math classes are almost exclusively offered in private schools, thus restricting access to students from lower income families.

Shapka and Keating (2003) suggest that the positive effects of single-sex education for females may outweigh the negative effects. Females in co-educational environments are exposed to social biases that serve to systematically disadvantage female math students in many ways (AAUW, 1998). Evidence suggests single-sex math classes may decrease gender achievement and enrollment gaps in mathematics there by influencing future occupational choices (Shapka & Keating, 2003). However, examining female-only math classrooms within public high schools, Shapka and Keating (2003) conclude that while single-sex math instruction for females positively affects female performance, single-sex education does not affect female attitudes towards math.

Shapka and Keating (2003), argue that while females, enrolled in single-sex secondary math classes, report similar levels of math anxiety to females enrolled in co-educational math classes, females in single-sex math classes tend to report disproportionately higher levels of math anxiety than males educated in co-educational math classes. While most of the research confirms that there are gender-based achievement and self-confidence, and enrollment gaps in elementary and middle school, little research examines these gaps on a co-educational college level. More research into gendered differences in achievement, enrollment and self-confidence in math on the college level is needed to understand the pervasiveness and durability of gender-based gaps in mathematics.

METHODS

This study is a quantitative and qualitative investigation of gender-based achievement, enrollment, and self-confidence gaps at Trinity College. Due to the lack of evidence on the affects of single-sex education on sex-based gaps in math, this study also focuses on gender differences in math achievement, self-confidence, and enrollment gaps by high school type (single-sex or co-ed).

Quantitative Analysis

The quantitative aspect of this study examines data from the Trinity College mathematics department on first-year students' high school type, SAT-Math scores and Trinity College Quantitative Reasoning Test scores. The study also examines gender-based

enrollment gaps by looking at participation in math classes by sex and class year, and the breakdown of Trinity math majors by gender.

Qualitative Analysis

In addition, this study involves administering a questionnaire to a random sample of twenty Trinity College students (first-year through senior-year) concerning students' perceptions of gender-based achievement, enrollment, and self-confidence gaps in mathematics at Trinity. Participants will be asked to complete a 30-item, 5-point (1-Strongly agree, 2-Agree, 3-Neither agree nor disagree, 4-disagree, 5-Strongly disagree) Likert-format questionnaire intended to measure perceptions of gendered gaps in math, students' confidence in their math skills, and students' experiences with math and visual-spatial reasoning. Completed questionnaires will be examined for any correlations or discrepancies between Trinity students' answers and the data obtained from the Math Center and previous literature on research on gender-based achievement, enrollment, and confidence gaps in mathematics.

THESIS

Based on previous research and existing literature, this study proposes a three-part thesis: (1) Gender gaps in math achievement, enrollment and self-confidence continue exist at Trinity; (2) Female Trinity students from single-sex high schools do not score significantly higher on measures of math achievement ; (3) significant gender-based gaps in math achievement, enrollment, and self-confidence gaps suggest that female Trinity students are not as quantitatively literate or self-confident in mathematics as male Trinity students.

RESULTS

All data for the quantitative analysis section of this study was obtained from Charlotte Gregory, Assistant Director and Lecturer in the Aetna Life and Casualty Foundation of the Trinity College Mathematics Center. All data is confidential and the names of the students whose scores are used in this study were coded numerically to ensure students confidentiality. The data obtained for the qualitative analysis section on this study was obtained from surveys administered to a random sample of 20 Trinity College students. Participants' identities remained confidential.

Quantitative Data

Achievement Evidence

Out of 268 Male first-year Trinity students and 257 female first-year Trinity students, males score disproportionately higher than females on all measures of mathematic achievement (SAT, Trinity College Quantitative Reasoning Exam). In addition, female Trinity students from single-sex high schools scored the lowest on all measures of achievement. The data on mathematic achievement supports the first two parts of the study's thesis: (1) gender gaps in math achievement continue to exist at Trinity College; (2) Female Trinity students from single-sex high schools do not score significantly higher on measures of math achievement.

Figure I. Gender & High School Type (Single-Sex, Co-Educational)

HIGH- SCHOOL TYPE	MALE	FEMALE
Single-Sex	31	28

Co-Ed	237	229
Total	268	257

Figure II. SAT Math Scores

SAT MATH (800)	MALE	FEMALE
Single-Sex	651	625
Co-Ed	638	628
Avg. Score	650	627

Figure III. Math SAT and Gender & High School Type

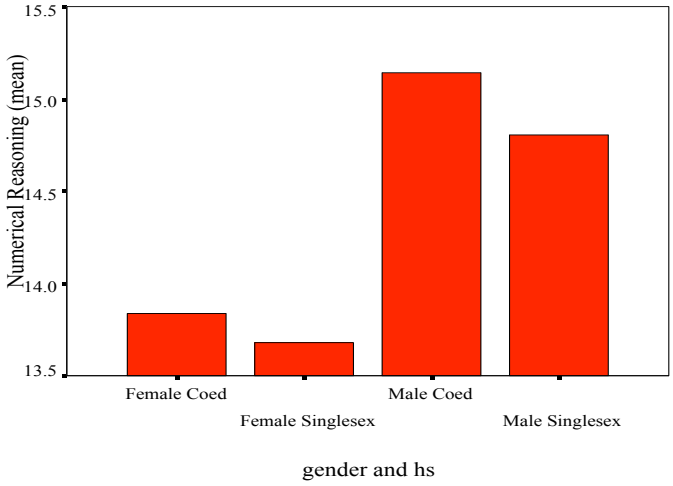


Figure IV. Qualitative Reasoning Test (Numerical Reasoning, Statistics, Algebra, Logic)

SECTION	MALE	FEMALE
Numerical Reasoning (20)		
Single-Sex	15	14
Co-Ed	15	14
Avg. Score	15	14
Statistics (10)		
Single-Sex	7	6
Co-Ed	7	7
Avg. Score	6	6.5
Algebra (20)		
Single-Sex	15	14

Co-Ed	15	14
Avg. Score	15	14
Logic (10)		
Single-Sex	6	5
Co-Ed	6	5
Avg. Score	6	5
Total Score (60)		
Single-Sex	42	39
Co-Ed	43	40
Avg. Score	43	40

Figure V. Numerical Reasoning and Gender & High School Type

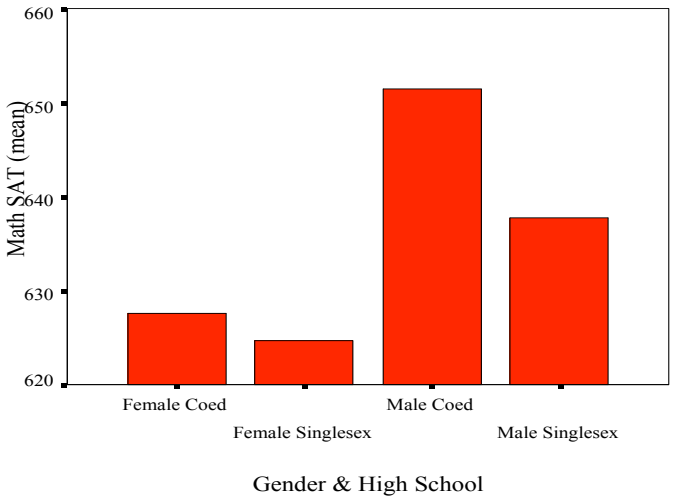


Figure VI. Proficiency Score (0-4)

PROFICIENCY (0-4)	MALE	FEMALE
=0		
Single Sex	2	5
Co-Ed	31	37
Total	33	42
=1		
Single-Sex	5	7
Co-Ed	20	42
Total	25	49
=2		
Single-Sex	8	4
Co-Ed	42	48

Total	50	52
=3		
Single-Sex	9	7
Co-Ed	81	57
Total	90	64
=4		
Single-Sex	7	5
Co-Ed	63	45
Total	70	50

Enrollment Evidence

The data obtained on enrollment in math classes at Trinity suggest that there continues to be a gender-based gap in math enrollment at Trinity College. Out of approximately 1,900 Trinity students enrolled for the 2004-2005 academic year, 331 of males (17%) and 266 of females (14%) were enrolled in a math course during the first quarter of the first semester. The most significant gender gap in math enrollment is in Math 107, Elements of Statistics of which approximately 9.8 % of current Trinity students (and) were enrolled in. Out of all students who took a math class this semester, 34.8% of males and 28% of females were enrolled in Math 107. One possible explanation of why 9.8 % of all current Trinity students are enrolled in Elements of Statistics is that Math 107 is a required course for more than just the math major. Many social science majors also require Elements of Statistics, including Economics, which research suggest is also a male-dominated field of study.

Figure VIII. Enrollment in Trinity College Math Classes by Gender

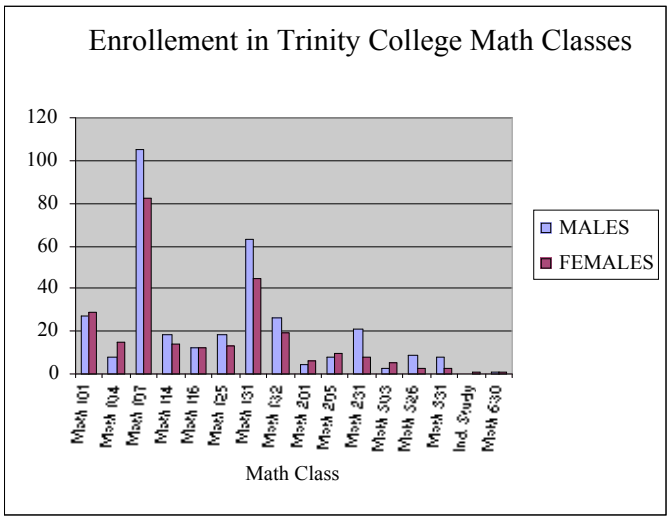


Figure VII. Sex-Base Enrollment in Math Classes at Trinity College

MATH CLASS	MALES	FEMALES
Math 101	27	29
Math 104	8	15
Math 107	105	82
Math 114	18	14
Math 116	12	12
Math 125	18	13
Math 131	63	45
Math 132	26	19
Math 201	4	6
Math 205	8	10
Math 231	21	8
Math 303	3	5
Math 326	9	3
Math 331	8	3
Ind. Study	0	1
Math 630	1	1

Qualitative Evidence

Self-Confidence Evidence

The data obtained from the survey administered to a random sample of 20 Trinity College students (10 males and 10 females) suggest that male Trinity students

disproportionately show a higher level of self-confidence in their math abilities than female Trinity Students. Question # 17, "I am good at balancing my checkbook," was omitted because of the lack of responses to the question. One possible explanation for this is that the participants who neglected to answer this question, or simply replied "N/A" is that they do not have a checkbook which they balance. Out of 20 participants, only 6 participants answered this question.

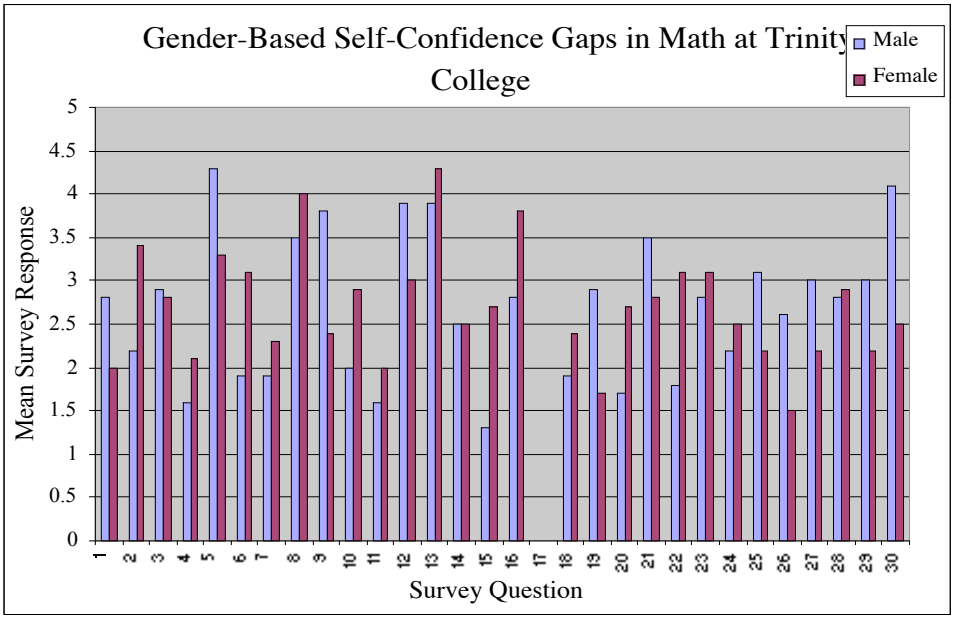
The most interesting and significant difference between male and female responses was the responses participants gave for question # 30, "My math skills are better than average." The mean response for male participants was 4.1, signifying that on average male participants agreed with this statement. The mean response for female participants was 2.5, signifying that on average female participants disagreed with this answer.

Two additional questions that elicited significant differences between male and female responses were questions # 9, "I am good at solving puzzles and other visual games (ex. Checkers, Backgammon, Chess)," and # 15, "I am band at assembling things together." On question 9 the mean response for males was 3.9 (agree) and the mean response for females was 2.4 (disagree). On question number 15 the mean response for males was 1.3 (strongly disagree) and the mean response for females was 2.7 (somewhat agree). Both questions address participants' confidence in their visual-spatial reasoning, a skill research suggests males tend to rely on and exercise more so than females (Casey, Nuttal, & Pezaris, 2001). Based on participants' responses to both answers, male participants tend to express more confidence in their visual-spatial reasoning skills, which supports existing research on gender-based gaps in self-confidence in math ability.

The only question that elicited the same mean response for male and female participants was question # 14, “My friends tend to be better at math than me.” The mean score for both groups of participants was 2.5, suggesting that the male and female students surveyed tend to disagree with this answer. One explanation for this similarity is that Trinity student are aware that if their friends are significantly gifted in mathematics, there is a chance that they would attend a different university. As a liberal arts college, Trinity prides itself on the diverse curriculum it offers its students. Trinity is not an institution which specializes in any one area of study, including mathematics. Responses to this answer suggest that both the male and female participants in this study are confident that their piers are not significantly better in math than they perceive themselves to be.

Figure IX. Survey Answers by Gender

Question	Male	Female	Question	Male	Female
1	2.8	2	16	2.8	3.8
2	2.2	3.4	17	NA	NA
3	2.9	2.8	18	1.9	2.4
4	1.6	2.1	19	2.9	1.7
5	4.3	3.3	20	1.7	2.7
6	1.9	3.1	21	3.5	2.8
7	1.9	2.3	22	1.8	3.1
8	3.5	4	23	2.8	3.1
9	3.8	2.4	24	2.2	2.5
10	2	2.9	25	3.1	2.2
11	1.6	2	26	2.6	1.5
12	3.9	3	27	3	2.2
13	3.9	4.3	28	2.8	2.9
14	2.5	2.5	29	3	2.2
15	1.3	2.7	30	4.1	2.5



CONCLUSION

According to the National Council on Education and the Disciplines, it is vitally important that as a country we acknowledge "the rapidly increasing uses of quantitative thinking in the workplace, in education, and in nearly every other field of human endeavor." Without quantitative literacy, our country would be left behind in a fast advancing technological world. "Academic Mathematicians point out that the quality and quantity of mathematics students who received their secondary and college mathematics education in the United States have reached dangerously low levels" (Wade, Ellis, Jr.). Existing research and the data obtained in this study suggest that our country has already left a significant population of Americans behind. At Trinity College females continue to fall behind males in quantitative performance and participation in math classes, while exhibiting lower levels of confidence in their math skills. It is crucial that researchers examine this issue further in order to get to identify were this significant social dilemma originates and how pervasive it truly is.

Based on the data obtained from this study, it is clear that the gender gaps in quantitative literacy, enrollment in math courses, and self-confidence in math skills continue to exist up to and through the college level. The results of the study support parts 1, 2, and 3 of the study's thesis and suggest that there are significant gender-based achievement, enrollment, and self-confidence gaps in mathematics at Trinity. The results also suggest that single-sex education does not advantage female Trinity students educated in single sex environments over female Trinity students educated in co-ed environments. Disproportionate gender-based gaps in math achievement, enrollment, and self-confidence gaps imply that females at Trinity College are not as quantitatively literate or self-confident in mathematics as male at Trinity College. "As our society is driven increasingly by science and technology the need to establish levels of quantitative literacy becomes ever more important" (Rita Colwell). More research on the college level is needed to further our understanding how females are significantly disadvantaged in a technologically advanced society where quantitative literacy is more important than ever before.

LIMITATIONS

There are various limitations involved in this study. Due to the fact that Trinity College is a liberal arts institution, we must acknowledge that most students do not come to Trinity to specialize in math. Also, it is important remember that the results are based n Trinity student's scores and responses only. Although the data is suggestive of gender-based gaps in general, this research project only examines gender-gaps in math at Trinity.

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