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Where are the girls? Gender differences in secondary science and math grades

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Where are the Girls? Gender Differences in Secondary Science and Math Grades

by

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ABSTRACT

To investigate gender differences in secondary science and math grades, I used a cumulative numerical grade, a method to reduce a single student's many grades into a single number. Subjects were 640 students, who graduated from two small, mid-west high schools from the years of 1986-1993. Gender differences in cumulative numerical grades were not continuously supported in single class tests, in single school tests, or combined school tests. There were instances gender differences in cumulative numerical grade were upheld, however. A definite interaction was evident between math and science cumulative numerical grades. The differences between male and female cumulative numerical grades were found to fluctuate over the time of the study.

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Chapter 1

Introduction

The differences between males and females have been studied and investigated throughout history. These differences have shaped history, especially in the arena of education. An example of this was seen in Europe during the 1700's when women were not allowed to even enroll in schools of higher learning. The roles of males and females have slowly changed. The act of telling a woman that she can not enroll in an institution of higher learning has become an unheard of event in the United States.

Women are encouraged to enroll in any line of study. High school is a time for students to be exposed to many different content areas. The grades received by students in high school may influence their future choice of study. This study looked at the difference in grade scores received by males and females in high school. The performance of females in the science and math content areas has been studied in recent years. This inquiry has led to a recognition of a gender difference in science and math content areas.

Holmes (1991) found three percent of women compared to 19 percent of men choose engineering as a major. Since 1970 the performance gap between the sexes in science increased at age nine

and more than doubled at age 13, according to trend data from National Assessment of Educational Progress (Holmes, 1991). This gap showed males' performance was at a greater level than females' performance. In 1991, men averaged 497 on the math section of the Scholastic Aptitude Test while women averaged 453 (Holmes, 1991). As a science and math teacher, these numbers made me wince.

The purpose of this study was to determine whether there are differences between genders in terms of their secondary science and math grade scores. The definition of gender differences for this study was a separation between males and females on a given standard. For example, a gender difference exists for height. The average male is 7% taller than the average female (Moir, 1989). My interest in this study came from a multitude of sources, including college, teaching, and work experience at a research and development company.

College was where my interest about gender differences in math and science began. I spent three years studying electrical engineering at a small college in the mid-west. The male-to-female ratio at that small college at that time was 3.5 to one. After classes started my second fall semester, I spoke with a friend of mine who was almost ready to graduate. I asked him the question, "Where are the girls?" His answer was that I should be prepared for

all male classes from this point forward. My friend continued that if finding girls at this college was my goal, then I needed to switch majors to the biological sciences. In those courses, males still outnumbered females according to enrollment figures, but not to the extent that they did in engineering.

Why would male enrollment outnumber female enrollment at this one college to such an extreme? At the time, I gave the same answer most of my fellow male-engineers-to-be would have given-that males are just better than females at science. This was simply an uninformed opinion.

Another source of curiosity came from my high school teaching experience in 1991. The Advanced Algebra students I was instructing decided to split into two groups, an accelerated group and a normal-paced group. The accelerated group decided to increase their learning pace due to upcoming standardized testing. I agreed to split the students, but with the following provision. Attendance in the accelerated group was by teacher invitation only. When I invited a group of 4 males, they all accepted. When I invited a group of 3 females, however, they all declined. I was surprised by the girls' reluctance to join this accelerated group since they were all fine students with a true aptitude for math as shown by their previous achievement on tests and regular homework assignments.

In 1992 I was employed with a company involved in research and development, a common area in which scientists and engineers work. The 10-to-one male-to female-ratio of engineers and scientists at this company made me question why the males outnumbered the females.

Campbell (1986) determined that women make up five percent of the nation's scientists and less than five percent of the practicing engineers. The number of males employed in scientific or engineering fields is clearly much larger than the number of females. The idea that males are just better than females at science was just my opinion. The large difference in employment numbers is, however, a fact.

The large difference in the number of males versus females involved with science and math has been a cause of concern for society. The amount of study devoted to gender differences in math and science over the past twenty years is an indicator of this concern. Gender differences in math and science do exist. If these differences are due to environment, and can be changed, then they need to be explored.

Another consideration is one for the schools. A student's choice of an area of study and employment may be affected by his or her expectations and experiences in high school science and math.

As stated earlier by Holmes (1991), three percent of women compared to 19 percent of men choose engineering as a major. This discrepancy needs to be addressed by the schools to maintain equal opportunity for everyone. The right to equal opportunity in education and employment is a concern for all schools. If gender differences in science and math grades are affecting females' ability to achieve in the science and math fields, schools need to find a way to overcome these differences to maintain an equal opportunity for all students.

This is why I, and others, have an interest in this topic. In my opinion, the school's main method of communicating with students, parents, and the community at large is the grade reports given by teachers. The question addressed in this study was to determine if year nine through 12 math and science grade results would show any gender differences, and if so, whether these differences were static or fluctuating over time. A second part of this question was to determine the direction of the differences. If the differences were fluctuating, then were the differences becoming larger or smaller. If the differences were static, then were both sexes improving, staying the same, or were both sexes declining in their grade scores.

Chapter 2

Review of Literature

A review of the literature concerned with gender differences in, or related to, education showed that gender differences do exist in both areas. The methods and procedures of the studies differed, but most agreed that differences, in one form or another, were statistically supported. This review of literature was split into two areas. The first dealt with educational gender differences in general. The second deals with the more specific areas of gender differences in math and science education.

Educational Gender Differences in General

Standardized Testing

A common area for study were differences in standardized testing figures. Scholastic Aptitude Test (SAT) numbers were referred to earlier in this study by Holmes (1991). Standardized testing numbers were found in *Failing at Fairness* , a book by Sadker and Sadker (1994). The Preliminary Scholastic Aptitude Test (PSAT) is a standardized test taken by high-school students in October of their junior year. The results of the PSAT are also used to help pick Merit Scholarship semifinalists. PSAT scores for males are higher

than females, hence, 2 out of 3 Merit Scholarship semifinalists are male. This ratio exists even after the developer of the PSAT "... rigs the scoring in an attempt to reduce the gender gap. The developers of the PSAT count the verbal section twice (traditionally an area of female dominance) and the math section once when reporting results" (Sadker and Sadker, 1994, p. 139). This still does not reduce the gap to equality with 18,000 males reaching the highest PSAT categories, while only 8,000 females attained these categories in 1991 (Sadker and Sadker, 1994).

The SAT is the next standardized test for many of these students, and the gender gap continues. Male SAT scores in 1991-1992 were 50-60 points higher than those of females (Sadker and Sadker, 1994). The differences on standardized testing scores continue into college. The standardized test for college graduates to enter graduate school is the Graduate Record Exam (GRE). The 1987-1988 GRE results showed males scoring 80 points higher than females in math, 21 points higher in the verbal section, and 26 points higher in the analytical section (Sadker and Sadker, 1994).

Piagetian Reasoning Ability

Another common area of study for gender difference researchers was reasoning ability. These studies broke reasoning

ability into the two levels of concrete and formal. These Piagetian tasks are good predictors of success with scientific tasks. A study conducted by Shemesh (1990) was concerned with gender differences in the formation of formal reasoning skills. Students from the seventh through the ninth grade were assessed for their level of mastery of formal reasoning skills. A videotaped group test was used in intact classes. The videotaped group test consisted of twelve tasks, two from each of the following: conservation of weight and displaced volume, control of variables, proportional reasoning, probabilistic reasoning, combinational analysis, and recognizing correlations. The subjects' mean scores on the videotaped group test were analyzed with t-test and ANOVA routines. The findings of this study found gender differences in the performance of formal reasoning tasks. Males mastered formal reasoning skills earlier and to a greater extent than females.

A study by Graybill (1975) also explored the acquisition of formal operations. This study found gender differences in the age that formal operations were obtained. This study involved children between the ages of nine and 15 solving the following four Piagetian tasks: Equal Angles, Floating Bodies, Separation of Variables and Chemical Combinations. The results showed males obtaining formal operations about age 13 with the females lagging behind.

An investigation by Hernandez, Marek, and Renner (1984) involved 70 males and 70 females 16.25 to 17.25 years of age. The subjects were tested on their ability to correctly solve four Piagetian tasks: (1) Conservation of Volume, (2) Separation of Variables, (3) Equilibrium in the Balance, (4) Combination of Colorless Chemical Liquids. The study tested the relationship between gender and intellectual development. Intellectual development was broken into four groups: early concrete, late concrete, early formal, and late formal. The results showed a higher level of intellectual development in males than in females.

A study conducted by Howe and Shayer (1981) showed a gender difference on a task of volume and density. These results had males performing at a higher level than females. After a period of instruction, both males and females performed at a greater level on the task. However, the difference between the two sexes remained the same.

An examination of 778 students in the 7th, 9th, and 11th grades by Linn and Pulos (1983) investigated the role of aptitudes and experiences in gender differences in scientific reasoning. This study used a scientific reasoning task called Predicting Displaced Volume which was solved more often by males. Students were given four strategies for solving this task, one of which was correct.

Males used the correct strategy more often than females.

The previous studies were a sampling of the numerous investigations into gender differences. The majority of the studies found gender differences. The rest of this review addresses gender difference studies in math, math and science, and science.

Gender Differences in Math and Science

A study conducted by Sherman (1980) was concerned with cognitive skills and attitudes toward math. In grade eight, males and females were similar in their cognitive skills and attitudes. In grade 11, however, males performed significantly better in math. The attitudes toward math of females decreased in relation to the attitudes of males during this time.

An investigation conducted by Stanley and Benbow in 1980 (Moir, 1989) involved highly gifted students of both sexes. The results of this study showed for every mathematically exceptional female there were more than 13 mathematically exceptional males. This study also reported that the most exceptional female never performed at a greater level on math performance tests than the most exceptional male.

In an article by Reyes and Padilla (1985), further figures concerned with math and science gender differences were supplied.

A meta-analysis of almost 300 studies showed the achievement of males in elementary school was just slightly better than females with an effect size of 0.04. The effect size, a difference stated in standard deviation units, had increased by middle school to 0.32.

In the introduction to the book *Science for Girls?*, Kelly (1987) presented some interesting figures. The author compared the percentages of males versus females passing selected science courses. These numbers showed the percentage of males passing physics class was larger compared to the percentage of females. These figures showed the same results for chemistry class. However, the percentage of females passing biology class was larger than the percentage of males. The author also compared the magnitude of the difference between the percentages of males and females passing these classes. For example, if 53% of females passed biology while 36% of males passed biology, then the magnitude of the difference between the percentages of males and females passing biology would be 17. The magnitude of the differences between the percentages of males and females for: (1) physics were largest, (2) biology were smaller, (3) chemistry were smallest. This data was for each year from 1966 through 1984. The magnitude of the differences between males and females passing these courses was constantly changing from year to year.

A study conducted by Jones (1991) on gender differences in science competitions showed there was a significantly greater number of males participating in the science fairs studied. Males tended to have a greater participation in the physical sciences, while females tended to have a greater participation in the biological sciences.

An investigation by Vockell and Lobonc (1981) showed that only the physical sciences, and not the sciences in general, are considered masculine by high school students. These results were more likely to occur in coeducational schools rather than female-only schools. This study was completed in four coeducational public schools and four female only private schools. The study involved students filling out a questionnaire rating career fields as masculine or feminine. The subjects were 280 girls and 329 boys in the coeducational schools and 476 girls in the female-only schools.

An examination that involved 300 incoming freshmen college students was conducted by Ware, Steckler, and Leserman (1985). The subjects were evenly split 150-150 male and female. Both groups were predisposed toward science with nearly identical SAT scores and number of high school science and math courses completed. At the end of the freshmen year, 69% of males chose science related fields, while only 50% of females chose these fields.

This difference was significant at the 0.05 level.

A study by Erickson and Erickson (1984) involved the British Columbia Science Assessment. This test was administered to all students attending school the day the test was given. The subjects were students in grades four, eight, and 12. The students' understanding of scientific knowledge and ability to apply scientific knowledge was tested. The results showed males outperformed females in physics, chemistry, and earth/space science at all three grade levels. The largest difference between scores occurred in the 12th grade.

An investigation by Steinkamp and Maehr (1984) was a meta-analysis of studies using some measure of motivation and achievement in science. The results of this study showed that gender differences in both motivation and achievement do occur. These differences tend to favor males.

A study by Kahle and Lakes (1983) analyzed the 1976-77 National Assessment of Educational Progress survey of science attitudes. This analysis was concerned with motivation and experience of nine, 13, and 17 year old students. The results showed females at age nine had similar or greater desire to participate in science related activities, but these girls had fewer science related experiences in their past than nine year old males. At age 13 and 17,

the girls' desire to participate had declined, and they still had fewer experiences than the same aged males.

In summary, a review of the literature concerned with gender differences led to many conclusions: (1) Gender differences in science do exist. The studies cited all describe a difference between the sexes in some area. (2) These differences in science favored males. The studies by Jones (1991), Howe and Shayer (1981), Shemesh (1990), and Graybill (1975) all pointed toward these differences favoring males. These studies coupled with the figures about employment from Campbell (1986) and the figures about testing from Holmes (1991) led to this conclusion. The studies by Kelly (1987) and Jones (1991) showed the magnitude of these differences were varied for the particular science subject being studied. The biological sciences tend to have a smaller difference than the physical sciences. (3) Gender differences exist in math and tended to favor males. The studies by Sherman (1980), Moir (1989), and Sadker and Sadker (1994) led to this conclusion. The larger gender differences in the physical sciences may have a root in the math gender differences. (4) Gender differences were not stable over time. The studies by Sherman (1980), Reyes and Padilla (1985), Kelly (1987), and Sadker and Sadker (1994) led to this conclusion.

The preceding conclusions were all reached through a review of the literature that pertained to gender differences. The review of literature showed gender differences exist, but grade reports were not used as a research tool. The grades received by students, in my opinion, is the major communication method for teachers and schools. If this main communication method is also showing gender differences, then parents and others may become more aware of gender differences.

Chapter 3

Methods and Procedures

The focus of this study was to determine if these differences would be significant in the science and math grades received by graduating students for grades nine through 12. The questions and hypotheses used to test this focus follow.

Questions and Hypotheses

The research questions for this study included the following:

(1) Will gender differences appear in math and science grades for graduating students for their ninth through twelfth years of school? [Q1]

(2) Will an interaction between math and science grades be evident for these students? [Q2]

(3) What trend will the differences follow over time? [Q3]

These questions led to the following null hypotheses:

(1) There will be no significant differences between male and female science and math CNG in single year tests. [$H_0$1]

(2) There will be no significant differences between male and female science and math CNG in single school tests. [$H_0$2]

(3) There will be no significant differences between male and

female science and math CNG when all the CNG are combined. [$H_0$3]

(4) There will be no significant interaction between math and science CNG. [$H_0$4]

(5) The differences between male and female average CNG will remain static over the time of the study. [$H_0$5]

These null hypotheses led to the following research hypotheses that were investigated in this study:

(1) Male CNG will be significantly greater than female CNG in single year tests at each school in both math and science. [H_R1]

(2) Male CNG will be significantly greater than female CNG in single school tests in both math and science. [H_R2]

(3) Male CNG will be significantly greater than female CNG when all the CNG are combined. [H_R3]

(4) There will be a significant interaction between math and science CNG. [H_R4]

(5) The differences between average math and science CNG will fluctuate over the time of the study. [H_R5]

This study was an ex post facto study using archival grade records obtained from two small, rural schools in the mid-west which were then converted into cumulative numerical grades. The five research hypotheses were tested by the Statistical Package for

the Social Sciences (SPSS) program. A definition section precedes a list of the hypotheses tested in this study.

Definitions

ANCOVA: Analysis of Covariance (ANCOVA) is a method for the comparison of means in order to decide if some statistical relation exists between variables after the effects of one or more covariates are removed.

ANOVA: Analysis of Variance (ANOVA) is a method for the comparison of means in order to decide if some statistical relation exists between variables.

CNG: A cumulative numerical grade (CNG) is assigning the grades received by students a numerical value and then adding these values together. The basis for this measure was the grade point average (GPA) used by colleges. GPA is calculated by assigning a student's grades a number, summing these numbers, and then dividing by the total number of grades. The difference between CNG and GPA is the division by the total number of grades. This division is not done in CNG. The values were based on an entire year's work in one class. If a student enrolled in more than one science or math class in one year, that student received two scores for that year. Each score was summed into the cumulative numerical grade. These

values were the average of two semester grades. The scores for the four years of high school were then added together. The archival grade records used for this study expressed grades in two ways, letter grades and percentages. If the grades were expressed as letters, they were given the assigned value: one for an F or below, two for a D, three for a C, four for a B, and five for an A. If the grades were given in percentages, then the scale was as follows: 72% and lower were assigned one, 73%-79% were assigned two, 80%-86% were assigned three, 87%-93% were assigned four, 94%-100% were assigned five, and if no class was taken a zero was assigned. An example for a student graduating in 1990:

Table 1

Year	1st semester	2nd semester	Average
86-87	A	B	4.5
87-88	90	85	3.5
88-89	F	0	0.5
89-90	D,A	F,A	1.5,5.0
			CNG=15.0

As can be seen by the illustration above, each year had an average grade for a single class. These averages were then added together. All science and math classes taken by the subjects were

counted to eliminate any bias for those students who were taking college preparatory classes. This study was designed to view all students equally, regardless of their post-high school goals. This system was chosen as a method of combining the many grades for a single student into a single score.

F-statistic: A random variable formed from the ratio of two independent variables, each divided by its degrees of freedom. The mathematical computation for the F statistic is shown in the appendix.

Interaction: Interactions were differences due to the unique combination of variables.

Significant: The probability of the null hypothesis being true is equal to or less than 0.05.

Subjects

The subjects of this study were the graduating students of two high schools. The schools were selected because the author was familiar with and known at these schools. A sample of 20 males and 20 females from each year from each school was gathered covering the years from 1986-1993. The sample was selected by placing the records for a particular graduating class on a table in alphabetical order. Each record was then selected from the top of this pile. To

assure a random selection of records, a die was rolled to determine if a specific record would be kept or discarded. An odd roll of the die excluded a record, while an even roll included the record. This was continued until the specified number of records were obtained. The number of records for each class was determined by dividing the smallest graduating class size by two and then rounding down to the nearest 10. The sizes of the graduating classes ranged from 86 to 173 students. Special education students were removed from the population. This was accomplished by simply viewing the section of each record labeled "TRACK". If the entry in this section was "SPECIAL", the record was removed from consideration since special education students' grades may have been assigned for classes taken outside the curriculum available to the student population at large.

Procedures

In order to determine if CNG gender differences existed, the CNG for each graduating class was compared using the ANOVA routine contained in the SPSS package. This routine, used to test the first three research hypotheses, can determine if differences between male and female CNG are statistically supported. The ANOVA routine is a way to compare group means to see if differences occur. The t-test could have been used for this test, but

the t-test and ANOVA routines for an independent variable with two levels are exactly the same test. The ANOVA routine was used rather than the t-test because of a personnel preference of this researcher. The fourth research hypothesis was tested by running the ANCOVA routine from SPSS to determine if the math and science CNG had an interaction. The ANCOVA routine was used here because if an interaction had not been supported, then a test of science CNG with a math CNG as a covariate, and vice versa, would be possible. The fifth research hypothesis was tested by running a simple regression program to determine the lines of best fit for the average CNG for each year from each school. The slopes and Y-intercepts for each group were then compared. This test was run to determine the general direction of average science and math CNG for males and females.

Chapter 4

Results

The results of this study showed the research hypotheses stating male cumulative numerical grades (CNG) would be significantly greater than female CNG in single year tests at each school in both math and science [H_R1], male CNG would be significantly greater than female CNG in single school tests in both math and science [H_R2], and male CNG would be significantly greater than female CNG when all the CNG are combined [H_R3] were not supported.

Research hypotheses stating that there would be a significant interaction between math and science CNG [H_R4], and that the differences between average math and science CNG would fluctuate over the time of the study [H_R5] were supported. How these conclusions were reached will be handled in the order the hypotheses were presented.

Research hypothesis one stated male CNG would be significantly greater than female CNG in single year tests at each school in both math and science [H_R1]. The results showed statistically greater CNG for males in science happening only once in

1987 at school A and twice at school B in 1987 and 1992. Table 2 shows the results for each year.

The second half of the first research hypothesis was that males would outperform females each year in math CNG. This occurred only once in 1992 at school B (F(1,38)=4.61, p<.05). The other years tested showed results similar to those shown below. The results of these tests did not support this research hypothesis.

Table 2

SCHOOL A SCIENCE

	Males(n=20)		Females (n=20)		Statistics
YEAR	x	S	x	S	F(1,38)
1986	10.65	7.21	11.18	7.13	0.05
1987	14.75	5.74	10.62	6.44	4.57*
1988	10.50	4.41	11.98	4.43	1.11
1989	9.48	5.97	10.37	6.00	0.22
1990	12.08	6.63	9.60	4.54	1.90
1991	13.03	7.95	13.12	4.91	0.00
1992	14.63	7.30	14.10	4.43	0.07
1993	12.40	6.16	14.98	6.42	1.67

Table 2 continued

SCHOOL B SCIENCE

	Males(n=20)		Females (n=20)		Statistics
YEAR	x	S	x	S	F(1,38)
1986	9.98	5.74	8.05	5.53	0.29
1987	10.83	7.52	6.53	2.51	5.88*
1988	8.52	8.52	9.27	4.67	0.28
1989	11.37	5.72	9.32	5.12	1.42
1990	11.65	5.33	9.85	4.46	1.34
1991	11.17	6.95	12.65	5.01	0.59
1992	13.03	6.58	9.28	4.67	4.32*
1993	12.05	6.61	11.57	5.74	0.06

x=mean CNG, S=standard deviation, *=significant at .05 level

The second research hypothesis tested in this study stated male CNG would be significantly greater than female CNG in single school tests in both math and science [H_R2]. In science, the results for school A showed this hypothesis was not supported. The same results were also shown in math. School B showed support for this hypothesis, however. Table 3 below shows the numerical results.

Table 3

SCHOOL & SUBJECT	Males (n=160) x	Males (n=160) S	Females (n=160) x	Females (n=160) S	Statistics F(1,318)
A SCI	12.19	6.60	11.99	5.79	0.08
A MATH	10.62	5.04	10.22	4.74	0.53
B SCI	11.07	6.17	9.56	5.03	5.72*
B MATH	9.45	5.60	8.25	4.67	4.26*

x=mean CNG, S=standard deviation, *=significant at .05 level

The third research hypothesis stated male CNG would be significantly greater than female CNG when all the CNG were combined [H_R3]. This hypothesis was supported for math and supported at a lesser confidence level for science. Table 4 shows the numerical results for this test.

Table 4

	Males (n=320)		Females (n=320)		Statistic
SUBJECT	x	S	x	S	F(1,638)
SCI	11.63	6.41	10.78	5.55	3.22**
MATH	10.03	5.35	9.24	4.80	3.90*

x=mean CNG, S=standard deviation,
*=significant at .05 level, **=significant at .07 level

The fourth research hypothesis tested in this study stated there would be a significant interaction between math and science CNG [H_R4]. Each test showed a statistically significant probability <0.001 of the null hypothesis being true. This test showed a definite math and science CNG interaction.

The fifth research hypothesis tested stated the differences between average math and science CNG would fluctuate over the time of the study [H_R5]. The slopes of the lines of best fit on the yearly average CNG were compared to test this hypothesis. This hypothesis was supported due to the unequal slopes of the lines of best fit. Table 5 shows this data.

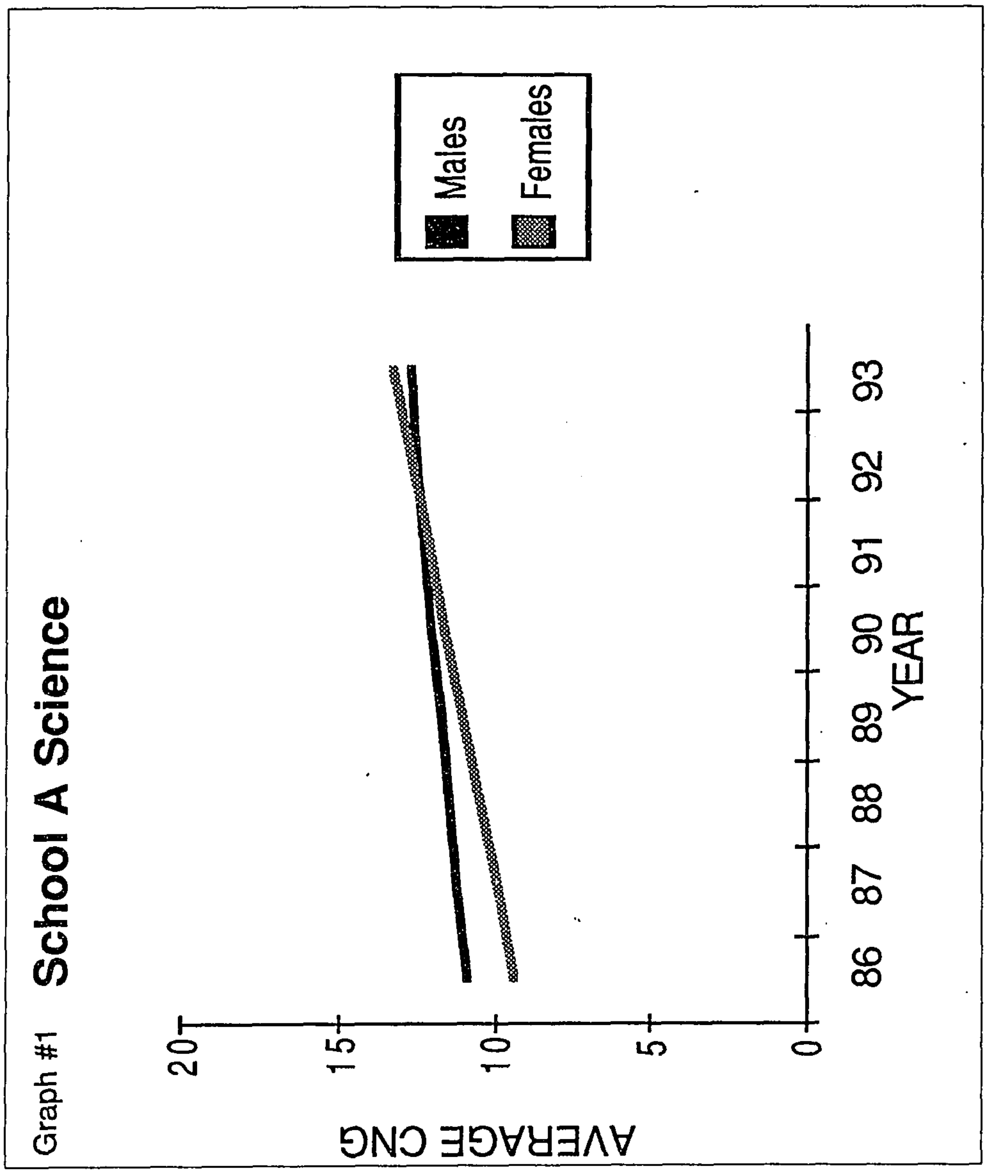
Table 5

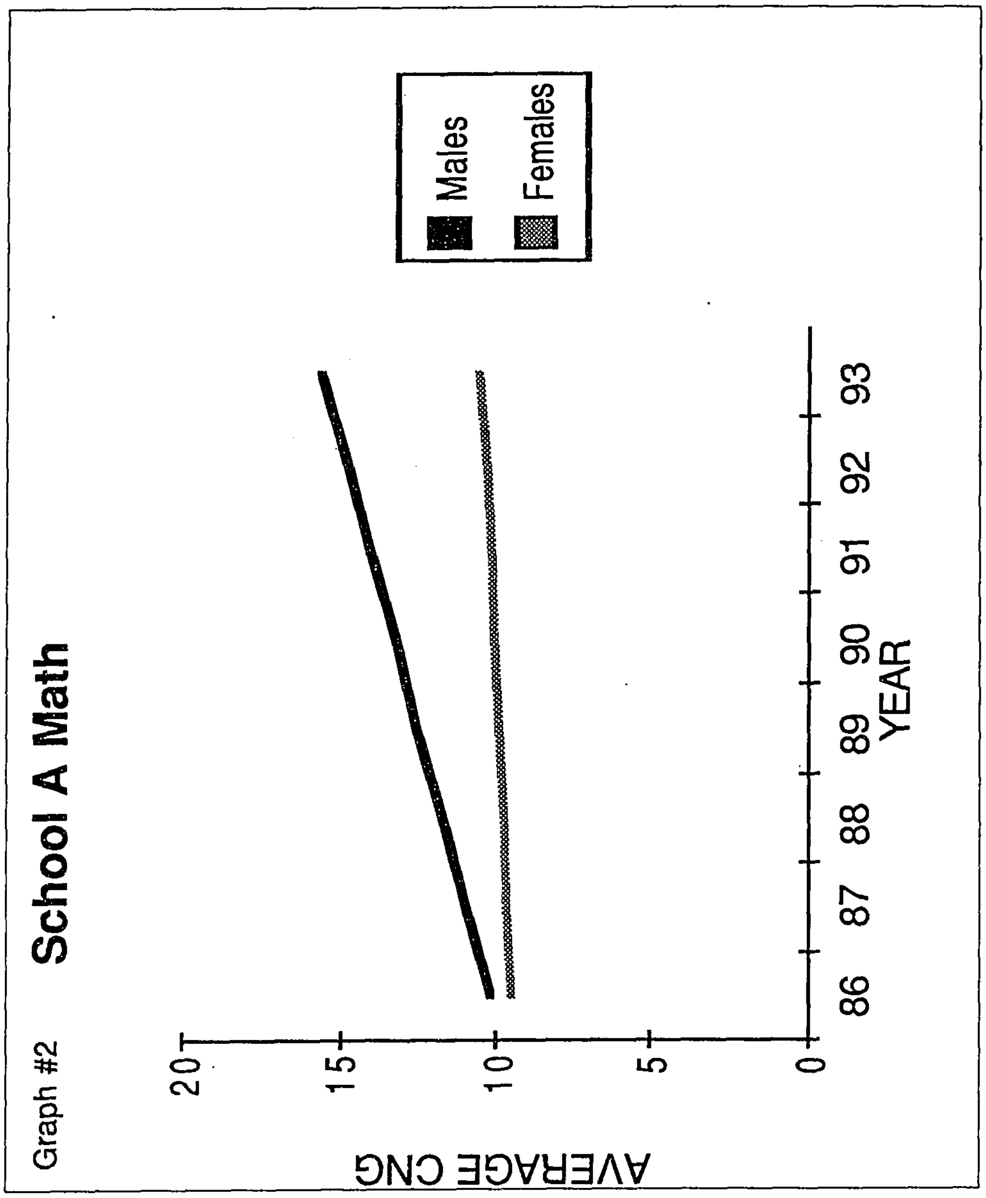
SCHOOL & SUBJECT	Males			Females		
	m	Y	R^2	m	Y	R^2
A SCIENCE	0.26	11.02	0.11	0.55	9.50	0.51
A MATH	0.77	10.28	0.03	0.16	9.52	0.17
B SCIENCE	0.40	9.27	0.52	0.58	6.94	0.57
B MATH	0.07	9.14	0.02	0.11	7.76	0.09

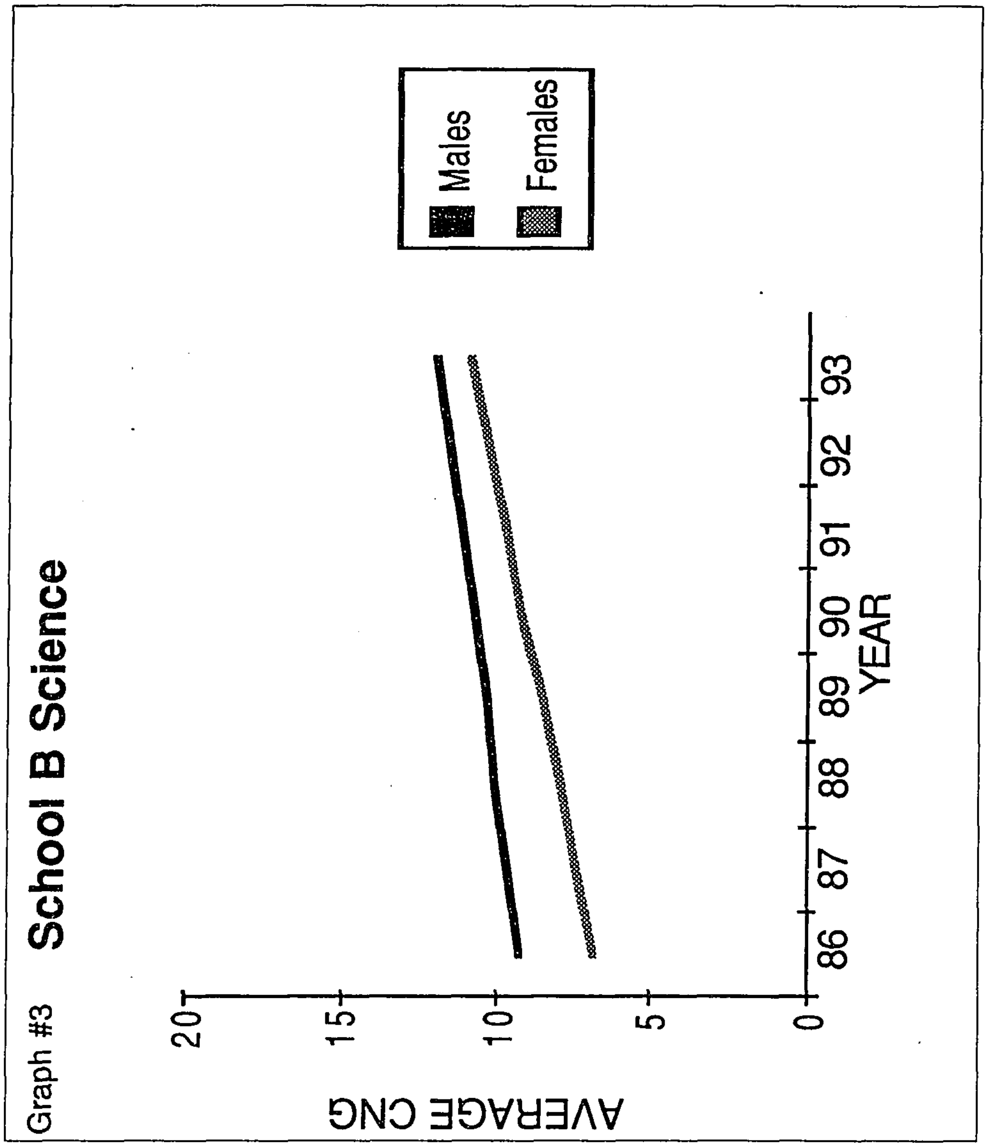
m=slope, Y=Y intercept, R^2=degree of fit

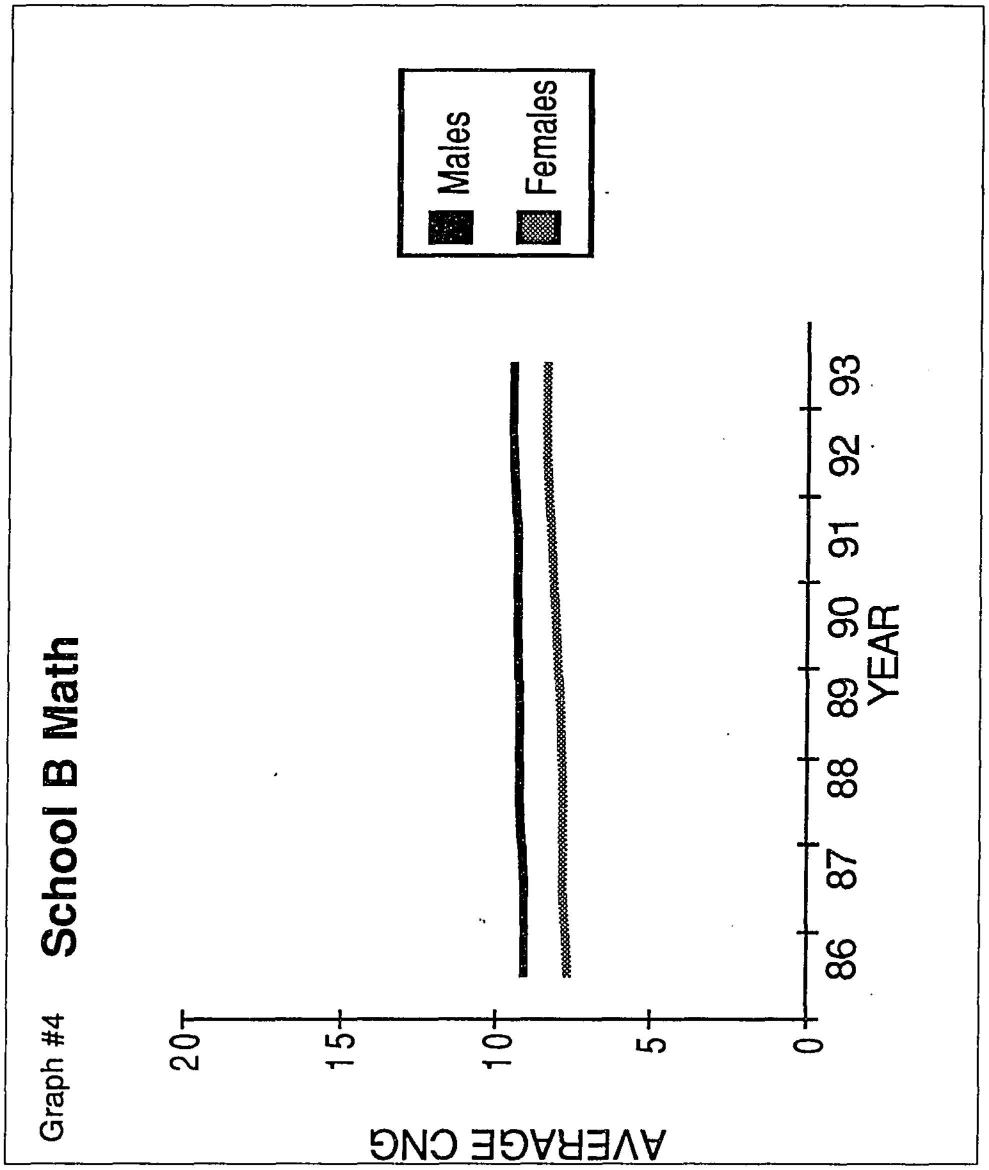
The slopes for these lines were close but were not equal. The general trend showed female average CNG was increasing at a greater rate than male average CNG. There was only one (A MATH) that showed males having a greater slope. The fit of the lines, shown by the R^2 statistic, was not large enough in all instances to be sure of this data. Graphs #1-4 show the lines of best fit.

The results of the tests showed the null hypothesis could be rejected for two of the five hypotheses. These two null hypotheses rejections were the interaction between math and science CNG and the fluctuation of math and science CNG. The other three hypotheses tested did not show the null hypotheses being rejected.


Graph #1
School A Science
AVERAGE CNG
20
15
10
5
0
86
87
88
89
90
91
92
93
YEAR
Males
Females


Graph #2
School A Math
AVERAGE CNG
20
15
10
5
0
86
87
88
89
90
91
92
93
YEAR
Males
Females


Graph #3
School B Science
AVERAGE CNG
20
15
10
5
0
86
87
88
89
90
91
92
93
YEAR
Males
Females



Graph #4
School B Math
AVERAGE CNG
20
15
10
5
0
86
87
88
89
90
91
92
93
YEAR
Males
Females

Chapter 5

Discussion

Research hypothesis H_R1, which stated male cumulative numerical grade (CNG) will be significantly greater than female CNG in single year tests at each school in both math and science, was not supported. The expected gender difference in single year tests was not apparent. The requirement of significant differences in science and math CNG appearing each year was not supported. This hypothesis was supported on only three out of 16 instances. These three instances showed males had the greater CNG. These results led this author to conclude that if a gender difference does exist in single year CNG tests, then the difference favors males, but a larger sample was needed to test this conclusion with any certainty.

Research hypothesis H_R2 stated male CNG will be significantly greater than female CNG in single school tests in both math and science. This hypothesis was not supported. The expected gender differences in math and science CNG in single school tests was sustained in one school, but not the other. School B showed significant differences in both math and science CNG. School A did not show significant differences in either subject.

These results for the single school tests were interesting. A possible explanation may have been the economic differences between the schools' populations. Economic status has been shown to be an influence on grades (Stockard and Wood, 1984; Maple and Stage, 1991) as shown by the following quote. "Middle class females appear to be most likely to receive grades commensurate with their measured ability..." (Stockard and Wood,1984, p.834). School A has a larger population and is located closer to the major city in this mostly rural area. This location may increase the number of middle class students. Due to a lack of further information on the schools' populations, this explanation was impossible to test.

Research hypothesis H_R3 said male CNG will be significantly greater than female CNG when all CNG are combined. As with research hypothesis H_R2, this hypothesis was not supported. The expected gender differences in science CNG were not supported when CNG was combined from both schools. The expected math CNG differences were supported when ANOVA tests were run on this data. Therefore, only half of this research hypothesis was supported.

The results for the single content area tests were intriguing. Science grades showed no significant gender differences, while math grades did show differences. These results led this author to

two possible conclusions. The first possible conclusion was males were succeeding at a greater rate in math compared to females. The second possible conclusion was males were enrolled in more math classes as compared to females.

The number of classes a student took was an important aspect of CNG. The value of CNG for an individual student was increased as the number of classes taken by that student increased. In an attempt to test whether males were taking a greater number of math classes than females, the average number of math classes taken by males and females was calculated. In this study the 320 males took 2.99 math classes on average, while the 320 females took 2.70 math classes. These figures lead to the second conclusion that males enrolled in more math classes.

The results for the science classes showed no significance at the $p<0.05$ level. The F statistic was significant at the $p<0.07$ level. These results led to the same possible conclusions for science CNG as those for math. These possible conclusions led to the testing of the number of classes taken by the genders in science. The average number of science classes taken by males was 3.40 while the average number of science classes taken by females was 3.23. These figures also lead to the second conclusion that males enrolled in more science classes.

Research hypothesis H_R4 stated there will be a significant interaction between math and science CNG. This hypothesis was supported by the data gathered in this study with a null hypothesis probability of <.001. An interaction of this strength led this author to conclude that these classes should be emphasized together. The instruction of math in science courses and vice versa may improve the grades of students performing poorly in these classes.

The research hypothesis numbered five [H_R5] stated the differences between average math and science CNG will fluctuate over the time of the study. This hypothesis was supported in all the groups tested. The females were closing, or had closed, the gap in average science CNG for both schools. Male average math CNG remained greater than female average math CNG at both schools.

The results of the final test comparing the slopes of the lines of best fit were worth noting. All the slopes were positive, and the females' slopes had a greater magnitude than the males' slopes in science. This led to the conclusion that all the students were improving in science and math CNG and the females were improving at a greater rate in science.

In conclusion, the results of this study did not show gender differences in secondary science and math grades. The computations of certain F statistics were less than .05 in some areas but were not

continuously significant throughout the study.

Limitations

There was a limitation of this study due to its power. The power of this study was directly related to the ability of the F statistic to be as large as possible. The F statistic was found by dividing between group mean squares by within group mean squares (see Table 2). Increasing the between group mean squares or decreasing the within group mean squares would have increased the power of this study. The small N of the single school tests did not allow the within group mean squares to be diminished enough.

A limitation with the error components of each CNG score also existed. An assumption underlying ANOVA is the error component of each score is independent. The fact the same teacher assigned many of the grades was a possible violation of this assumption.

I was able to view confidential grade records due to my familiarity with the schools. I taught at one of these schools. I attended the other. My familiarity may have lent a bias to this study.

Implications

The results of this study suggest that there is a gender difference in science and math CNG, but the power of the study

needed to be improved. The single year tests did not consistently show a difference. The three times these tests did show a difference the males showed a greater CNG. When the single school tests were performed, one school showed a difference and the other did not. Again, this difference showed the males with the greater CNG. The single subject tests showed a CNG gender difference with a 7% confidence. As the power of the tests became greater due to the enlarging sample, the statistical significance of the results became greater. The results were not able to support research hypotheses one, two, and three, but every time a significant difference was found, the difference favored males. As mentioned earlier, a larger sample was needed to make this study stronger.

Questions for Further Study

A question for further educational research is whether the magnitude of gender differences are becoming less over time. The results of this study showed a possible closing of the gap in science but not in math CNG. This led to the question of whether the differences are being reduced, and if so, why?

Another question for educational research is what aspects of schools can cause gender differences to become apparent. School A showed no significant differences, while School B did. The schools

are separated by only 20 miles, so the populations of these schools should not be different due to location. As mentioned earlier, there may be a difference between the schools' populations due to economic differences. If schools are somehow causing or increasing gender differences in science and math, then schools need to address how to reduce or eliminate these differences.

A final question for further research is whether the interdisciplinary approach to the teaching of math and science courses would increase the CNG of students. A possible way to test this question would be to look at the grades of students from schools instructing with the interdisciplinary approach (team teaching) versus grades from schools using the independent teaching approach.

In conclusion, the results from this study showed:

(1) Gender differences in math and science CNG were not supported, but were suggested.

(2) The study did show an interaction of math and science CNG.

(3) The differences in math and science CNG were fluctuating. The direction of the trend showed differences in science CNG were being reduced or equalized, while the differences in math CNG were remaining approximately equal or increasing. Although research hypotheses one, two, and three were not supported, the results

suggest that further study on CNG gender differences needs to be completed before any final conclusions can be reached.

The results of this study showed females gaining or surpassing males in science CNG (see graphs one and three). The schools in this study should be proud of their accomplishment. As mentioned earlier, if schools are somehow causing or increasing gender differences in education, then schools need to address how to reverse these differences. These schools may have been able to solve this problem that has been studied for over 20 years by educational researchers. If these results can be consistently repeated at other schools, then educators have a reason to exult. If these results are not repeated at other schools, then educators need to investigate how the schools in this study achieved their results, and copy their science programs.

As mentioned earlier, the purpose of this study was to determine if the high school grade scores received by males and females were significantly different. The premise of this study was that those students who earned high grades in specific subject areas may have been more apt to continue pursuing those areas in institutions of higher learning. Whereas a student who receives a poor grade in a specific area may be less apt to follow that line of course work. The enrollment figures cited by Holmes (1991) showed

a larger percentage of males enrolled in engineering courses as compared to females. The roots of these figures may be found in the grades students receive in high school. If an equal opportunity for all students in all areas is a concern for educators, and if differences in grades do exist, these differences must be addressed.

Appendix

$$\text{Between Groups Sum of Squares} = \sum_j \frac{\left(\sum_i Y_{ij}\right)^2}{n_j} - \frac{\left(\sum_j \sum_i Y_{ij}\right)^2}{N}$$

$$\text{Within Groups Sum of Squares} = \sum_j \sum_i Y^2_{ij} - \sum_j \frac{\left(\sum_i Y_{ij}\right)^2}{n_j}$$

Between Groups Degrees of Freedom = J-1

Within Groups Degrees of Freedom = N-J

$$\text{Between Groups Mean Squares} = \frac{\text{Sum of Squares Between}}{\text{Degrees of Freedom Between}}$$

$$\text{Within Groups Mean Squares} = \frac{\text{Sum of Squares Within}}{\text{Degrees of Freedom Within}}$$

$$F = \frac{\text{Mean Squares Between}}{\text{Mean Squares Within}}$$

Y is the i score in the j group

N is the total number of subjects

J is the total number of groups

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