Gender Differences in Science Performance

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Abstract

The purposed of this study was to examine the gender differences in students' science performance in their third, fifth, and eighth grade. This study utilized the Early Childhood Longitudinal Study Kindergarten Class of 1998-1999 (ECLS-K) K-8 full sample data public-use data file and had the sample size of 7,305 students. An independent sample t-test was conducted to compare science performance in male and female students in each grade level. Results indicated that gender had significant effects on students' science performance in third, fifth, and eighth grade. Starting in third grade, male students performed better than female students. This trend continued; males still outperformed females in the fifth and eighth grade. The gender difference on science performance already existed in third grade. It is not clear why female students performed less than the other counterparts. Future studies should investigate students' science learning progress and their science learning experience in the classrooms of the early elementary grades.

Keywords: Science, Science Performance, Science Assessment, Science Achievement, Gender

1. Introduction

Do male and female students learn academic subjects differently? There is no gender difference in the intelligence test. However some gender differences do exist in some cognitive areas (Halpern, 2012). In the National Assessment Educational Progress (2011) report it indicated that there was strong evidence of female students that outperformed male students in reading and writing (Orr et al., 2011). In mathematic achievement, several studies showed that there is no gender difference in math achievement. Male students did not score higher than females (Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Orr et al, 2012).In science, the learning outcomes between genders had been varied. Some studies indicated that males performed better than female students. Others indicated the opposite findings (Amelink, 2009).

2. Literature Review

In the U.S., there are few nationwide studies that track students' science performance between elementary and secondary schools. Due to the limited scoped of the data source, the findings have been inconsistent.

2.1 National assessment of educational progress (NAEP)

The Nation's Report Card is conducted by the National Assessment of Educational Progress (NAEP). The Nation's Report Cardin forms the public about the academic achievement of elementary and secondary students in the United States. The Nation's Report Card is a continuing and nationally representative measure of achievement in various subjects over time.

NAEP assessments have been conducted periodically since 1969 in reading, mathematics, science, writing, U.S. history, civics, geography, and other subjects. NAEP collects and reports information on student performance at all levels of local, state and national. NAEP makes the assessment an integral part of our nation's evaluation of the condition and progress of education.

NEAP found that differences between males and females in K-12 education began in elementary school and continued at the high school level. In 2009, more than 300,000 students in 4th, 8th, and 12th grades were assessed in science achievement. The results from the 2009 report indicated that male students outperformed female students in science achievement at all three grade levels (4th, 8th, and 12th grades) (National Center for Education Statistics, 2012a).Again, in 2011 science report card, showed that 8th grade male students continued to perform better than female students in science achievement (National Center for Education Statistics (2012b).

2.2 National education longitudinal study (NELS)

NELS is a longitudinal study which was conducted by the National Center for Education Statistics. This study has consisted of several waves of data collection in 1988, 1990, 1992, 1994, 2000, and 2004. Students of each cohort reported their school experiences and achievement test in reading, mathematics, science, and social studies, when they were in 8th, sophomores, or seniors in high school. There were significant differences by gender on

science performance in 1988, 1990, 1992, 1994, and 2000, but not in the 2004 which showed limited influence of gender on science achievement (Chang, Singh, & Mo, 2007; Amelink, 2009). In another study that used NELS: 88 data showed that even the gender differences were small, but did favored males students (Burkam, Lee, &Smerdon, 1997).

2.3 Trends in international mathematics and science study (TIMSS)

TIMSS is conducted by the International Association for the Evaluation of Educational Achievement (IEA), an international organization of national research institutions and governmental research agencies. The assessment provides data on the mathematics and science achievement of U.S. students compared to that of students in other countries.

TIMSS data was collected in 1995, 1999, 2003, and 2007. The comparisons between genders in 4th grade were available in 1995 and 2003. The fourth grade males had higher science scores than females (Gonzales, et al., 2004). The same trend occurred in 8th grades, according to the 1995, 1999, and 2003 reports. From a recent study, in 2007the results showed that males still performed better than females in fourth, eighth, and twelfth grade in their science performance (Gonzales, et al., 2008).

2.4 Early childhood longitudinal study, kindergarten class of 1998–99 (ECLS-K)

The Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K) was initiated by the U.S. Department of Education, Institute of Education Sciences (IES) in response to a congressional mandate requiring an account of the status of education in the United States. The National Center for Education Statistics (NCES) was entrusted with the data collection, processing, distribution, and reports for this longitudinal project. Approximately 23,000 kindergarten children and parents participated during the first year (1998–1999) of the project. This longitudinal study followed these same children from kindergarten through the 8th grade. Information was collected in the fall and the spring of kindergarten (1998-99), the fall and spring of first grade (1999-2000), the spring of third grade (2002), the spring of fifth grade (2004), and the spring of eighth grade (2007) (Tourangeau, Nord, Lê, Sorongon, &Najarian, 2009).

The earlier studies that focused on students' science performance from using 1998-1999 ECLS-K data, Kohlhaas and her colleagues found that gender difference started as early as in the third grade with male students having higher science average mean scores than the female students (Kohlhaas, Lin, & Chu, 2010a). In fifth grade, male students still had better performance in science than females (Kohlhaas, Lin, & Chu, 2010b).

Research findings from the previous study suggested that male students had better science performance than female students. However, these findings among the studies were not consistent. Most of the studies used cross sectional methods. Due to the limitation of the data, it is hard to understand how the male and female students' science achievements would progress over time.

3. Purpose of the Study

The purpose of this study was to compare the science performance between genders from a longitudinal approach. Students' science achievement was examined between genders in third, fifth, and eighth grades.

4. Research Method

4.1 Data file and samples

The data came from the Early Childhood Longitudinal Study Kindergarten Class of 1998-1999 (ECLS-K) K-8 full sample data public-use data file. In order to control the effect of the gender on science performance, students with learning disabilities were not of interest in this study and might skew the estimates. After removing the group of students with learning disabilities, there were 7,305 students whose data and achievement scores in science were examined.

4.2 Weights

The ECLS-K used a multistage probability sample design to select a nationally representative sample of children attending kindergarten in 1998-99. Based on the recommendation made by the National Center for Education Statistics (NCES), the third, fifth, and eighth grade "direct child assessment" weight of C567CW0 was applied in this study, so the results can be applied to the norm (Tourangeau, et al., 2009). Educators can use the results to interpret children's performance in the population and help students improve the science learning outcomes.

4.3 Measures of independent variable

Gender. The ECLS-K students' gender data were first collected in kindergarten from a composite of parents' and teachers' surveys. The genders were coded dichotomously into "1" for males and "2" for females.

4.4 Measure of dependent variables

The dependent variables for this study were the third, fifth, and eighth graders' science performance. The ECLS-K measured science performance through different items that focused on conceptual understanding and scientific investigation frameworks. The variables of C5R2SSCL (third grade), C6R2SSCL (fifth grade) C7R2SSCL (eighth grade) science IRT scores were used to study students' science performance.

Since the IRT scale scores in the database represent estimates of the number of items children would have answered correctly at each point in time if they had taken all of the 111 sciences items in all of the third, fifth, and eighth grades. Thus, the science assessment gain scores can be computed to check for the students' science knowledge accumulation over time between third and eighth grade (Tourangeau, et al., 2009).

This study included two additional dependent variables, fifth grade gain scores. They were the different scores between third and fifth grade (C6R2SSCL - C5R2SSCL).The 8th grade

gain scores were computed between the differences of fifth and eighth grade (C7R2SSCL - C6R2SSCL).

4.5 Statistical Analyses

An independent sample t-test was conducted to compare science performance in male and female students in each grade level.

5. Results

This study had 7,305 students with 3,554 (49%) males and 3,751 (51%) females. Table 1 displays the sample size, mean, and standard deviation of students' science IRT scale scores before and after applying weight analyses.

Table 1. Descriptive Statistics of Students' Science IRT Scores by Grade Level

Grade Level	N	M	SD	Rang	Min.	Max.	M	SD	Rang	Min.	Max.
			Unweight						Weight		
3rd Grade	7022	53	14.97	77	18	95	51	15.27	77	18	95
5th Grade	6977	67	15.03	81	22	103	66	15.70	81	23	103
8th Grade	7024	87	14.97	80	28	108	84	16.16	80	28	108
5th Grade Gain	6861	14	8.56	68	-22	47	14	8.34	68	-22	47
8th Grade Gain	6731	19	9.67	106	-39	66	19	9.93	106	-39	66

Table 1 displays the average weighted third grade Science IRT scale score was 51 with a standard deviation of 15.27 and a range from 18 and 95. The average weighted fifth grade Science IRT scale score was 66 with a standard deviation of 15.70and a range from 23 and 103. The average weighted eighth grade Science IRT scale score was 84 with a standard deviation of 16.16 and a range from 28 and108.

Table 2 shows the mean scores and the deviations of each grade by gender. Independent-samples oft-tests were conducted to test gender effects on the science performances in third, fifth, and eighth grades. Table 3 displays the degree of freedom, *F* value, and p value for the t-tests by grades.

The third grade males had a mean score of 53 (SD = 15.35), which was three points higher than females' mean score of 49 (SD = 14.92) (Table 2) There was a significant difference in the scores between males and females, t (2770631) = 226.30, p < 0.000).In the fifth grade, males had a mean scores of 68 (SD = 15.22) and scored five points higher than the females (M = 63, SD = 15.87). The t-test result indicated a statistical significance between the genders in the fifth grade, t (2782655) = 227.16, p < 0.000. The gap of the science IRT scores in eighth grade between males (M = 86, SD = 15.80) and females (M = 83,SD = 16.33) was

three points (see Table 2). For the eighth grade, the t-test of the IRT science scores between the gender also showed the statistical significant, t (2788362) = 179.72, p < 0.000.

Table 2. Mean of Science IRT Scores between Genders by Grade Levels

	Male		Female	
	M	SD	M	SD
3rd grade	53.55	15.35	49.44	14.92
5th grade	67.69	15.22	63.46	15.87
8th grade	86.25	15.80	82.79	16.33

Table 3. T-tests for the Gender Effects on Students' Science Performance

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Differ-ence	Std. Error Differ-ence
3rd Grade	EVA	2518.40	0.000	226.30***	2770631	0.000	4.12	0.02
	EVNA			226.16	2756275	0.000	4.12	0.02
5th Grade	EVA	3272.53	0.000	227.16***	2782655	0.000	4.24	0.02
	EVNA			227.34	2782603	0.000	4.24	0.02
8th Grade	EVA	1612.47	0.000	179.72***	2788362	0.000	3.46	0.02
	EVNA			179.81	2788361	0.000	3.46	0.02

Note: EVA: Equal variances; EVNA: Equal variances not assumed

P***<.001

Gain science IRT scores were computed with the differences of each individual student's scores in third, fifth, and eighth grade. Fifth grade gain scores were the differences between the third and fifth grade science scores. Eighth grade gain scores were obtained by the subtracting from the eighth grade scores to the fifth grade scores.

The average weighted fifth grade gain Science IRT scale score was 14 with a standard deviation of 8.34 and a range from -22 and 47. The average weighted eighth grade gain Science IRT scale score was 19 with a standard deviation of 9.93 and a range from -39 and 66 (see table 1).

Table 4 shows the gain scores between the genders and grade level. Both males and females had average gain scores around 14 with similar standard deviation. In eighth grade, females'

mean gain scores was slightly higher than males' (Female M = 19.33; Male M = 18.66). Table 5 lists the t-test results of comparing the genders' gain science scores in both grades. The statistical comparison between two groups in fifth and eighth grade reached the statistical significant.

Table 4. Mean of Gain Science IRT Scores between Genders

	Male		Female	
	M	SD	M	SD
5th grade gain	14.25	8.33	14.04	8.36
8th grade gain	18.66	9.88	19.33	9.96

Table 5. T-tests for the Gender Effects on Students' Gain Science Performance

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Differ-ence	Std. Error Differ-ence
5th Grade Gain	EVA	11.32	.001	20.90***	2768490	.000	0.21	0.01
	EVNA			20.90	2763613	.000	0.21	0.01
8th Grade Gain	EVA	34.59	.000	-55.98***	2781375	0.000	-0.67	0.01
	EVNA			-55.98	2778975	0.000	-0.67	0.01

Note: EVA: Equal variances; EVNA: Equal variances not assumed

P***<.001

6. Discussion

This study utilized the ECLS-K, a large-scale national database, to investigate gender on students' science outcomes in the third, fifth, and eighth grade. The longitudinal study allowed the educators to understand students' development on learning science as well as to compare male and female students' science learning outcomes over time.

The gender gap on science performance started as early as in third grade. Male students had higher mean scores than female students. This trend persisted in the fifth and eighth grade. Compared to the females, male students consistently had higher mean science scores (See Figure 1). The results support the early findings from the studies of National Report Cards as well as the TIMSS with males performed better than females in the elementary and middle schools.
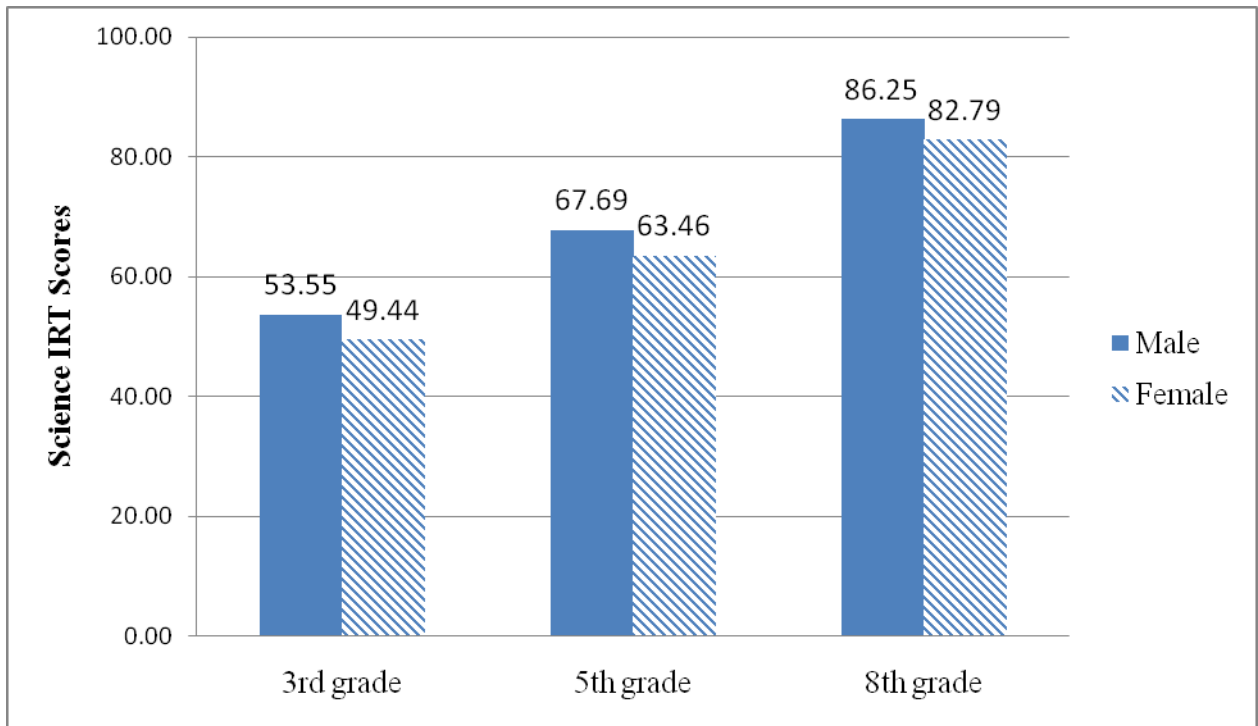
Figure 1. Science IRT Scores by Gender and Grade Levels

This study also examined the students' gain on the science learning outcomes, as students progressed through the grades in schools. Comparing the difference between students' third and fifth grade on the science performance, male and female students showed very similar learning speed, with average of gaining 14 points over a two–year period. The difference between students' fifth and eighth grade was females had slightly higher on the average gain science score (See Figure 2).

The conclusion of this study was that gender differences do exist between male and female students. This difference was found as early as the third grade. The speed in which science knowledge is learned between male and females remained similar. However, the size between the gender gap stayed the same with male students constantly being four points higher than females throughout the assessed time periods of third, fifth and eighth grades.
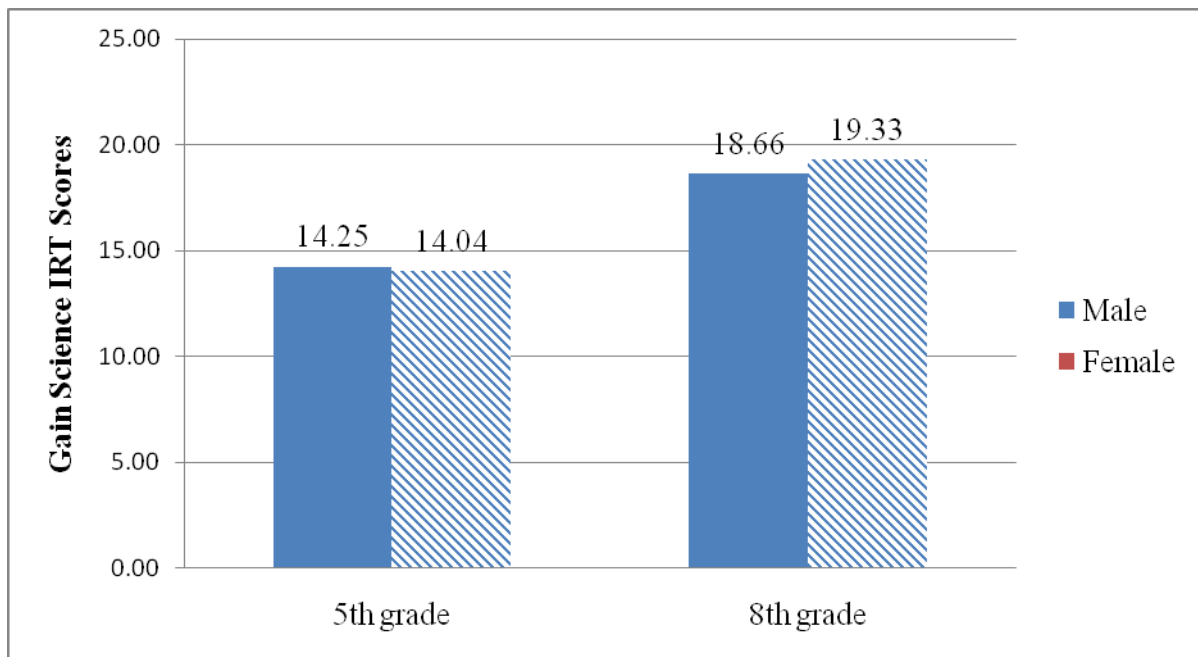
Figure 2. Science Gain IRT Scores by Gender and Grade Levels

6. Future Studies

The gender difference on science performance already existed in third grade. It is not clear why female students performed less than the other counterparts. Future studies should investigate students' science learning progress and the science learning experience in the classrooms of the early elementary grades.

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