International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Effects of Single-Sex and Coeducational Schooling on the Gender Gap in Mathematics Achievement in Public Schools in Beirut - Lebanon

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Abstract: ***In education, there has been several debates regarding student achievement and success; among these is the subject of gender gap in math. Even though schools have tried to minimize the gap throughout the years, males still outperformed females in math, particularly at the upper level. The purpose of this study was to compare the students' mathematics achievement in coeducational and single-gender schools. Within this framework, the researcher examined class type and gender using the 9th and 12th grades of Lebanese official exams scores of students in the area of mathematics. It has been suggested in the literature that differences in the size of the mathematics gap across countries may be explained by differences in the prevalence of single-sex schooling. The Lebanese education system is interesting both for the fact that a sizeable proportion of children attends single-sex schools, and because these single-sex schools are part of the general and public educational system, rather than serving a particular socio-economic group. We exploit this fact to test whether the gender composition of schools affects the mathematics achievement between genders. Quantitative and qualitative data were collected to validate the results found. The sample consisted of nine public school principals and seventeen teachers. Three instruments were used: official exam scores of grade 9 and grade 12 students collected from schools, Brain dominance test, and workshop brochures which are informative paper documents presented by the ministry of education. Findings showed significant difference in math achievement for boys and girls in single-sex schools and co-educational schools in favor of co-educational setting for boys and in favor of single-sex setting for girls, significant difference between males and females with the left hemisphere of the brain in favor of males and a significant difference between males and females concerning the right hemisphere in favor of female, and teachers have not been exposed to professional development opportunities regarding implementing instructional strategies for boys and girls in different educational settings. Recommendations for further studies were suggested as to investigate students' perceptions towards mathematics in both types of schooling.***

Keywords: Single-sex and co-education, instructional strategies in mathematics, public schools, students' math achievement, Brain Hemispheres

1. Introduction

For quite a while, gender differences in education was part of long standing political, public and scientific discussions and debates; accordingly, numerous endeavors to diminish gender disparities in achievement has been held [23]. Also, there is a fret in a few countries that many schools are not supporting students of both genders in accomplishing mathematical achievement, thus, improving mathematics performance has been a vital focal point in many countries and difference in educational achievement for students attending single-sex schools and coeducational schools has been discussed [49] [42].

Single-sex education is defined as "education at the elementary, secondary, or postsecondary level in which boys and girls attend school exclusively with members of their own sex" [49].

Co-educational schools arose after the World War II in most of European nations, and after 1970 in numerous different nations [15] to provide both genders with equal education opportunities [47].

Even though co-educational schools are viewed nowadays to be more useful than single-sex schools, by numerous parents and schools, the discussion is as yet open in various countries. Few countries have been experimenting with single-sex classes within coeducational schools in an attempt to raise overall achievement and some research have suggested that single-sex schooling might reduce the gender gap in mathematics [18]. In addition, a report distributed by UNESCO (2007) expressed that single-sex schooling has progressively been the subject of examination for its job in improving gender equality in education. In light of the above-mentioned, examining whether the schooling system positively or negatively impacts education and achievement particularly in STEM and expressly in mathematics is vital for improving the level of education in schools around the world. In the Middle East and especially Lebanon where students are taught in both single-sex and co-educational public schools, there is a huge contrast between achievement of boys and girls explicitly in math classes [18]; consequently, research on the achievement gap between the two genders in both single-sex and co-ed schools in STEM in the Middle East gets fundamental attention.

Gender differences in educational achievement have been broadly detailed in various countries including the USA, UK, Australia and New Zealand [1] [20]. Many previous studies have found that girls outperformed boys in math and science, while boys outperformed girls in other subjects. However, different researches have showed different outcomes. Although recent research indicate that girls have exceeded boys in general educational performance in many developed countries [48], boys continue to outperform girls

in mathematics [18] [46]. Lee and Bryk found in a research in Australia that students in single-sex schools had higher levels of achievement than those in coeducational schools and that the benefits for single-sex schools would in general be more prominent female students than male students [11]; Similarly, Van de Gaer et al. found out that single-sex schools had no critical impact on male students' achievement, however, for female students, it had a huge constructive outcome on math achievement [70]. In a research on the Lebanese educational system, Malacova , on the other hand, found that single-sex education benefited both girls and boys [38]. Ayyash-Abdo discovered that Lebanon still suffers from gender discrimination in a variety of sectors, including schooling and career orientation, and Sarouphim noted that mathematics is still regarded a male domain [5] [53]. However, in Lebanon no study has been conducted on the impact of single-sex education on mathematical achievement in public schools, as Sarouphim and Ayyash-Abdo conducted their studies in the Lebanese private sector [5] [53]. It is worth investigating gender gap in mathematics in the Lebanese public, especially that Shapka and Keating stated that "mathematics appears to act as a critical filtering process which often prohibits prospective students from entering post-secondary programs that require a background in advanced math and science, thereby diverting them from subsequent career pathways" [60].

However, there is limited information in Lebanon about the impact of single-sex education on mathematical achievement.

The purpose of this study was to examine whether gender differences in mathematics achievement of grade 9 and 12 students vary for those attending single-sex and coeducational schools in Lebanon. The questions that guided our study were: (1) To what extent is there a difference in mathematics achievement between girls and boys in grade 9 and grade 12 attending coeducational school, or single-sex school in Lebanon? To answer this question, the following hypotheses were considered: (a) males have a better math achievement when enrolled in single-sex school, and (b) females have a better math achievement when enrolled in a single-sex school. (2) To what extent is there a significant difference in the left-right brain hemisphere between boys and girls in grade 9 and grade 12 in Lebanese public schools? To answer this question, the following hypothesis was considered: Boys possess more left-brain hemisphere dominance than girls in grades 9 and 12 in Lebanese public schools. and (3) To what extent are teachers exposed to professional development opportunities regarding implementing instructional strategies for boys and girls in grade 9 and grade 12 in single-sex and coeducational Lebanese public schools?

2. Literature Review

Since the 1970s, when single-sex schooling was made illegal by federal law, there has been less research on single-sex education; however, the option of single-sex schooling has resurfaced thanks to federal policies associated with NCLB (No Child Left Behind), allowing some parents who are dissatisfied with their children's educational achievement to choose a different way of learning, which is single-sex education [12]. A review of related literature was done to determine whether significant differences existed between boys' and girls' achievement in mathematics at the intermediate and secondary level in single-sex versus co-educational schools. Many studies afterwards looked into the problem of gender at the school level in many countries including reasons for and against single-sex education, as well as the impact on students' math performance.

Single-sex versus co-educational schools

The first category of arguments for single-sex schools, according to Hurst and Johansen, is pedagogical, in which supporters argue that teaching methods that take into account the social or biological differences between girls and boys can be more effective [28] [2]. The second category is social and focuses on the perceived negative influence on learning caused by social interactions between male and female students in the classroom, where both genders may intellectually constrain themselves to impress the opposing sex. Furthermore, according to Sax in his book *Why Gender Matters*, boys and girls differ biologically and psychologically, including variances in brain structure, vision, hearing, language development, and social interest [56]. Moreover, in certain single-sex classes, teachers adjust their teaching strategies and curriculum materials to cater to males' perceived needs and interests by devoting more time to teaching rather than behavior management, and by establishing a safe learning atmosphere that is "insulated from the distractions and off-task behavior of the other sex, where there is less harassment . . . and confidence can be built up" [68]

Single-gender schools are preferred to co-educational schools for a variety of reasons, according to proponents. Salomone wondered if "separating the sexes at certain points in the educational experience can alleviate to any degree the negative effects of the differences between boys and girls" [52]. She went on to say that there is no evidence that single-sex schools hinder kids intellectually; on the contrary, girls profit intellectually, academically, and "psychosocially" from single-sex schools because they give them more, self-confidence, comfort, and opportunities to broaden their interests. Single-sex classes empowers instructors and teachers to provoke female students' cliché reactions to STEM subjects like math and science [66], and assists them with creating fearlessness in their own capacities through an contended climate away from the "peacock behavior" of young male students [62] [6] [9].

Divya also investigated the possibility that people all around the world have distinctive social and religious views, which could impose certain constraints on male-female relationships [14]. Divya adds that female students are more likely to be abused by male students in co-educational institutions in different countries. Besides, educating boys and girls in the same classroom puts stress upon boys because boys have a fear of appearing less masculine in front of girls, so they often manifest behaviors which can become self-destructive, both academically and personally [14]. According to Gurian and Stevens , many "cultures

separate boys from girls just before and during puberty to accommodate the natural transformations boys and girls go through in order to create gender-safe and gender-monitored environments" [24]. Thus, when genders are separated, girls and boys learn in a nonthreatening setting to maximize their strengths, and help them achieve better.

It is evident that proponents of both types of education have compelling reasons. However, Sax went into greater detail about the benefits and drawbacks of single-sex education; the benefits include: (a) "decreasing distraction from the opposite sex" (b) "encourage boys to work together and be more cooperative", (c) "enhancing student success when teachers use techniques geared toward the gender of their students", (d) "creating classes that are less distracting than co-educational classrooms" and (e) "improving student-teacher interaction and peer interaction ", (e) "making girls feel less pressure and more comfortable to compete with boys in male-dominated subjects such as math and science", and (f) limiting students opportunity to work cooperatively later on in real life when work environment requires both genders to be in the same meeting room" [56].

This study employs Bandura's social learning theory which is considered as a form of constructivism [10]. The Social Learning Theory stresses how one's social settings, such as family, community, and broader society, influence one's learning and behavior performance [13]. According to social learning theory, behavior is influenced by a mixture of environmental (social) and psychological elements. Teachers must set an example of good behavior and expose students to a variety of alternative models in order to boost their confidence [8]. As a result, teaching boys and girls in the same classroom could be detrimental to the girls' education since it exposes students especially girls to judgments from others about their own incompetence in certain subjects, and it has a direct impact on their confidence and self-esteem [63]. Another theory contends that there are significant biological variations between males and girls that result in significant disparities in learning styles, necessitating significantly different classroom teaching strategies for boys and girls [24] [56]. Boy and girl brains have been the subject of intense investigation over the last few decades. According to research, boys' and girls' brains grow at various times and through different phases starting at conception [24] [64].

Gender Gap in Math Achievements between single-sex and co-educational schools

Researchers are attempting to analyze the influence of both single-sex schools and co-educational schools on mathematics achievement among schoolchildren. Several studies have been conducted to determine which method of instruction, whether single-school or coeducational school is the most effective way to increase student achievement in boys and girls and reduce the gap between them. However, there are a limited number of studies that have been conducted in the United States and rarely in the Middle East and Lebanon. Most studies attribute results to the learning environments and brain structure of both genders [51] [65].

McFarland, Benson, and McFarland concluded girls in single-sex schools scored higher than boys in single-sex and coeducational schools and boys in single-sex schools had higher mathematics achievement than boys in the coeducational schools [39]. Similarly a study by Mulholland, Hansen, and Kaminski conducted in Australia showed a significant increase in boy performance in single-gender settings in English but not in mathematics performance when compared to boys in coeducational schools and girls performed better than boys in single-sex schools [44].

Moreover, Guarisco discovered that students in single-sex schools do better because teachers tend to use a variety of teaching strategies and activities, particularly in mathematics and language classes [26]. Similarly, research in Australia has shown the gap between the achievement of both boys and girls is growing both at the elementary and secondary levels [50]. The study found girls in single-sex schools performed better than girls in coeducational schools and boys in single-sex schools performed better than boys in coeducational schools (p.48).

In general, research has not shown any evidence to refute whether single-sex schools are better than coeducational schools. In 2005, The U.S. Department of Education made study on public, single-sex schools in the United States to determine if single-sex schools improved students' achievement. According to the results of the study,

"The findings are equivocal. There is some support for the premise that single-sex schooling can be helpful, especially for certain outcomes related to academic achievement and more positive academic aspirations… There is no evidence of either benefit or harm." (U.S. Department of Education, 2005, p. 10).

In the Middle East (where single-sex schooling is common), interest in the gender differences on math academic achievement has recently increased. A study involving Syria, Oman, Iran, and Jordan, supports that females outperform males in single-sex schooling [4]. Alkhateeb's study in the United Arab Emirates show that no major differences occur in academic performance between boys and girls [3]. Similarly, in a study performed by Georgiou et, al. in Cyprus, the students' grades did not yield a large difference between boys' and girls' math performance [21].

In Lebanon, many studies on gender in co-ed schools rather than single-sex schools were conducted and showed that boys outperform girls in math exams. For example, in findings from the 2007 TIMSS Mathematics Achievement Test conducted in 2007, where Lebanese co educational schools participated in this test, major disparities existed in math achievement in grade eight students in 24 out of 47 countries. Eight of these countries, including Lebanon, favored boys while 16 favored girls (TIMSS 2007 International Mathematics Report). In Lebanon, one of the participating countries, boys exceeded girls in performance by a large and statistically noteworthy margin. Lebanese grade eight males performed better than females in math by 13 score points as an average (figure 1) [22].

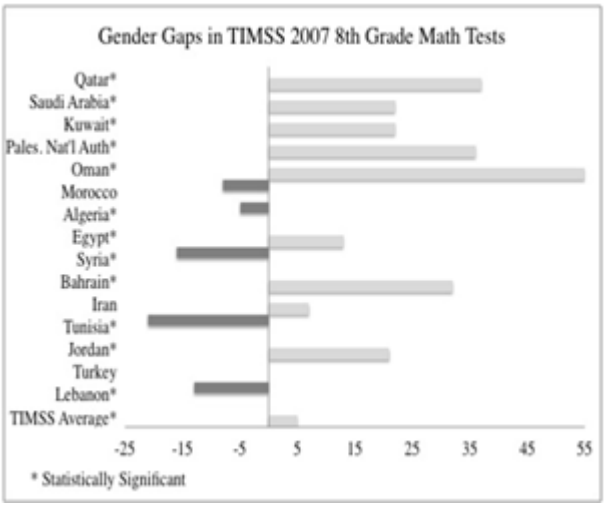


Figure 1: Gender Gaps Relative to the International TIMSS Average

Figure 1 was generated using mathematics score data from the TIMSS 2007 International Mathematics Report. The level of statistical significance was not reported. The TIMSS scale average is 500 points.

Positive values correspond to a gap in favor of girls, while negative values correspond to a gap in favor of boys.

These results are debated by other researchers. For instance, Sarrouphin and Chartouny and Hassan yielded opposing findings in their research [54] [29]. Hassan concluded that there is no major gender disparity in the performance of boys and girls in mathematics in the mentioned grades. These results are opposed to the results of the MLA (Monitoring Learning Achievement project) studies in other countries who conducted their studies in different geographic distributions, both single-sex and co-educational schools, and where major gender differences occur in math achievement [29]. Furthermore, in Sarrouphin's and Chartouny's study, both girls and boys also held positive attitudes towards math [54].

In summary, results on gender differences in achievement in mathematics are inconsistent. As the countries, schools, grade levels and tests vary, the math achievement of students varies as well. This perhaps suggest that "boys and girls are different. One is not better than the other; they are just different" [19].

Brain Differences in Genders

An examination of the brain reveals differences between male and female brain composition and development [56]. These differences do not mean one brain is superior to the other; the research simply shows the brains are "just different" [41].

Performing research on the variation between the brain structure and function of males and females largely impacts the educational theory; if males and females are structured differently, this is why they have different feelings, learning experiences, and reactions to experiences [37]. Although men and women are similar in a variety of ways, there are large differences between their brains concerning the size, the hemispheres, the mathematical skills, the language abilities, and the spatial recognition [37]. Likewise, theories in cognitive processing reason that teachers expect each of boys and girls to perform differently in school [32].

Researchers believe that men and boys are left-brain dominant while females or girls are right-brain or balanced in hemispheres. Studies also show that these two hemispheres behave differently in some cognitive tasks when compared between males and females [34] [61]. These differences usually justify why females tend to be more intuitive than men and perform more tasks that have do with creativity and arts; while men are more likely to achieve higher results in quantitative problem solving and mental rotation. They are also better in tasks that involve the cognitive process of preserving and deploying a visual image in mind [27].

In a study performed for about a million students from USA, psychological tests show that male students outperform females in math, science, and technical subjects, which all require visual-spatial skills while female students perform better in verbal subjects like history, languages, and literature [55]. This perhaps explains why boys may daydream or "space out" in a language lesson. At the same time, they can be more motivated to stay focused in a visual learning environment, which contains many symbols, objects, photographs, and diagrams. When too many words are used, males are more likely to lose their focus [24]. Similarly, Maccoby and Jacklin revealed in their study that male students outperform females in mathematical abilities and have better spatial skills than females when they are in secondary schools [37].

Many other studies contradict with the studies mentioned above which state that there are no differences between gender in terms of achievement or hemisphericity. For instance, in a study by Fernandez, results showed no difference between boys and girls in terms of what part of the brain is used to do a certain task [17].

Lebanon's Educational Context

Lebanon is a Middle Eastern country with a robust educational system built on three types of K-12 schools: government-run public schools, free-private schools, and fee-based private schools [16]. Public schools in Lebanon are of three types: (a) male single-sex schools, (b) female single-sex schools, and (c) co-educational schools. About 29% of Lebanese students are enrolled in public schools. The official language of instruction is Arabic; a second language, such as English or French, is necessary. The Ministry of Education mandates that all public schools in Lebanon follow a uniform curriculum and utilize the same textbooks. Principals oversee all administrative matters in public schools, and academic inspectors visit schools to discuss instructional difficulties and curricular problems for different subject-matters [5].

The Lebanese educational system is divided into primary education (K-6), intermediate education (Grades 7-9), and secondary education (Grades 10-12). At the end of grade 9, students sit for the Lebanese Brevet official exam, which allows them to proceed to the secondary level, while at the end of Grade 12 students sit for the Lebanese Baccalaureate

official exams [59]). The Lebanese Official Exams are designed and administered by a committee whose members are assigned by the Ministry of Education in Lebanon. The degree obtained is required for admission into a higher education institution.

Students in public schools encounter a variety of obstacles, including socioeconomic challenges (CERD, 2011) and inequities in school enrolment between girls and boys depending on parental beliefs [67], resulting in high dropout rates beginning in fourth grade (Ministry of Education [MEHE], 2013).

Significance of the study

Gender segregation has received little attention in previous studies, which have focused on research from Western developed countries. Our research was intended to add to the literature on single-sex versus co-education in public schools in Lebanon.

To our knowledge, few studies were done in Lebanon regarding this aspect, and no studies were found on Lebanese public schools regarding this topic. Consequently, findings of this study and derived data are considered a significant contribution to the educational practice in Lebanon since such results would help educators choose and implement teaching strategies that fit the needs of both boys and girls and influence their math achievement and reduce gender gap, interact with boys and girls equally, modify their perceptions, and determine the effects of biological factors on math achievements of students in Lebanon.

3. Methodology

A mixed method research and data was used in this study thereby using both qualitative and quantitative methods approach to examine whether gender differences in mathematics achievement vary for those attending single-sex and coeducational schools in Lebanon.

The research took place at intermediate and secondary public schools that teach math programs either in English or in French as a second language, thus this is a natural setting in Lebanon. For the purpose of triangulation, official exam scores of grade 9 and grade 12 students were collected from schools; Brain dominance test was distributed to grade 9 and grade 12 students to test and assess the difference in hemisphere between both genders, and finally, to further validate the results, workshop brochures which are informative paper documents presented by the ministry of education as a guideline of workshops delivered to teachers on a variety of topics to support teacher's goals and teaching strategies were analyzed to check if teachers had any training or experience for teaching different genders in different educational settings [45]

Utilizing mixed methodology. The study is qualitative through data collection document analysis. It is also quantitative through tests conducted by students, and grades collected and analyzed.

Population and Sample

Nine public schools in Lebanon were selected, located in the Beirut district and its southern suburb. The sample was a total of 1050 students. Moreover, students participated voluntarily with a non-random sampling method, responding to verbal invitations during school days.

Instruments

Three instruments were developed to answer the research questions:

Achievement test scores as documents

Document is defined by Hefferman as:

"It refers to the various procedures involved in analyzing and interpreting data generated from the examination of documents and records relevant to a particular study)". "It can also be considered as a form of quantitative research to systematically evaluate documents and find meaning in them" [7]

Basically, documents are a ready data source accessible and ready for the researcher to analyze. The three important document types available for the researcher for analysis are public records, physical material, and personal [40]. The documents in this study are public records represented by grade 9 and grade 12 students' official. This tool is used to prove the following hypothesis "(a) males have a better math achievement when enrolled in single-sex school, and (b) females have a better math achievement when enrolled in a single-sex school."

Document analysis through workshop brochures

In this research, public records represented by workshop brochure were analyzed. Information and insights derived from documents can be important and valuable add-ons to knowledge- based information; this is why workshop brochures can be considered supplementary data.

A workshop brochure is a book that shows all workshops given to teachers at public schools by different trainers. Therefore, workshops that are introduced to teachers by the Ministry of Education about various educational topics are analyzed to check whether teachers attended workshops related to different gender teaching, especially in the math classroom in both single-sex and coeducational classrooms.

The workshop data were analyzed to answer the research question, "To what extent are teachers exposed to professional development opportunities regarding implementing instructional strategies for boys and girls in grade 9 and grade 12 in single-sex and coeducational Lebanese public schools?"

Hemisphere test - the Brain Dominance Test

Tests are mainly used in experimental study to measure the effect of intervention; however, tests are also used as scales to measure a psychological construct or trait, which is the case in this research. The Brain Dominance Test is a test is a standardized test retrieved from http://www.edu-nova.com/apps/brain_dominance.html. It is performed to determine a person's brain hemisphere dominance easily and quickly, whether left or right. This instrument is used to prove the following hypothesis: "Boys possess more left-brain hemisphere dominance than girls in grades 9 and 12 in

Lebanese public schools." The hemisphere test's construct and criterion validity have been maintained as the test is standardized (edu-nova.com, 2018).

Thus, to conclude, qualitative and quantitative data collection tools were used to answer the research questions posed in this study. Hence, this research employed triangulation as mixed methodology using both qualitative and quantitative approaches to collect data relevant to the questions.

Data collection and procedure

Data collection: After obtaining the Ministry's permission to collect data from public schools, meetings with the principals and teachers were arranged to inform them about the purpose of our study. The next step was to administer tests given to students. Students were reminded that the test does not involve any risks to them and will not affect the grade in any way and that there is no right or wrong answer. Students were then asked to take the test after reading each question carefully before choosing any response. The test was distributed and collected in periods other than the math period so that the students had complete freedom to express their opinions. The researcher and the classroom teacher were present during test collection. Students were given five minutes to answer the test items which was considered as sufficient time.

The students' Brevet and Baccalaureate official exam grades were obtained from the school's administration at the end of the school year. The grades were given to the researcher in a sealed envelope.

Data Analysis Procedure: To answer the following research question "To what extent is there a difference in mathematics achievement between girls and boys in grade 9 and grade 12 attending coeducational school, or single-sex school in Lebanon?" Man Whitney test was used to examine if there is a significant difference between girls and boys scores collected from the official exams document as the data were not normal.

To answer the following research question "To what extent is there a significant difference in the left-right brain hemisphere between boys and girls in grade 9 and grade 12 in Lebanese public schools? And test the following hypothesis "Boys possess more left-brain hemisphere dominance than girls in grades 9 and 12 in Lebanese public schools", Chi square test was used to examine if there is a significant difference between brain hemisphere and gender.

To answer the following research question, "to what extent are teachers exposed to professional development opportunities regarding implementing instructional strategies for boys and girls in grades 9 and 12 in Lebanese public schools?" analysis of workshop brochures was conducted.

4. Results

Gender Gap in Math Achievements between single-sex and co-educational schools

The research in this study examined whether gender differences in mathematics achievement vary for those attending single-sex and coeducational schools in Lebanon.

Achievement gap in mathematics in Official Exams for boys between single-sex and coeducational schools

The research hypothesized that (a) males have a better math achievement when enrolled in single-sex school, and (b) females have a better math achievement when enrolled in a single-sex school; the researcher tried to test this hypothesis through examining scores collected through mathematical achievement of grades 9 and 12 students in single-sex versus co-educational schools.

Analysis of official grades showed a significant difference concerning the official grades between males in co-educational and single sex schools in favor of co-educational setting.

Our Sample is n>100, The researchers relied on Kolmogrov Smirnov to determine the normality of these variables. Sig<0,05 in both variables, they were then not normally distributed, the researchers used non parametric tests.

In order to compare these two, the researchers used Man Whitney U test. Having U=18875; p<0,05 the researchers sued that there was significant difference concerning the official grades between males in co-educational and single sex schools.*(Table2)*

Table 1

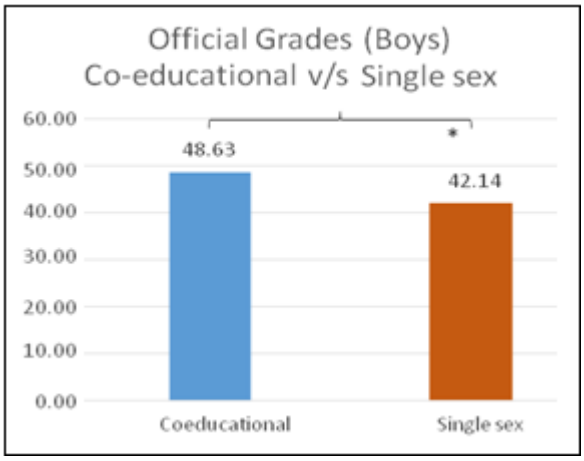


Table 2

Tests of Normality							
	Type	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
Official grade Boys	Coeducational	.148	352	.000	.873	352	.000
	Single sex	.142	126	.000	.763	126	.000
a. Lilliefors Significance Correction							

Test Statistics[a]	
	Official grade Boys
Mann-Whitney U	18875.000

Wilcoxon W	26876.000
Z	-2.481
Asymp. Sig. (2-tailed)	.013
a. Grouping Variable: Type	

Achievement gap in mathematics in Official Exams for girls between single-sex and coeducational schools

Analysis of official grades showed that there is significant difference concerning the official grades between females in co-educational and single sex schools in favor of single-sex setting *(table 3)*. Since the sample size was greater than 100, the researchers used on Kolmogrov Smirnov to determine the normality of these variables. Sig<0,05 in both variables, they were then not normally distributed, we will use non parametric tests.

In order to compare these two, the researchers used Man Whitney U test. Having U=21429,5; p>0,05 showed that there was no significant difference concerning the official grades between females in co-educational and single sex schools. *(Table 4)*

Table 4

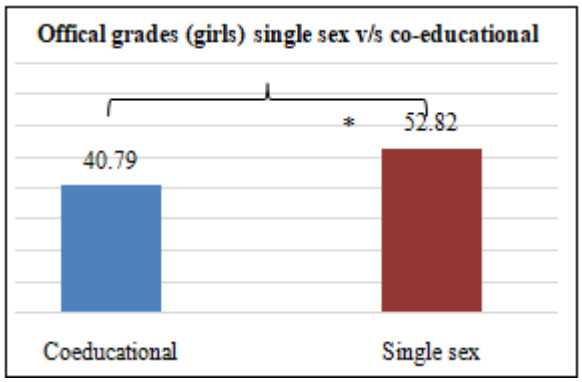


Table 4

Tests of Normality							
	Type	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Official grade girls	Coeducational	.091	358	.000	.894	358	.000
	Single sex	.164	127	.000	.886	127	.000
a. Lilliefors Significance Correction							

Test Statistics[a]	
	Official grade girls
Mann-Whitney U	17072.000
Wilcoxon W	81333.000
Z	-4.173
Asymp. Sig. (2-tailed)	.000
a. Grouping Variable: Type	

Ranks				
	Type	N	Mean Rank	Sum of Ranks
Official grade girls	Coeducational	358	227.19	81333.00
	Single sex	127	287.57	36522.00
	Total	485		

Achievement gap in mathematics in Official Exams between boys and girls in single-sex

Analysis of official grades showed that there is no significant difference concerning the official grades between female and male students in single sex schools (*table 5*). Since the sample size was greater than 100, the researchers relied on Kolmogrov Smirnov to determine the normality of these variables. Sig<0,05 in both variables, they were then not normally distributed, the researchers used non parametric tests.

In order to compare these two, the researchers used Man Whitney U test. Having U=17963,5; p>0,05 showed that there is no significant difference concerning the official grades between females and males in single sex schools. *(Table 6)*

Table 6

Tests of Normality							
	Genre	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
Official Exam Single Sex	Boys	.142	126	.000	.763	126	.000
	Girls	.150	322	.000	.854	322	.000
a. Lilliefors Significance Correction							

Test Statistics[a]	
	Official Exam Single Sex
Mann-Whitney U	17963.500
Wilcoxon W	25964.500
Z	-1.885
Asymp. Sig. (2-tailed)	.059
a. Grouping Variable: Genre	

Hemispheres

This category answers the following question "To what extent is there a significant difference in the left-right brain hemisphere between boys and girls in grade 9 and grade 12 in Lebanese public schools?" through students' Left Right Brain Dominance Test. The researchers hypothesized that boys possess more left-brain hemisphere dominance than girls in grades 9 and 12 in Lebanese public schools.

Chi square test was conducted to test the hypothesis, and the results showed that $\chi 2(1)=255,024$ and $p<0,01$which means that there is a dependence between the two variables so there is a significant difference between males and females concerning left hemisphere in favor of males as shown in table 7.

Table 7: Chi-square

Chi-Square Tests

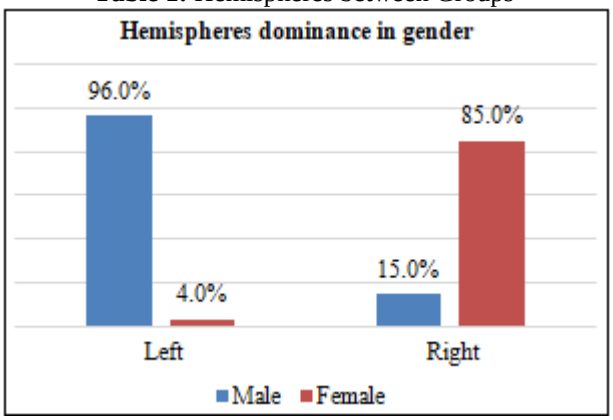
	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	258.504[a]	1	.000		
Continuity Correction[b]	255.024	1	.000		
Likelihood Ratio	293.815	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	257.823	1	.000		
N of Valid Cases	380				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 55.97.					
b. Computed only for a 2x2 table					

It is noticed that $\chi^2(1)=258.024$ and p<0,001 which means that there is a dependence between the two variables so there is a significant difference between males and females concerning hemispheres (table 53)

Table 7: Hemisphere group cross tabulation

Hemisphere * Group Crosstabulation					
			Group		Total
			Male	Female	
Hemisphere	Left	Count	218	9	227
		% within Hemisphere	96.0%	4.0%	100.0%
	Right	Count	23	130	153
		% within Hemisphere	15.0%	85.0%	100.0%
Total		Count	241	139	380
		% within Hemisphere	63.4%	36.6%	100.0%

Table 1: Hemispheres between Groups



Document analysis (workshop)
All teachers of public schools attended same workshop regardless of the school they teach in whether single-sex school or coeducational. To begin with workshop brochures collected from the ministry of education, they showed that teachers who attended different workshops were introduced first to the way of preparing lesson plans through (a) exhibiting broad clarity of instruction, (b) Creating a relaxed and a task-focused environment (c) managing behavioral problems in math class, (d) and demonstrating alternative approaches for responding to problems. In the workshop, teachers were introduced to solutions to various behavioral problems hindering their teaching and their students' learning experience which means they had not been subject to workshop on gender education in math.

Math and science teachers underwent a training that enabled them acquire skills for designing activities and skills that encouraged students to use different math and science skills in the classroom and everyday life mainly in economics and sociological situations presented in different models. None of these workshops showed the difference in activities between different gender in the classroom; hence, they all focused on both genders.

Teachers were exposed to active learning methods in math classroom versus traditional ways of teaching. Technology was a basic concept in many workshops beginning with the use of excel sheets and power point presentations to more advance technologies like active board in both science and math classes. As a conclusion, scientific curiosity was brought up to math and science teachers in one of the workshops, where teachers were taught how to respect the students' curiosity, help them ask meaningful questions, and guide them to find the answers by themselves. Again, none of these workshops showed the difference in skills and strategies between different gender in the classroom; hence, they all focused on both genders.

5. Discussion and Conclusion

The aim of the present study was to (a) examine whether gender differences in mathematics achievement vary between girls and boys in grades 9 and 12 attending single-sex and coeducational schools in Lebanon (b) study if there a significant difference in the left-right brain hemisphere between boys and girls in grade 9 and grade 12 in Lebanese public schools and (c) check if teachers exposed to professional development opportunities regarding implementing instructional strategies for boys and girls in grade 9 and grade 12 in single-sex and coeducational Lebanese public schools

Gender Gap in Math Achievements between single-sex and co-educational schools. The results of official exam grades showed significant difference in math achievement for boys and girls in single-sex schools and co-educational schools in favor of co-educational setting for boys and in favor of single-sex setting for girls.

The findings agree with the views of Wilder, et, al. that certain theories look at the biological differences between genders and intrinsic differences in brain development and causes a gender gap in mathematics achievement between the sexes [69]. Within the theoretical framework, the theme of boys versus girls revealed how they learn differently based upon brain theory which shows that males have a larger inferior-parietal lobule (IPL), the part responsible for numerical brain function, than females which influences mathematical ability and achievement; this may explain why males outperform females in mathematics exams [31]. For this reason, the findings of this study were in line with brain theory and obtained that males are better than females in mathematics; additionally, the results of this study were

supported by Bandura's social learning theory which emphasized how one's social settings influence one's learning. The findings of this study showed that female teachers could affect positively girls' math performance in single sex schools, as compared to their counterparts in coeducational schools

The findings of this study showed that the type of schooling was not a major factor affecting students' performance. such findings agree with Marks, & Byrd, Rowe , and 39], Benson, and McFarland who stated that girls benefit more from a single-sex educational and score higher than boys in single-sex schools [36] [50] [39]. Similarly, results agree with Van de Gaer et al. who found out that single-sex schools had no critical impact on male students' achievement, however, for female students, it had a huge constructive outcome on math achievement Thus, the hypothesis "females have a better math achievement when enrolled in a single-sex school" could be supported [70].

On the other hand, results do not agree with Mulholland, Hansen, and Kaminski and McFarland, Benson, and McFarland who affirmed that boys in single-sex schools had higher mathematics achievement than boys in the coeducational schools [44] [39]. Thus, the hypothesis "males have a better math achievement when enrolled in single-sex school" could not be supported.

Some explanations to such different results might be related to (a) different and difficulty level of the tests administered by different researchers; (b) school type: in this study, only public schools in Beirut were considered for the study while other schools could be private and (c) grade levels chosen the study; in this study, grades 9 and 12 were chosen considering that the official exams results were chosen as standardized tests

Also, final results do not agree with Guarisco who stated that students of both genders do better in single-sex schools because teachers tend to use a variety of teaching strategies and activities, particularly in mathematics and language classes [26].

Hemispheres

Another question that guided this study was "to what extent is there a significant difference in the left-right brain hemisphere between boys and girls in grades 9 and 12 in Lebanese public schools?" The researcher aimed at testing the hypothesis that "Boys possess more left-brain hemisphere dominance than girls in grades 9 and 12 in Lebanese public schools." The hypothesis was tested through a students' Left Right Brain Dominance Test.

Chi square test was conducted to test the hypothesis and the results showed that there was a significant difference between males and females concerning left hemisphere in favor of males and there was a significant difference between males and females concerning right hemisphere in favor of females. This means that the brain hemisphere of a student whether male or female affects the academic performance of the student.

The findings agree with the views of Maccoby and Jacklin, Kimura & Hampson, Kimura , Gurian et al.,and Fernandez who stated that boys are more likely to use their left hemisphere and have better spatial skills than females, hence, impact student achievement in mathematics [37] [35] [34] [24] [17]. Additionally, Shapka and Keating found that when girls work in small girls' group, they feel comfortable with female peers, so they have a tendency to focus on collaboration, rather than on competitive aspects [60].

On the other hand, final results do not agree with Miller who didn't find any significant difference between hemispheres that might affect mathematical achievement and whose study showed that both boys and girls, when grouped alone, performed better in mathematics than when working with each other [43]. Some explanations to such different results might be related to grade level difference of participants

The results of this study regarding brain dominance should be taken positively as a challenge in the educational environment, specifically for learners and teachers. Students should be aware of their own neurological strengths and weaknesses and should help themselves strengthen the weaker parts where girls should work on strengthening their left part while males should work on strengthening their right part, of their brains. Teachers, on the other hand, should consider teaching strategies of more balanced approach that will equally address the needs of students of both genders. They must recognize the right-brain and left-brain characteristics in their learners for them to plan instructional classroom activities that will stimulate the use of learners' both hemispheres to attain the expected learning outcomes.

Workshops. The researcher wanted to check if teachers have been exposed to professional development opportunities regarding implementing instructional strategies for boys and girls in grades 9 and 12 in single-sex and coeducational Lebanese public schools. It was shown that teachers have been exposed to different professional development opportunities regarding diverse subjects but have not been exposed to professional development opportunities regarding implementing instructional strategies for boys and girls in grades 9 and 12 in Lebanese public schools; this was investigated through analyzing workshop documents, principals' interviews, teacher's questionnaires regarding professional development, classroom observation, and workshop documents.

Neither of the workshops presented by the ministry of education is related to gender difference in math classroom. The results conflict with Salomone whose recommendation was that students' needs should be met by providing more professional development to teachers regarding gender differences in mathematics; besides, the lack of professional development prevented teachers from dealing with the specific needs of boys and girls and addressing the strengths of each gender [52]. Also, results do not agree with Thompson and Sax who stated that workshops should allow teachers to understand students and be prepared to deal with students of different genders and provide them with (a) different activities that help both genders grasp different math concepts, (b) diverse ways to recognize how each

gender think, and (c) alternative teaching and assessment methods as part of their practices according to each gender, and (d) different ways to help get rid of gender stereotypes at school [67] [57].

6. Limitations and Future Studies

As a mixed method study, the sample size was limited to nine schools which cannot yield to generalize the results. To build on our findings, further studies could (a) address large sample size in public and private Lebanese schools, and (b) investigate student's perception and attitude about learning Mathematics in single *versus* co-educational public schools in Lebanon.

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