IB MATHEMATICAL STUDIES INTERNAL ASSESSMENT

Handedness vs Grade Point Average

Name: Olivia Braley
Candidate: 2340-071
Date: March 21, 2012
Course: IB Mathematical Studies
Exam Session: May 2012
Period: 1B

Introduction

Statistically, only approximately 15% of the world population is currently left-handed, and men are twice as likely as women to be lefties. Being a left-handed female myself, I have heard myths all of my life about left-handed people's intelligence, things like "While the general population may be 15% left handed, MENSA membership is populated to 20% left handed people" (Left Handed Facts). Intrigued by the statistics, I decided it would be interesting to do some independent exploratory research in the field of handedness and intelligence.

Statement of Task

In this project, I have elected to investigate the relationship, if any, between the grade point average (GPA) of International Baccalaureate (IB) junior and senior students and handedness when writing. My group of subjects will consist of a minimum of 30 juniors and seniors; however, I aim to collect data from as many students as I am able to in order to achieve the most accurate information possible. Surveying solely students that are enrolled in the International Baccalaureate program will ensure that the coursework is consistent in difficulty level and that the GPAs are weighted the same, with 5.0 being the highest attainable grade point average due to the weighted grade scale of the rigorous classes. I plan to collect data via an online survey. The most efficient way that I can reach the greatest number of students is though the social networking website Facebook.com. In creating a Facebook poll, every one of my friends will be able to see the poll and answer quickly and conveniently from their household. The poll will specify that only IB junior and senior students should answer. After collecting sufficient data, I will process it through a variety of charts; I plan to visually display my data in the form of a pi chart, comparing the percentage distribution of left and right-handed people's GPA in the IB program, as well as a bar graph comparing the frequency of the GPAs of left-

handed students to that of right-handed students to effectively illustrate if either group shows a consistently higher score. To ascertain if the data I collected shows a significant difference between my observed and expected values, I will then conduct the Chi-Squared Statistic test. Finally, I will evaluate my data and results to draw conclusions about the correlation between International Baccalaureate students' handedness when writing and Grade Point Average. From my collected data, I predict that I will find that a student's handedness and grade point average are independent.

Evidence of Research

I conducted my research in the form of a poll on the social networking website Facebook.com. After creating the poll on the website, it was posted where all of my Facebook friends were able to see it and answer in a quick and convenient manner. Every one of my friends was able to see this poll, but in the designated description space, I provided this supplemental information: "I'm asking only IB students, so please only post if you are in it. For IB students, please post your weighted GPA! Use the GPA on your first marking period report card. If you would like for you GPA to remain confidential, just send me a private message- you will be anonymously put into my data. No one's identity will be disclosed in my final data. Thank you!!" For security purposes, I am unable to replicate this data, but a table with the collected data is composed below.

Mathematical Investigation
Data Collection

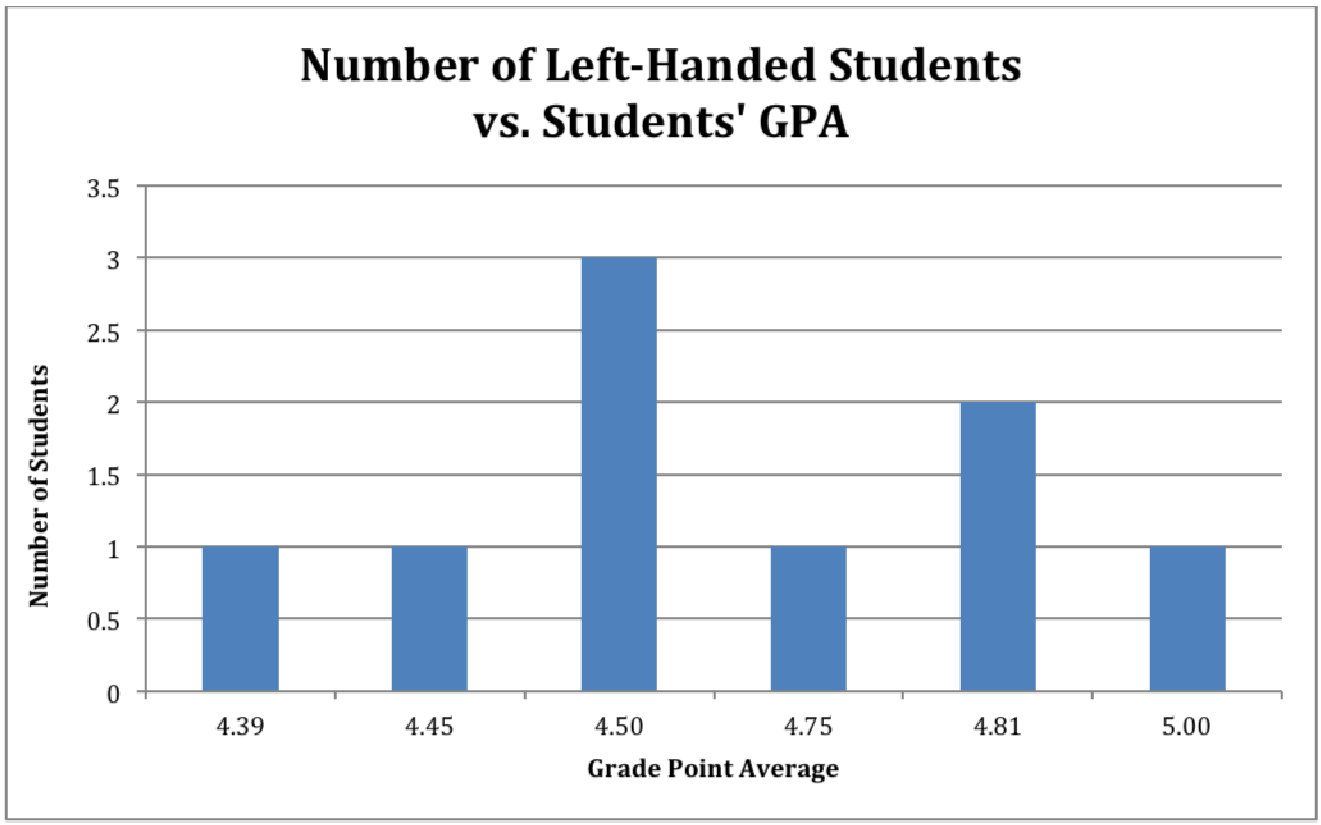
Table A: IB student dominant hand when writing and current GPA

Handedness	GPA
Left	4.81
Right	4.25
Right	4.75
Left	4.50
Left	4.50
Left	4.50
Right	4.75
Left	4.45
Right	4.50
Right	4.50
Right	5.00
Right	5.00
Right	5.00
Left	5.00
Right	4.39
Right	4.39
Right	4.39
Right	4.25
Right	4.47
Right	4.25
Right	4.25
Right	4.63
Right	4.25
Right	4.13
Right	4.13
Left	4.39
Right	4.13
Right	4.13
Right	4.81
Right	4.81
Right	4.81
Right	4.81
Right	4.95
Left	4.75
Right	4.81
Right	4.81
Left	4.81

This table contains the handedness of the 39 surveyed IB students (left column) and their corresponding GPA (right column). For anonymity and to prevent bias, their names, gender, and all other identifying information has been omitted from the data investigation.

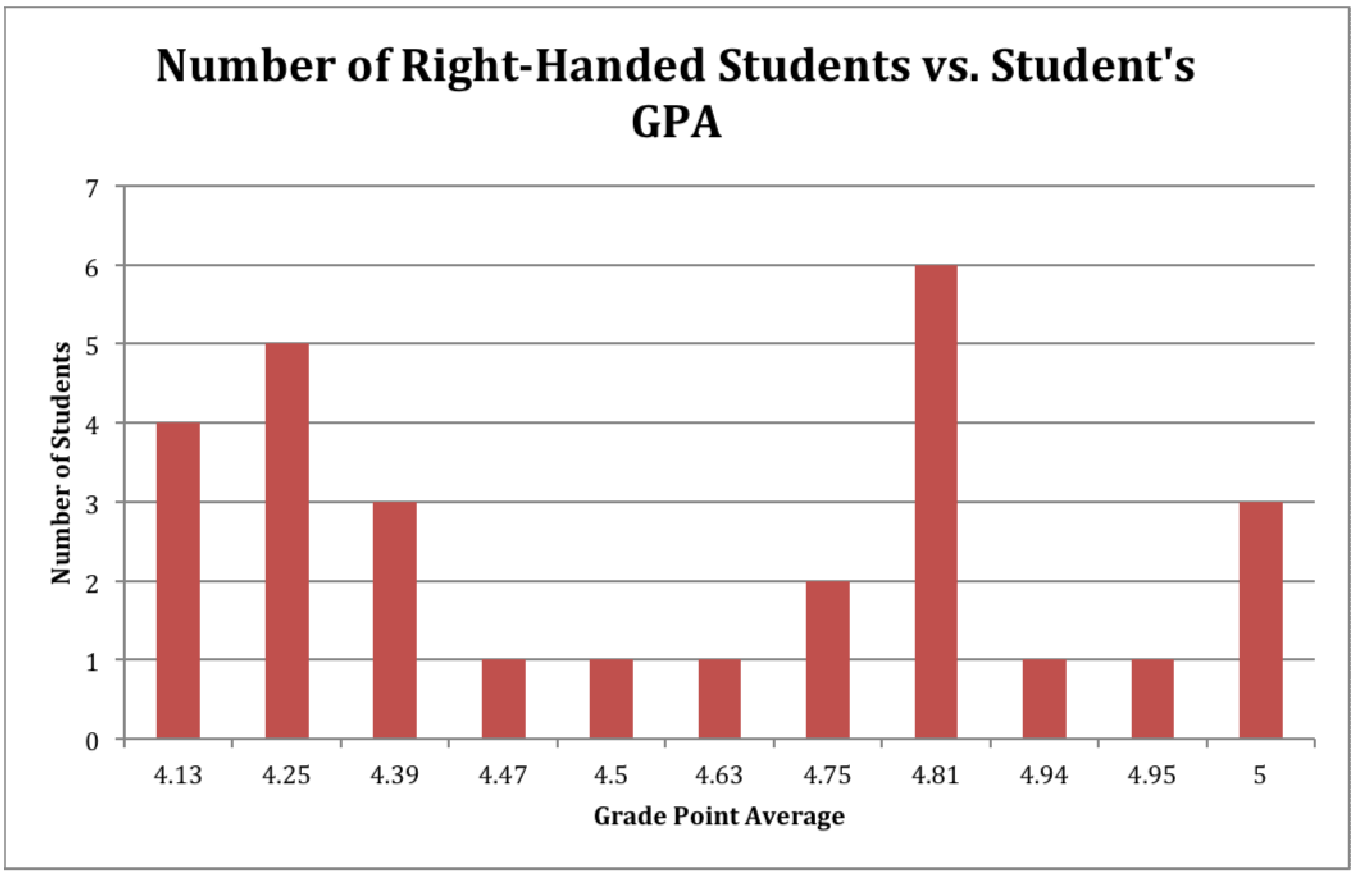
Right	3.75
Right	4.94

Graph A: Number of Left Handed Students vs. Left-Handed Students' Current GPA



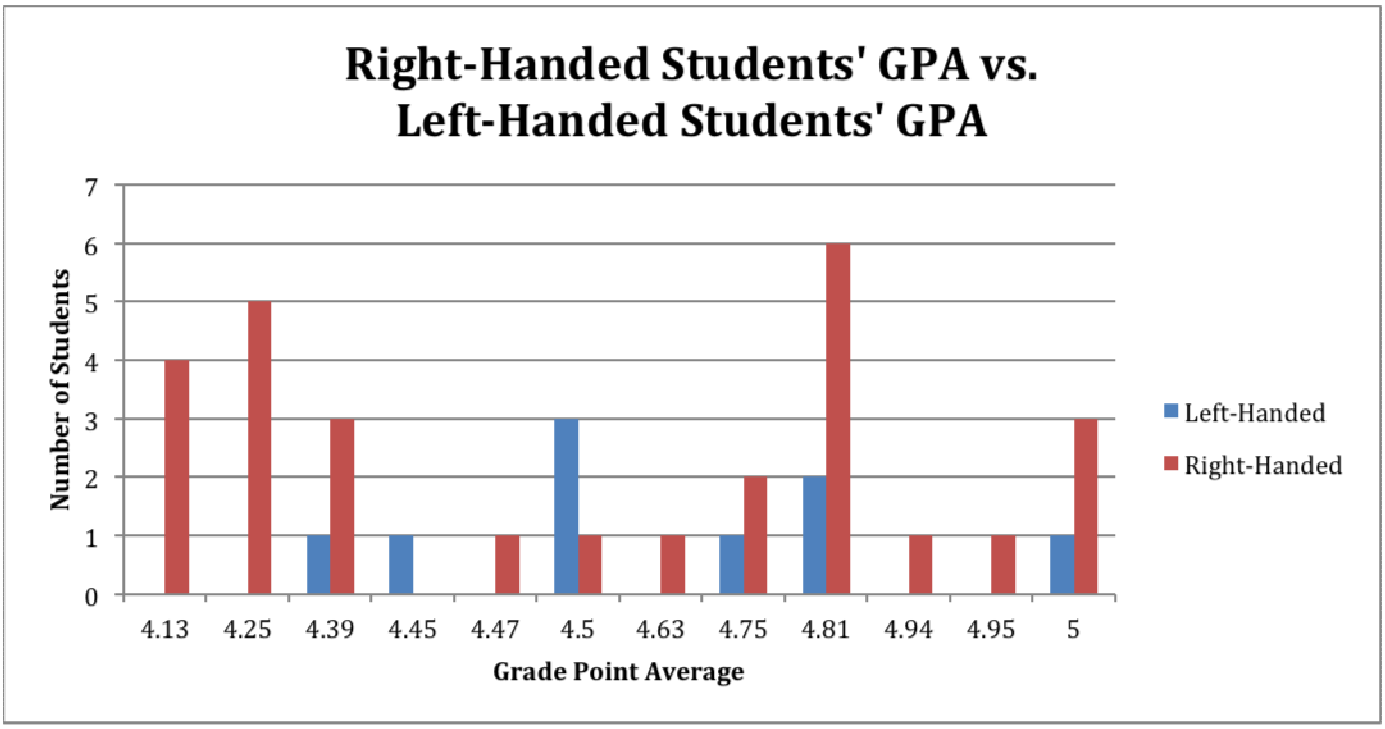
This histogram depicts the GPAs of left-handed students and the frequency of the number of students with that GPA. It is represented in a bar graph of the frequency distribution of the various GPAs of left-handed students such that the height of the bar corresponds to the number of students with that GPA. It is significant in depicting which averages are the most and least common for left-handed students for the purpose of comparison with the right-handed counterparts.

Graph B: Number of Right-Handed Students vs. Right-Handed Students' GPA



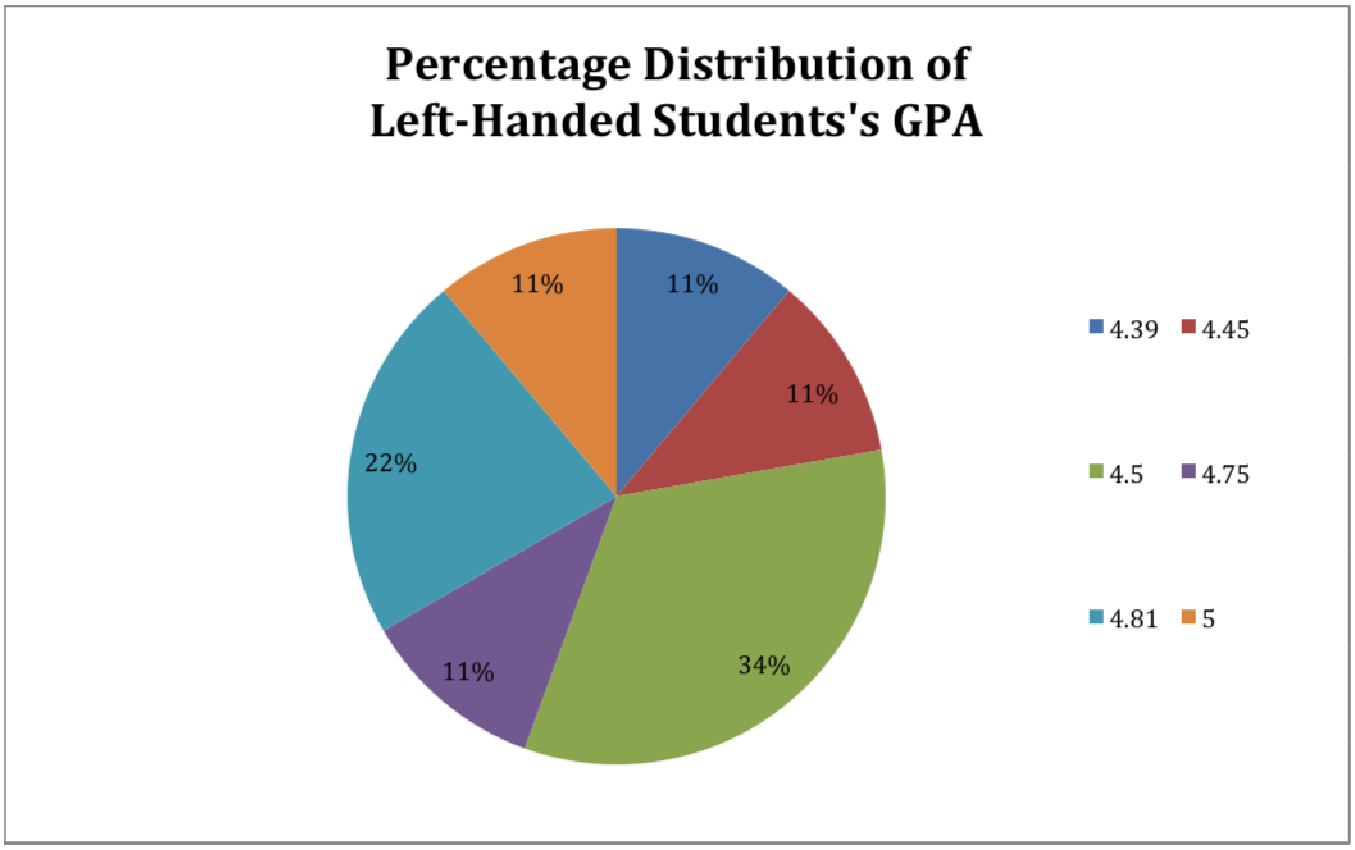
This histogram depicts the GPAs of right-handed students and the frequency of the number of students with that GPA. It is represented in a bar graph of the frequency distribution of the various GPAs of right-handed students such that the height of the bar corresponds to the number of students with that GPA. It is significant in depicting which averages are the most and least common for left-handed students for the purpose of comparison with the right-handed counterparts.

Graph C: Right-Handed Students' GPA vs. Left-Handed Students' GPA



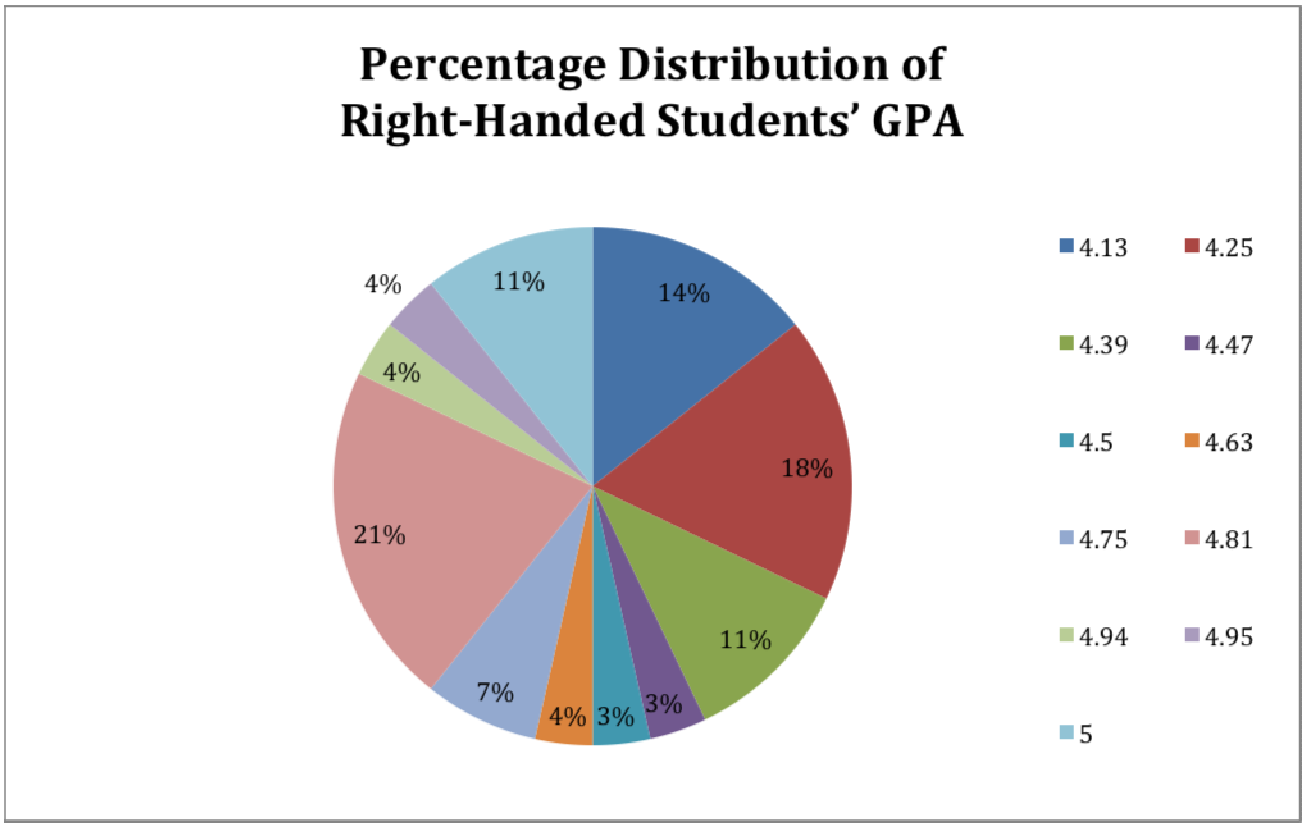
This histogram combines the two preceding histograms in order to compare the frequency of the GPAs of right and left-handed students. It is represented in a bar graph of the frequency distribution of both left and right-handed students such that the height of the bar corresponds to the number of students who currently have that GPA. It depicts the frequencies of the various GPAs of left and right-handed students in a singular unifying histogram so as to clearly compare the data attained from both groups.

Graph D: Percentage Distribution of Left-Handed Students' GPA



This pie chart creates a visual aid to depict the percentage distribution of the GPAs of left-handed students. It serves as another way to display the frequency and distribution of the GPAs of left-handed IB students.

Graph E: Percentage Distribution of Right-Handed Students' GPA



This pie chart creates a visual aid to depict the percentage distribution of the GPAs of right-handed students. It serves as another way to display the frequency and distribution of the GPAs of right-handed IB students.

Calculation of Chi-Squared (x^2) Test

Chi-squared tests evaluate the observed and expected frequencies of a set of collected data in order to determine if there is a significant difference between then. It is determined with the equation:

$$x^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

Observed Values (variables)

GPA / Dominant Writing Hand	4.0-4.2	4.21-4.4	4.41-4.6	4.61-4.8	4.81-5.0	
Left Hand	a	b	c	d	e	$a+b+c+d+e$
Right Hand	f	g	h	i	j	$f+g+h+i+j$
Total	$a+f$	$b+g$	$c+h$	$d+i$	$e+j$	$a+b+c+d+e+f+$

Expected Values (variables)

GPA / Dominant Writing Hand	4.0-4.2	4.21-4.4	4.41-4.6	4.61-4.8	4.81-5.0	Total
Left Hand	$(a*f)/N$	$(b*f)/N$	$(c*f)/N$	$(d*f)/N$	$(e*f)/N$	f
Right Hand	$(a*g)/N$	$(b*g)/N$	$(c*g)/N$	$(d*g)/N$	$(e*g)/N$	g
Total	a	b	c	d	e	N

Null Hypothesis:

Students' GPA and dominant hand when writing are independent.

Alternative Hypothesis:

Students' GPA and dominant hand when writing are not independent.

GPA / Dominant Writing Hand	4.0-4.2	4.21-4.4	4.41-4.6	4.61-4.8	4.81-5.0	Total
Left Hand	0	1	4	1	3	9
Right Hand	4	8	2	3	11	28
Total	4	9	6	4	14	37

Table D: Observed Values

Calculation of Expected Values

$$(a * f)/N = \frac{(4 * 9)}{37} = \frac{36}{37} = 0.97 = 1$$

$$(b * f)/N = \frac{(9 * 9)}{37} = \frac{81}{37} = 2.19 = 2$$

$$(c * f)/N = \frac{(6 * 9)}{37} = \frac{54}{37} = 1.46 = 1$$

$$(d * f)/N = \frac{(4 * 9)}{37} = \frac{36}{37} = 0.97 = 1$$

$$(e * f)/N = \frac{(14 * 9)}{37} = \frac{126}{37} = 3.41 = 3$$

$$(a * g)/N = \frac{(4 * 28)}{37} = \frac{112}{37} = 3.03 = 3$$

$$(b * g)/N = \frac{(9 * 28)}{37} = \frac{252}{37} = 6.81 = 7$$

$$(c * g)/N = \frac{(6 * 28)}{37} = \frac{168}{37} = 4.54 = 5$$

$$(d * g)/N = \frac{(4 * 28)}{37} = \frac{112}{37} = 3.03 = 3$$

$$(e * g)/N = \frac{(14 * 28)}{37} = \frac{392}{37} = 10.6 = 11$$

GPA / Dominant Writing Hand	4.0-4.2	4.21-4.4	4.41-4.6	4.61-4.8	4.81-5.0	Total
Left Hand	1	2	1	1	3	8
Right Hand	3	7	5	3	11	29
Total	4	9	6	4	14	37

Table F: Expected Values

The expected values in the table above are shown as rounded to the nearest whole number for the purpose of maintaining a simple and concise table. However, in the chi-squared calculations done by hand (x^2_E) in Table G, the values were used to three significant figures (see Calculation of Expected Values, page 11) for more accurate data.

Degrees of Freedom

The degree of freedom dictates the acceptable amount of variance in the final statistical calculation. It is determined with the equation:

$$df = (amount\ of\ rows - 1)(amount\ of\ columns - 1)$$

Calculation of Degrees of Freedom

$$df = (2 - 1)(5 - 1)$$

$$df = (1)(4)$$

$$df = 4$$

Table G: Calculation of Chi-Squared (x_a^2)

f_o	f_e	$f_o - f_e$	$(f_o - f_e)^2$	$(f_o - f_e)^2 / f_e$
0	0.973	-0.973	0.947	0.976
1	2.19	-1.19	1.41	0.646
4	1.46	2.54	6.46	4.43
1	0.973	0.027	0	0
3	3.41	-0.405	.164	0.048
4	3.03	0.973	0.947	0.312
8	6.81	1.19	1.41	0.208
2	4.54	-2.54	6.46	1.43
3	3.03	-0.030	0	0
11	10.6	0.405	0.164	0.015

Values are shown exact or rounded to 3 significant figures when necessary. Exact values were used for all numbers when doing x^2calculations in a TI-84 calculator.

$$x^2 = 0.976 + 0.646 + 4.43 + 0 + 0.048 + 0.312 + 0.208 + 1.43 + 0 + 0.015$$

$$x^2 = 8.065474057$$

Rounded to 3 significant figures: $x_a^2 = 8.07$

Chi-Squared Test Verification

To verify my chi-squared level of significance result, I preformed a second x^2-test (x^2_{calc}) in my TI-84 calculator. To do this, I first went to $2^{nd} + x^{-1}$ to get to the Matrix screen. I arrowed over to the right 2 times, to the Edit column, and entered my observed values, seen in Table D, into a 2x5 matrix in Matrix [A]. I then went to $2^{nd} + 0$ to get to the Catalog screen, and arrowed down until I found x^2-test, which I selected. In my calculator screen, I think hit $2^{nd} + x^{-1}$ to get back to the Matrix screen. I selected [A], and then went back to the Matrix screen and selected [B] in order for the chi-squared test to be performed in both of the matrices. The calculator gave

me the answers $x^2_{calc} = 8.04$, which is an insignificant 0.03 difference from my manually attained x^2_{α} value of 8.07, and $df = 4$, which agrees with my manually attained degree of freedom. It is reasonable to assume that the slight difference in numbers is due to the fact that the manual x^2-test was calculated to 3 significant figures and the calculator x^2-test was calculated to further decimal places, making the answer slightly more accurate. Furthermore, it is logical to use the more accurate of the two values, x^2_{calc}, and henceforth assume that $x^2 = 8.04$.

Chi-Squared Analysis

At a 5% level of significance, the x^2 critical value with 4 degrees of freedom is 9.49. The x^2 critical value is therefore less than the determined x^2 value, 8.04>9.49, so the null hypothesis is accepted; thus, it can be assumed that students' handedness when writing and GPA are independent.

Discussions and Validity

Limitations

In the course of my investigation, there were a number of variables that could have affected the data.

One limitation is that the only data reflected is from my personal friends on Facebook. Students who do not have Facebook and/or are not friends with me on the social networking site would not have been able to submit their data into my survey.

Secondly, because only my personal Facebook friends were privy to my data collection, the data comes solely from student who attend my high school. This entails that while the data is a most likely a relatively accurate reflection of the relationship between Grade Point

Average and handedness at my high school, because the data is limited to such, there is no information regarding its accuracy for students in other places in the world.

Continuing, because I am currently in 11th grade (junior), more of my friends on Facebook are juniors as well, and thus, more of the data collected is from juniors than 12th grade seniors.

Another limiting factor is that of the handedness itself. As stated in the introduction, left-handedness is far less common than right-handedness, and because of that, approximately 78% (29/37) of my data was from students who identify themselves as right-handed, whereas only 22% (8/37) of the students identified as left-handed. Because of this, there is a comparatively insufficient amount of data about left-handed students. Ideally, there would be an equal or nearly equal amount of left and right-handed participants.

Conclusion

Despite the limitations, the determined x^2 value, 8.04, is still a valid result. The value decisively rejects the null hypothesis that handedness and GPA are independent and accepts the alternative hypothesis that students' GPA is dependent on their dominant hand when writing, despite the above limitations. To apply this to my introduction and the purpose of my project, this value entails that despite the claims that left-handed people are more intelligent, based on IB students' grade point averages, there is no statistical evidence that can conclusively prove that there is a difference in the intelligence level of left-handed students in comparison to their right-handed counterparts.

Works Cited

"Left Handed Facts." *Left Handed Facts*. PJC Associates, 2012. Web. 15 Dec. 2011. <http://lefthandedfacts.net/>.