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Music: Helpful or Hindering?

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Honors Thesis

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Abstract

This study looked at the effects of playing music while students complete a quiz. 191 students from the Helena School District between the eighth and tenth grades took an assigned quiz either silently or while listening to one of three tested music types. The songs used were *Royals* by Lorde to represent popular music, *She's Gone* by Hall and Oates to represent lesser known music, and *Symphony No. 25 in G Minor* by Mozart to represent classical music. The students were timed as they worked. These times were statistically analyzed to determine if playing music while students worked caused them to spend more time on the assignment. Next, the quizzes were all corrected. The numbers of correct answers were statistically analyzed to determine if playing music had an effect on the number of correct answers on the quizzes. From the analysis, there was not sufficient evidence that playing music had an effect on the time it took to complete the quiz or on the number of correct answers. There was no evidence that any one type of music was more helpful than any other or than none at all. There also was no evidence that any one type of music hindered student performance either.

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Introduction

As a future educator, I want to give my students the best experience in the classroom possible with the technology available. In this day and age, students are constantly bombarded with media in the form of television, music, and advertisements. In the classroom, many teachers play music while students complete seat work. As a student myself, I listen to music while I study or work on homework. I have wondered if this distracts me while I work or helps me study. I decided to conduct this study to determine if playing music while doing schoolwork is distracting or helps students perform better.

Methods

For this experiment, students were randomly assigned into four groups. Each group took the same quiz, either in silence or while listening to one of three different types of music. We timed each student and recorded the data. We then used an ANOVA analysis to compare all four groups at once and z-statistics to compare two groups at a time. We finally corrected the quizzes and analyzed the number of correct answers using ANOVA and z-statistics again.

In order to complete this experiment, we needed a pool of students to study. I will be certified to teach secondary education and therefore wanted my experiment to be on students at the level I will teach. For this reason, we chose an eighth grade class at Helena Middle School and two high school classes with grades nine and ten, one from Capital High School and the other from Helena High School. Each teacher let me test four periods of their classes, resulting in a total sample of 191 students.

We wanted the quiz to be equally difficult for all students; therefore, we used patterning questions instead of mathematical topics. These questions were found on an online IQ test ("Mathematical intelligence," 2011). However, patterning questions can be interpreted a variety of ways and there may be more than one correct answer for each problem. For this study, I only accepted one answer as correct for each question. I gave the same quiz to every student to reduce bias in my study. The quiz and answers can be found in Figure 1.

Figure 1: Assigned Quiz

Time_____

1. Which number should come next in this series?

   25, 24, 22, 19, 15

   10

2. Which number should replace the question mark?

17	8	5	5
13	7	5	4
6	12	6	3
10	6	4	?

   4

3. Earth is to 39672 as terha is to_____.

   73629

("Mathematical intelligence," 2011)

Statistical experiments require randomness, so we had to be sure every student had an equal probability of getting into each group. To be sure we met this requirement, we entered student names into a Microsoft Excel file. We used the randomizer function to assign each student a number. We then reordered the names numerically. We assigned the first quarter of the students to the first group, the control group. These

students took the quiz without any type of music playing. The second quarter of students was assigned to the second group. This group listened to the song *Royals* by Lorde while taking their quizzes. This song is known by almost everyone and is played frequently on the radio. This group was the popular music group. The next quarter of the class was assigned to group three, the lesser known music group. They listened to *She's Gone* by Hall and Oates. This song was a lesser known song. The last quarter of the classes was assigned to the fourth group. This group took their quiz while listening to *Symphony No. 25 in G Minor* by Mozart. This was the classical music group.

After randomly assigning students, we conducted our experiment. Each group took turns taking the quiz. All the students in the control group went first. The quizzes were set face-down on the students' desks. Students were instructed to wait until we instructed them to turn the quizzes over and begin. This method ensured accurate times and that students were not able to work on their quizzes in their heads, biasing the results. When the students were finished they raised their hands. When a hand went up, we used the split function on our stopwatch to record the student's time. We told them their place in their group (e.g. 1^{st}, 2^{nd}, 3^{rd}) and they wrote that number on their quiz. Once everyone in the group was finished, we collected the quizzes and recorded each time on the respective quiz. We repeated this process for each of the four groups for each class to collect our data.

Once all of the data was collected, we statistically analyzed the results. We used Excel to organize the data into tables and calculate the means and standard deviations

of each group. We used these values to analyze the results with an ANOVA test and z-statistics to determine if playing certain types of music while students work affects the time they take to complete assignments. We could use z-testing verses others such as t-tests because we had a sufficiently large sample size. Once we completed the analysis of the times, we corrected each quiz. We then recorded the number of correct answers for every quiz. We then used ANOVA and z-statistics again to determine if playing certain types of music while students work affects the number of correct answers they get on an assignment.

Results and Analysis

Before we could do any analysis, we needed to state on a hypothesis and an alpha value. Our null hypothesis was that the mean of one group was the same as the mean for another group:

$$H_0: \mu_a = \mu_b.$$

Our alternative hypothesis was that the means were different:

$$H_1: \mu_a \neq \mu_b.$$

Our alpha value was 0.05, making our critical z-value ± 1.96.

First, we analyzed the results of the times it took for students to complete the quizzes. We did this to determine whether or not listening to music, or certain kinds of music, made it more difficult for students to focus on their work. Second, we analyzed the results of the number of correct answers on each quiz. We did this to determine

whether or not listening to music or certain kinds of music made it more difficult for students to focus on their work.

Results of the Total Time Taken to Complete the Quizzes

Once we collected data from the four groups of students, we put it into tables and sorted it fastest to slowest. We then used the mathematical software R to create histograms and QQ plots of the data. Next, we calculated the sample mean $(\bar{x})$ and the sample standard deviation(s). The results of this analysis can be found in Table 1. Once this was done for each set of data, we completed an ANOVA analysis of the data using Excel to compare all five groups at once. Finally, we used z-statistics to compare pairs of groups to determine the effects of music in the classroom.

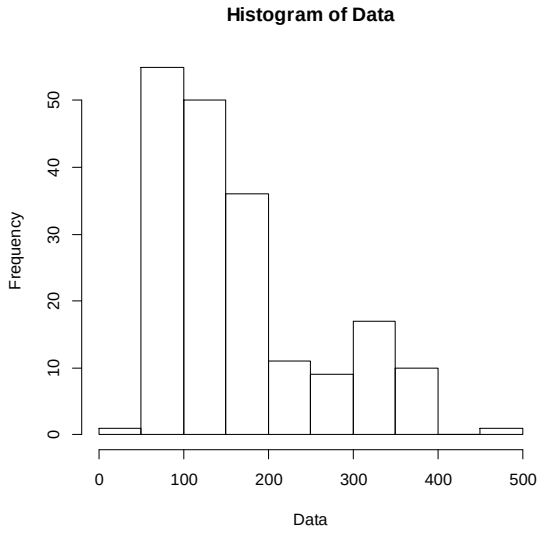
Table 1: Results of the Time to Take the Quiz

	Group 1: Control	Group 3: Popular Music	Group 4: Lesser Known Music	Group 5: Classical Music
Mean	173.8	153.5490196	174.4090909	159.2666667
Standard Deviation	87.21589445	87.29703631	103.9166299	96.9897839
Number in Sample	51	51	44	45

All Collected Data

First we looked at all of the data. We created a histogram of the data. It is found in Figure 2.

Figure 2: Histogram of the Data



The data was not normally distributed; however since we had a sample size of 191, the Central Limit Theorem applies. This theorem states that the sample mean follows a normal distribution regardless of how the population is distributed. (Cline, Central Limit Theorem). Therefore, we could use z-statistics to analyze this data set.

We wanted to be sure that the data was not normally distributed because we used different age groups. Therefore, we created histograms of the data collected from the middle school, Figure 3, and the data collected from the high schools, Figure 4.

Figure 3: Histogram of Data from the Middle School

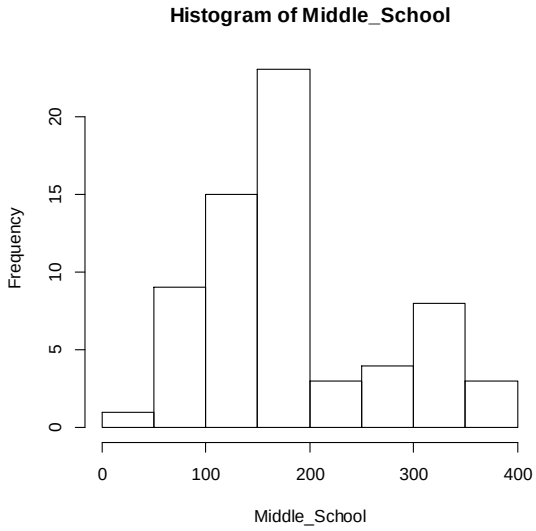
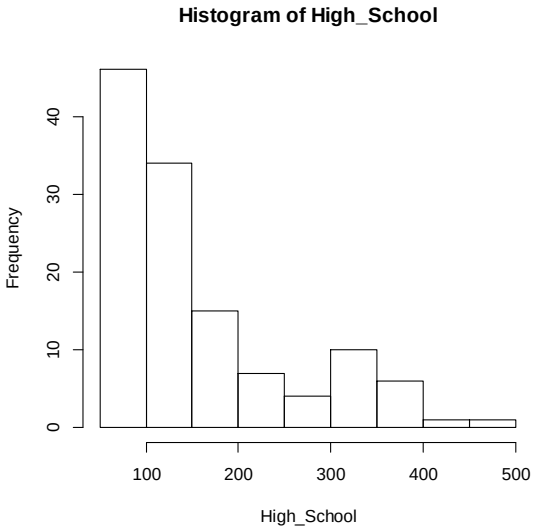


Figure 4: Histogram of Data from the High Schools



To determine whether or not this difference is the case, we used an ANOVA analysis to be sure that there was not a difference between the two age groups. We needed a critical value of 3.89 to say there was variation between the groups. The test statistic for the age groups was 3.75; therefore we could not say that the variation in times was due to the different ages. Because of this result, we analyzed the tested groups with both middle and high school times combined.

Control Group

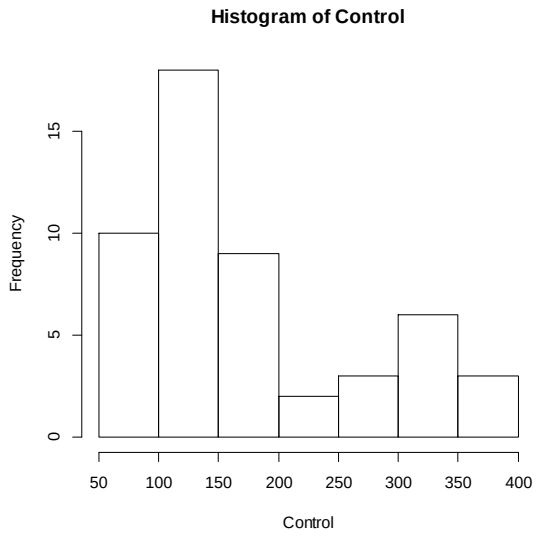
The first group of data we analyzed was the control group. The times for the group can be found in Table 2.

Table 2: Times of the Control Group

Times (in Seconds)								
56	85	111	127	138	176	200	310	354
72	91	116	128	138	179	226	311	363
74	94	119	129	139	188	235	324	378
76	100	119	134	150	190	261	329	
78	103	120	138	172	191	270	339	
85	106	125	138	173	198	271	341	

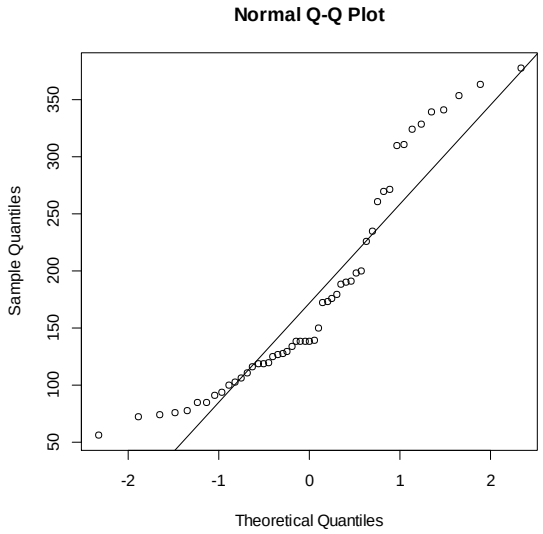
Using this data, we created a histogram which can be found in Figure 5.

Figure 5: Histogram of the Control Group



The mean time for the control group was 173.8 seconds with a standard deviation of 87.25 seconds. There are 51 in this sample so though the data is not normal, the Central Limit Theorem applies. However, we used R to make a QQ plot to examine the normality of the data. The plot can be found in Figure 6.

Figure 6: QQ Plot of the Control Group



This shows again that the data is not normally distributed.

Popular Music Group

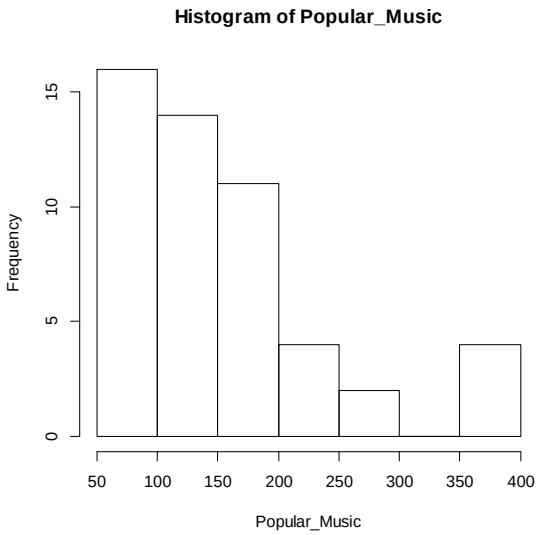
Next, we analyzed the data collected from the popular music group. The times for this group can be found in Table 3.

Table 3: Times from the Popular Music Group

Time (in seconds)								
51	76	93	112	128	151	164	242	371
54	77	93	118	130	151	164	247	391
62	77	96	121	132	152	166	249	391
66	84	98	121	133	158	175	284	
67	90	101	127	139	161	187	299	
73	90	112	128	144	161	212	362	

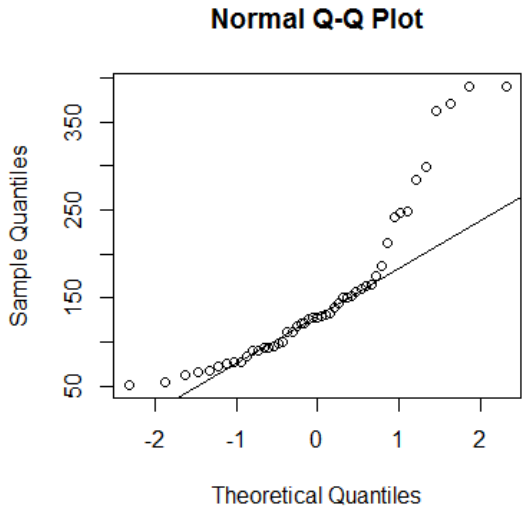
The mean time for this group is 153.5 seconds with a standard deviation of 87.30 seconds. There were 51 times in this group. Using this data, we created the histogram found in Figure 7.

Figure 7: Histogram of the Popular Music Group



This histogram shows that this data is not normally distributed. Again, we made a QQ plot of the times to examine this in a different format. The plot can be found in Figure 8.

Figure 8: QQ Plot of the Popular Music Group



This shows again that the data is not normally distributed. There are tails on both ends that do not follow the line. However, we have a sufficient sample size so the Central Limit Theorem applies to this group.

Lesser Known Music Group

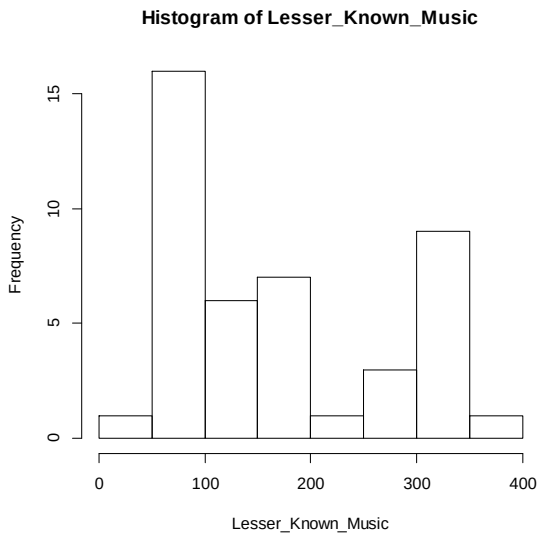
The third group of data that we analyzed was the lesser known song group. The times for this group can be found in Table 4.

Table 4: Table of Times for Lesser Known Music Group

Time (in seconds)								
31	79	90	99	114	164	223	316	332
67	79	90	100	116	170	290	318	343
69	88	95	103	133	173	300	320	344
71	89	96	104	151	176	300	324	363
74	90	97	112	154	184	316	327	

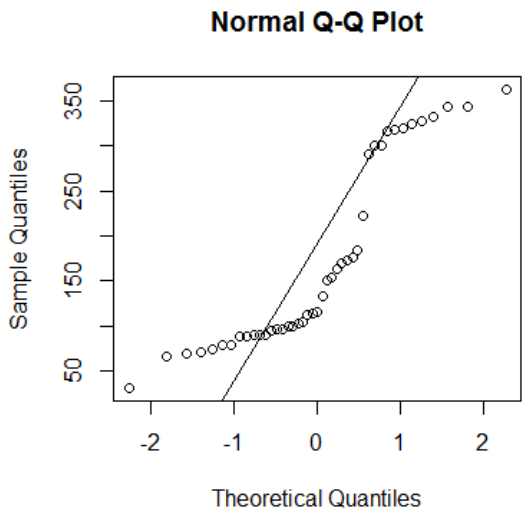
The mean for this group was 174.4091 seconds with a standard deviation of 103.9166 seconds. To examine the normality of this group, we created the histogram that can be found in Figure 9.

Figure 9: Histogram of the Lesser Known Music Group



There were 44 samples in this group, so the Central Limit Theorem applies; however, we created a QQ Plot for this data set. The plot can be found in Figure 10.

Figure 10: QQ Plot of the Lesser Known Music Group



Though the data does not appear to be normally distributed, we analyzed it.

Classical Music Group

The last group of data we analyzed was the classical music group. The times for the group can be found in Table 5.

Table 5: Times for the Classical Music Group

Time (in seconds)								
52	72	88	103	126	138	178	203	306
60	72	92	110	126	151	178	225	312
65	81	95	113	128	152	193	226	370
65	85	100	115	132	154	197	271	373
65	87	101	117	135	158	198	304	495

The mean time for the classical music group was 159.3 seconds with a standard deviation of 96.99 seconds. To examine the normality, we created a histogram of the data. It is found in Figure 11.

Figure 11: Histogram of the Classical Music Group

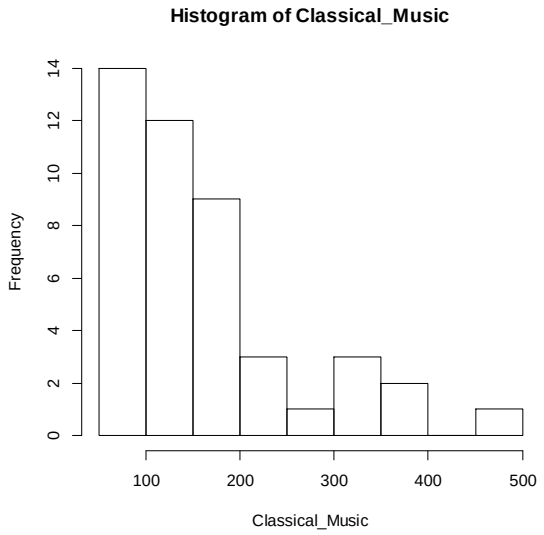
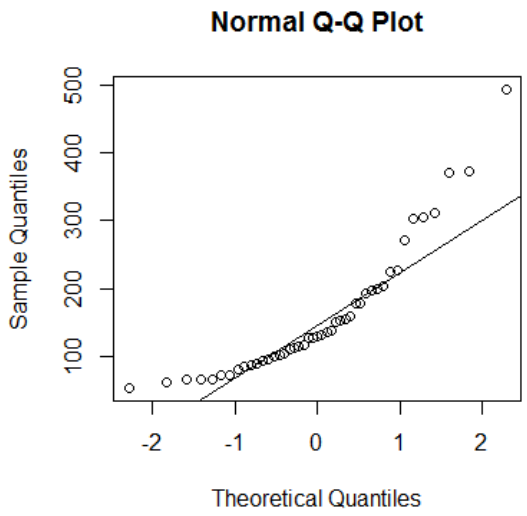


Figure 11 shows that the data for this group is not normally distributed. To examine the data in another format, we created a QQ plot of the data, found in Figure 12.

Figure 12: QQ Plot of the Classical Music Group



This plot reflects the histogram showing the data is not normally distributed. We can still analyze the data because of the Central Limit Theorem.

Analysis of the Total Time Taken to Complete the Quizzes

We compare the data in two ways. First we used Excel to do an ANOVA analysis to determine if playing music while students work caused them to take longer to complete their work. We then used z-statistics to compare two groups at a time to determine whether certain types of music caused students to work longer. From our ANOVA analysis, we got a test statistic of 0.57. This is smaller than our critical value of 3.89; therefore we cannot say that playing music while students work helps them perform faster than working in a quiet environment. However, we also cannot say it causes them to perform slower.

Next, we compared the sets of data against each other. As there were more than 30 in each sample, we could use z-statistics. The equation to find z-scores can be found in Equation 1.

$$z = \frac{\overline{x_a} - \overline{x_b}}{\sqrt{\frac{s_a^2}{n_a} + \frac{s_b^2}{n_b}}}, \text{where } n_a = \text{the number of samples in group a.} \qquad \text{(Equation 1)}$$

The data used for the analysis can be found in Table 6.

Table 6: Calculations Using in Z-Tests

	Group 1: Control	Group 2: Popular Music	Group 3: Lesser Known Music	Group 4: Classical Music
Mean	$\bar{x}_1 = 177.8$	$\bar{x}_2 = 153.55$	$\bar{x}_3 = 174.41$	$\bar{x}_4 = 159.27$
Standard Deviation	$s_1 = 90.95$	$s_2 = 87.3$	$s_3 = 103.92$	$s_4 = 96.99$
Number in Sample	$n_1 = 51$	$n_2 = 51$	$n_3 = 44$	$n_4 = 45$

Control Group vs. Popular Music Group

The second groups we compared were the control group and the popular music group. We did this to determine if playing well known music in the classroom helps them perform faster, distracts while they work, or has no effect. Our null hypothesis is $\mu_1 = \mu_2$ and our alternate hypothesis $\mu_1 \neq \mu_3$ with an alpha value of 0.05. Again using Equation 3, we calculated the z-score.

$$z = \frac{177.8 - 153.55}{\sqrt{\frac{(90.95)^2}{51} + \frac{(87.3)^2}{51}}} = 1.37$$

Since our critical value is ± 1.96 and $-1.96 \leq 1.37 \leq 1.96$, we failed to reject our null hypothesis.

Control Group vs. Lesser Known Music Group

The next groups we compared were the control group and the lesser known music group. We did this to determine if playing lesser known music in the classroom helps them perform faster, distracts while they work, or has no effect. Our null hypothesis was $\mu_1 = \mu_3$ and our alternate hypothesis was $\mu_1 \neq \mu_3$ with an alpha value of 0.05. Our z-score for these groups were

$$z = \frac{177.8 - 174.41}{\sqrt{\frac{(90.95)^2}{51} + \frac{(103.92)^2}{44}}} = 0.17$$

Since our critical value is ± 1.96 and $-1.96 \leq 0.16 \leq 1.96$, we failed to reject our null hypothesis.

Control Group vs. Classical Music Group

The fourth groups we compared were the control group and the classical music group. We did this to determine if playing well known music in the classroom helps them perform faster, distracts while they work, or has no effect. Our null hypothesis was $\mu_1 = \mu_4$ and our alternate hypothesis was $\mu_1 \neq \mu_4$ with an alpha value of 0.05. The z-score was

$$z = \frac{177.8 - 159.27}{\sqrt{\frac{(90.95)^2}{51} + \frac{(96.99)^2}{45}}} = 0.96$$

Since our critical value is ± 1.96 and $-1.96 \leq 0.96 \leq 1.96$, we failed to reject our null hypothesis.

Popular Music Group vs. Lesser Known Music Group

The fifth groups we compared were the popular music group and the lesser known group. We did this to determine which type of music we should play in the classroom, popular or lesser known music. Our null hypothesis was $\mu_2 = \mu_4$ and our alternate hypothesis was $\mu_2 \neq \mu_4$ with an alpha value of 0.05. We found our z-score to be

$$z = \frac{153.55 - 174.41}{\sqrt{\frac{(87.3)^2}{51} + \frac{(103.92)^2}{44}}} = -1.05$$

Since our critical value is ± 1.96 and $-1.96 \leq -1.05 \leq 1.96$, we failed to reject our null hypothesis.

Popular Music Group vs. Classical Music Group

The next groups we compared were the popular music group and the classical music group. We did this to determine if we should play popular or classical music while students work in the classroom. Our null hypothesis was $\mu_3 = \mu_5$ and our alternate hypothesis was $\mu_3 \neq \mu_5$ with an alpha value of 0.05. Using Equation 3, we found

$$z = \frac{153.55 - 159.27}{\sqrt{\frac{(87.3)^2}{51} + \frac{(96.99)^2}{45}}} = -0.30$$

Since our critical value is ± 1.96 and $-1.96 - 0.30 \leq 1.96$, we failed to reject the null hypothesis.

Lesser Known Music Group vs. Classical Music Group

The last groups we compared were the lesser known music group and the classical music group. We did this to determine if we should play popular or classical music while students work in the classroom. Our null hypothesis was $\mu_3 = \mu_4$ and our alternate hypothesis was $\mu_3 \neq \mu_4$ with an alpha value of 0.05. We found that our z-score was

$$z = \frac{174.41 - 159.27}{\sqrt{\frac{(103.92)^2}{44} + \frac{(96.99)^2}{45}}} = 0.71$$

Since our critical value is ± 1.96 and $-1.96 \leq 0.71 \leq 1.96$, we failed to reject the null hypothesis.

Results of Student Responses

The time it takes students to complete their work is only part of what we wanted to study. For this reason, we also statistically analyzed the student responses. We did this analysis to determine whether or not playing music has an effect on student answers.

We corrected each quiz and put the number of correct answers into tables and sorted the data from the least to most correct answers. Since the data was discrete, there were between zero and three correct answers; the data itself would not be randomly distributed. Again we used the Central Limit Theorem to analyze the data. We used the mathematical software R to create histograms of the data. Next, we calculated the sample mean $(\bar{x})$ and the sample standard deviation(s). The results of this analysis can be found in Table 7. Once this was done for each set of data, we completed an

ANOVA analysis of the data using Excel to compare all five groups at once. Finally, we used z-statistics to compare pairs of groups to determine the effects of music in the classroom.

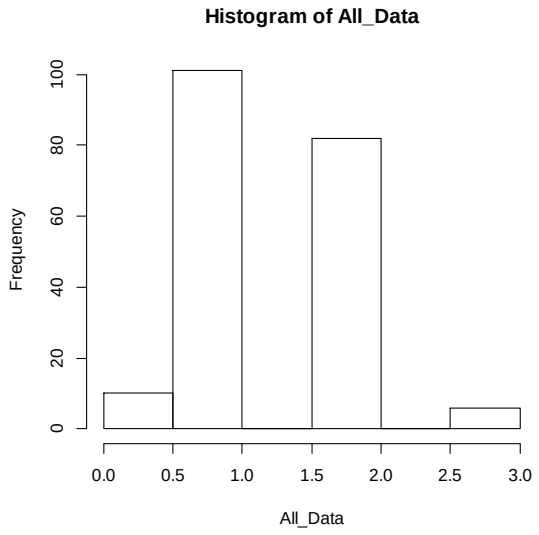
Table 7: Results of Correct Answers

	Group 1: Control	Group 2: Popular Music	Group 3: Lesser Known Music	Group 4: Classical Music
Mean	1.43	1.29	1.41	1.44
Standard Deviation	0.608437407	0.67213444	0.725552935	0.545875259
Number in Sample	51	51	44	45

All Collected Data

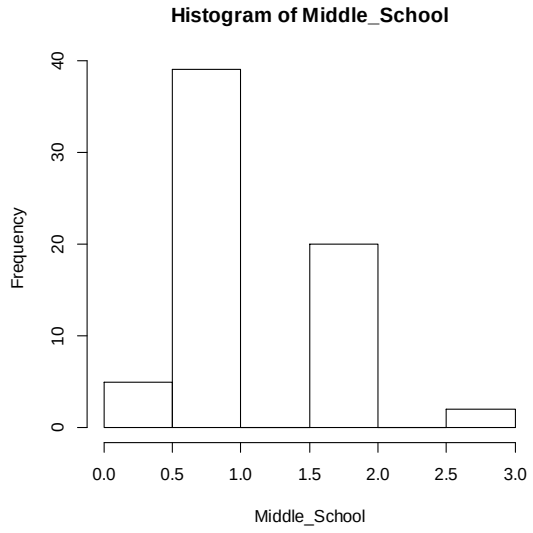
Again, we first looked at all of the data. We created a histogram of the data. It is found in Figure 13.

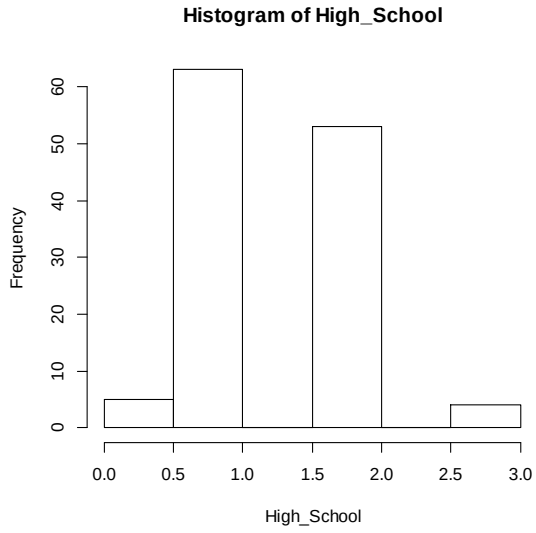
Figure 13: Histogram of the Data



Because the discrete nature of the data, we knew it would not be normally distributed. We also checked whether or not the number of correct answers was not different between the two age groups we used. We created histograms of the data collected from the middle school, Figure 3, and the data collected from the high schools, Figure 4.

Figure 14: Histogram of Data from the Middle School	Figure 15: Histogram of Data from the High Schools





Using an ANOVA test, we determined if there was a difference in the number of correct answers between the two age groups. Using the ANOVA command on Excel and an alpha value of 0.05, we found our test statistic to be 2.74 with a critical value of 3.89. Therefore, we could say that there was not a statistically significant difference between the two age groups. For this part of the analysis, we analyzed both ages together in each group.

Control Group

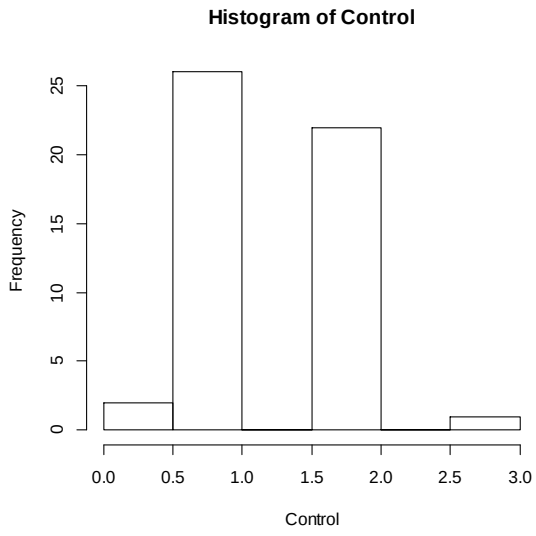
The first group of answers we analyzed was the control group. The number of correct quizzes for the group can be found in Table 8.

Table 8: Number of Correct Answers of the Control Group

Number of Correct Answers of the Control Group								
0	1	1	1	1	2	2	2	2
0	1	1	1	1	2	2	2	2
1	1	1	1	1	2	2	2	3
1	1	1	1	1	2	2	2	
1	1	1	1	2	2	2	2	
1	1	1	1	2	2	2	2	

Using this data, we created a histogram which can be found in Figure 16.

Figure 16: Histogram of the Control Group



The mean time for the control group was 1.43 correct answers with a standard deviation of 0.61 correct answers.

Popular Music Group

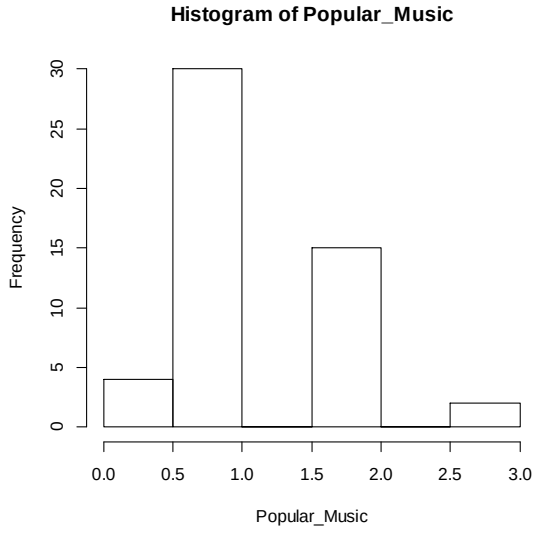
Next, we analyzed the number of correct answers for the popular music group. This data can be found in Table 9.

Table 9: Number of Correct Answers of the Popular Music Group

Number of Correct Answers in the Popular Music Group								
0	1	1	1	1	1	2	2	2
0	1	1	1	1	1	2	2	3
0	1	1	1	1	1	2	2	3
0	1	1	1	1	1	2	2	
1	1	1	1	1	2	2	2	
1	1	1	1	1	2	2	2	

Using this data, we created a histogram which can be found in Figure 17.

Figure 17: Histogram of Correct Answers for the Popular Music Group



The mean time for the control group was 1.29 correct with a standard deviation of 0.67 correct.

Lesser Known Music Group

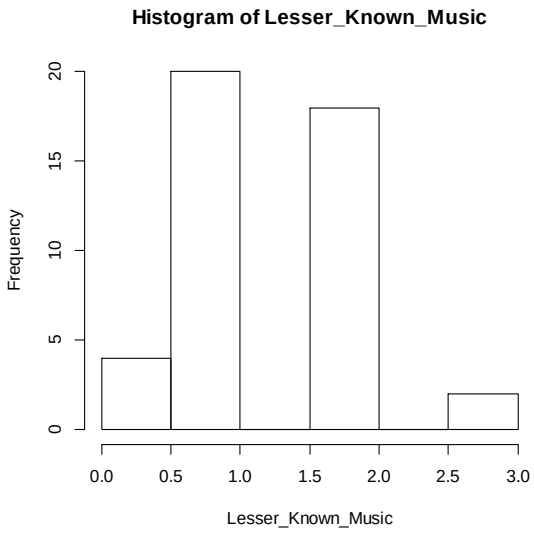
Third, we analyzed the lesser known music group. The number of correct answers for this group can be found in Table 10.

Table 10: Number of Correct Answers of the Lesser Known Music Group

Number of Correct Answers in the Lesser Known Music Group								
0	1	1	1	1	2	2	2	2
0	1	1	1	1	2	2	2	2
0	1	1	1	1	2	2	2	3
0	1	1	1	1	2	2	2	3
1	1	1	1	2	2	2	2	

Using this data, we created a histogram which can be found in Figure 17.

Figure 18: Histogram of Correct Answers for the Lesser Known Music Group



The mean time for the control group was 1.41 correct answers with a standard deviation of 0.73 correct answers.

Classical Music Group

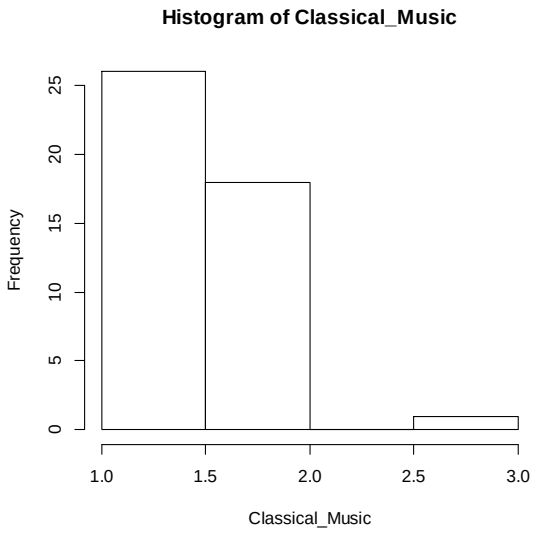
Finally, we analyzed the classical music group. The data for this group can be found in Table 11.

Table 11: Number of Correct Answers of the Classical Music Group

Number Correct								
1	1	1	1	1	1	2	2	2
1	1	1	1	1	2	2	2	2
1	1	1	1	1	2	2	2	2
1	1	1	1	1	2	2	2	2
1	1	1	1	1	2	2	2	3

Using this data, we created a histogram which can be found in Figure 19.

Figure 19: Histogram of Correct Answers for the Classical Music Group



The mean time for the control group was 1.44 correct with a standard deviation of 0.55 correct.

Analysis of Student Responses

Like the first half of analysis, we compared the data in two ways. First we used Excel to do an ANOVA analysis to determine if playing music while students work had an effect of the number of correct answers they had. We then used z-statistics to compare two groups at a time to determine whether certain types of music effected student work. From our ANOVA analysis, we got a test statistic of 0.57. This is smaller than our critical value of 3.89; therefore we cannot say that playing music while students work helps them perform better than working in a quiet environment. However, we also cannot say it causes them to perform worse.

Next, we compared the sets of data against each other. As there were more than 30 in each sample, we could use z-statistics. For this analysis, we again used Equation 1. The data used for the analysis can be found in Table 12.

Table 12: Calculations Using in Z-Tests

	Group 1: Control	Group 2: Popular Music	Group 3: Lesser Known Music	Group 4: Classical Music
Mean	$\bar{x}_5 = 1.43$	$\bar{x}_6 = 1.29$	$\bar{x}_7 = 1.41$	$\bar{x}_8 = 1.44$
Standard Deviation	$s_5 = 0.61$	$s_6 = 0.67$	$s_7 = 0.73$	$s_8 = 0.55$
Number in Sample	$n_5 = 51$	$n_6 = 51$	$n_7 = 44$	$n_8 = 45$

Control Group vs. Popular Music Group

The first two groups we compared were the control group and the popular music group. We did this to determine if playing well known music in the classroom helps them

perform better, distracts while they work, or has no effect. Our null hypothesis is $\mu_5 = \mu_6$ and our alternate hypothesis $\mu_5 \neq \mu_6$ with an alpha value of 0.05. Again using Equation 1, we calculated the z-score.

$$z = \frac{1.43 - 1.29}{\sqrt{\frac{(0.61)^2}{51} + \frac{(0.67)^2}{51}}} = 1.10$$

Since our critical value is ± 1.96 and $-1.96 \leq 1.10 \leq 1.96$, we failed to reject our null hypothesis.

Control Group vs. Lesser Known Music Group

The next two groups we compared were the control group and the lesser known music group. We did this to determine if playing lesser known music in the classroom helps them perform better, distracts while they work, or has no effect. Our null hypothesis was $\mu_5 = \mu_7$ and our alternate hypothesis was $\mu_5 \neq \mu_7$ with an alpha value of 0.05. Our z-score for these groups were

$$z = \frac{1.43 - 1.41}{\sqrt{\frac{(0.61)^2}{51} + \frac{(0.67)^2}{44}}} = 0.14$$

Since our critical value is ± 1.96 and $-1.96 \leq 0.14 \leq 1.96$, we failed to reject our null hypothesis.

Control Group vs. Classical Music Group

The third groups we compared were the control group and the classical music group. We did this to determine if playing well known music in the classroom helps them perform better, distracts while they work, or has no effect. Our null hypothesis was

$\mu_5 = \mu_8$ and our alternate hypothesis was $\mu_5 \neq \mu_8$ with an alpha value of 0.05. The z-score was

$$z = \frac{1.43 - 1.44}{\sqrt{\frac{(0.61)^2}{51} + \frac{(0.55)^2}{45}}} = -0.08$$

Since our critical value is ± 1.96 and $-1.96 \leq -0.08 \leq 1.96$, we failed to reject our null hypothesis.

Popular Music Group vs. Lesser Known Music Group

The next groups we compared were the popular music group and the lesser known group. We did this to determine which type of music we should play in the classroom, popular or lesser known music. Our null hypothesis was $\mu_6 = \mu_7$ and our alternate hypothesis was $\mu_6 \neq \mu_7$ with an alpha value of 0.05. We found our z-score to be

$$z = \frac{1.29 - 1.41}{\sqrt{\frac{(0.67)^2}{51} + \frac{(0.73)^2}{44}}} = -0.83$$

Since our critical value is ± 1.96 and $-1.96 \leq -0.83 \leq 1.96$, we failed to reject our null hypothesis.

Popular Music Group vs. Classical Music Group

The next groups we compared were the popular music group and the classical music group. We did this to determine if we should play popular or classical music while students work in the classroom. Our null hypothesis was $\mu_6 = \mu_8$ and our alternate hypothesis was $\mu_6 \neq \mu_8$ with an alpha value of 0.05. Using Equation 1, we found

$$z = \frac{1.29 - 1.44}{\sqrt{\frac{(0.67)^2}{51} + \frac{(0.55)^2}{45}}} = -1.21$$

Since our critical value is ± 1.96 and $-1.96 \leq -1.21 \leq 1.96$, we failed to reject the null hypothesis.

Lesser Known Music Group vs. Classical Music Group

The last two groups we compared were the lesser known music group and the classical music group. We did this to determine if we should play popular or classical music while students work in the classroom. Our null hypothesis was $\mu_7 = \mu_8$ and our alternate hypothesis was $\mu_7 \neq \mu_8$ with an alpha value of 0.05. We found that our z-score was

$$z = \frac{1.41 - 1.44}{\sqrt{\frac{(0.73)^2}{44} + \frac{(0.55)^2}{45}}} = -0.22$$

Since our critical value is ± 1.96 and $-1.96 \leq -0.22 \leq 1.96$, we failed to reject the null hypothesis.

Conclusions

Total Time Taken to Complete the Quizzes

From our statistical analysis, there are some conclusions that can be drawn. From our ANOVA analysis, we can say that there is no statistical evidence that playing music while students complete work, such as the provided quiz, helps them perform faster. Also, from our pair-wise comparison, there does not appear to be one type of music that is helps students perform better than any of the others that we tested. However, on the other hand, there is not any statistical evidence that playing music

negatively affects the time students spend on their work. There also is no evidence that one type of tested music is more distracting than any other type.

Student Responses

Once we took incorrect answers into account, the results solidified the conclusions drawn before. Again from our ANOVA analysis, there was no statistical evidence that music had an effect on the number of correct answers on the quiz. From our pair-wise analysis, there does not appear to be one type of music that helps students perform better than any of the other tested music types. The data also does not provide evidence that playing music while students are working causes them to make more mistakes in their work.

Taking both analyses into account, we cannot make recommendations about whether or not to play music in the classroom. There is no evidence that playing music helps students perform better or faster. However, there also is not evidence that it causes students to perform worse or slower. We also cannot make any recommendations about what type of music to play. There is no evidence that any one type of music is better than any others.

With some more time and more resources, there are a few changes to this study we would make. First, we would change the questions we used for the quiz. We chose these questions so that the age of the students taking the quiz would not bias the results. Through our ANOVA analysis of the two age groups, we found there was not a statistical difference between the two groups. However, because they were pattern

questions, there may have been more than one way to answer the questions. Therefore, we would use questions that had one clear answer. Also, we would have students take the quiz individually. The way the quiz was set up, each student in the group knew when the others finished. Some students may have rushed to finish the quiz because someone else finished, leading to biased results. Finally, we would like to extend this project into other teaching modes, such as group projects or exams, to see if playing music had an effect on these.

References

Bernstein, S., & Bernstein, R. (1999). *Elements of statistics ii: Inferential statistics*. McGraw Hill.

Cline, Kelly. "Central Limit Theorem." Probability and Statistics II. Carroll College. Helena, Montana. 29 Aug 2012. Lecture.

Cline, Kelly. "Comparing the Means of Two Possible Different Populations." Probability and Statistics II. Carroll College. Helena, Montana. 12 Oct 2012. Lecture.

Mathematical intelligence. (2011). Retrieved from http://www.intelligencetest.com/questions/mathematical.htm