The Effect of Background Music on Math Test Performance of High School Students

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Math and Music

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Abstract

There is often a general presumption that music and academics have a positive relationship. Researchers have investigated this relationship using a variety of subjects and testing many different variables. Since there was very little research done on the effect of background music on tests, I sought out to test if classical, rock, or rap background music has a positive effect on quiz scores. The experiment was done over four weeks with four Algebra II classes, two regular Algebra II classes and two accelerated Algebra II classes. To account for the four music types (classical, rap, rock, no music), and for the four quizzes over four weeks, a Latin Square design was used. When analyzing the results, a mixed effect linear model fit was used to accommodate absences, weeks, hours and music types. The data revealed that classical music had the most positive relationship with the quiz scores, even though most of the students confessed that they do not typically listen to classical music while doing their homework.

The Effect of Background Music on Math Test Performance of High School Students

For decades, various researchers have studied the relationship between listening to or playing music, and academic achievement. This relationship, however, is very broad because there are many different types of music as well as many different areas of academic achievement. Topics of research include the Mozart Effect, the relationship between academic achievement and participation in music, music therapy, and the effects of music on the brain. An article in the NASSP, National Association of Secondary School Principals, briefly summarizes some of the research that has been done regarding these topics (Kelstrom, 2000). In most of these research areas, there have been positive correlations between listening to or playing music, and academic achievement.

There are numerous variables in this area of research, ranging from the type of music to the type of musical background that each student has. However, very little research has been done relating listening to music and academic achievement, specifically in math test performance levels. The Mozart Effect represents a fraction of this area by observing the relationship between listening to Mozart and completing spatial tasks (Hetland, 2000). The Mozart Effect suggests that listening to Mozart causes the neurons in the brain to align, making thought processes quicker. Another area of research explores the effects of background music on various tasks such as testing, cognitive skills and on-task performance. The most relevant research has explored the effects of easy-listening background music on the on-task performance of fifth graders (Davidson & Powell, 1986). The results indicated that the background music was indeed effective because the students had a higher percentage of time spent on task while music was

played. Similar to this research, I plan to test the effect of listening to different types of background music while completing a standardized math quiz, specifically with high school students. Researchers have studied the effects of classical music on brain functions, but I wish to expand this and also see if rap and rock also have an effect. Since listening to Mozart and easy listening music have a positive effect on cognitive skills, I believe the classical music will have a positive effect on the math test performance. If this does indeed have a positive effect then teachers could simply play music during exams in order to increase test scores.

Experiment

Participants

Since my thesis research was conducted during my student teaching, I used the students in my four Algebra II classes at Henry Ford II High School. Two of the classes were accelerated and two classes were regular Algebra II students. 102 students gave consent to participate in this experiment and generally between 95 and 100 students participated each week due to absences on quiz days.

Consent Procedures

Most, if not all, of the students who participated in this study were under 18 years old. Therefore I sent home a consent form with the student for the parents and their student to sign (see Appendix A for the consent form). The students and parents knew the entire procedure ahead of time except for which music they were listening to while taking the test. There were three students who did not receive consent and therefore took their quiz in the hallway.

Confidentiality of Data

Since this experiment was performed in a classroom setting to explore a different teaching

technique, all of the students' records will be protected by FERPA (Family Educational Rights and Privacy Act). During the analysis of the data, the students' names were not matched with the scores. After completing their quizzes, they transferred their answers to an anonymous scantron. I only used the scantrons as part of the data collection. No other information was given on the scantron besides their answer selections.

Benefits

Many students enjoy listening to music and even listen to music while they are doing their homework. I think students enjoyed being able to hear music in the background while they took their quizzes. The students had to take this quiz anyway for their class, so playing music for them while they take the quiz hopefully helped them to relax and concentrate as if they were doing their homework.

Risks

The quiz taking procedure was similar to a normal test taking procedures in high school. The only change was the music playing in the background. The music should have had no effect on the students physically. The quizzes covered the material that was recently discussed in the class and the students were given a grade based on completion instead of accuracy, so that the students' performance on the quiz did not affect their grades. For the purpose of the experiment, however, the quizzes were graded and analyzed based on accuracy. The quizzes were written to only take about ten minutes to complete, but there was enough music to last about thirty minutes. The students were given as much time as they needed to complete the quiz.

Procedure

As discussed, the experiment tested the effects of different types of background music on math quizzes. To perform this experiment while taking into account the week, type of material, student

and music, I used the Latin Square technique. In an ideal experiment, no subject would be used more than once and every testing atmosphere would be the same (same type of student and same subject). The Latin Square technique helped sort out all of the repeated measures (students) so that every class received the same treatment. Each student took a quiz on different material each week with a different type of music. There were four types of music, with four different groups of about thirty students, quizzed once a week for four weeks. Each week, both groups of students in the same course were given the same quiz, but each group listened to a different type of music. This process continued for four weeks so that each group was exposed to every type of music. By using this method, the material on the quiz did not have to be changed for each group of students and the same material did not have to be covered on the quiz each week. The quizzes covered the material that was recently discussed in the class and the students were given a grade based on completion instead of accuracy, so that the students' performance on the quiz did not affect their grades. However the quizzes were intended to be worth enough participation points to motivate them to complete the quiz to the best of their ability (see Appendix A). For the purpose of the experiment, however, the quizzes were graded and analyzed based on accuracy. The students had an unlimited amount of time to complete the quizzes; however they only lasted about ten minutes. When grading the quiz for analysis, the answers were marked right or wrong with no partial credit. They took multiple choice quizzes and then transferred their answers to an anonymous scantron. I only used the scantrons as part of the data collection. No other information was given on the scantron besides their answer selections. The musical categories included classical, rock, rap and a control group with no music. In order for the music to stimulate the same effect on each student, the songs chosen should have been familiar to the students. After the quiz was completed, the students filled out a short anonymous survey

including, whether or not the student was familiar with the music that was played, if they regularly listen to music while doing their math homework and if they believe that the music helps them do better (see Appendix A).

Music

When choosing the music selection for this experiment, there was some discussion over whether the students should be familiar with the music or not. It would have been much easier to choose songs that none of the students knew. But when students do their homework while listening to music, they choose songs that they are familiar with. Similarly, I decided to choose songs that were popular and that the students should have known. The follow-up questions given at the end of the quiz, allowed me to find out whether they knew the songs or not and whether they usually listen to that type of music when they do their homework.

Rock

1. “Don’t Stop Believing” by Journey
2. “We Are Young” by Fun
3. “It’s My Life” by Bon Jovi
4. “We Will Rock You” by Queen
5. “Uprising” by Muse

When the students took their quizzes while listening to rock, they all completed their quizzes within the first three songs. None of the students heard any of the rock songs after track three, “It’s My Life” by Bon Jovi.

Rap

1. “Out of My Head” by Lupe Fiasco

2. “Fresh Prince of Bel Air” T.V. Theme

3. “Good Feeling” by Flo-Rida

4. “Where is the Love” by Black Eyed Peas

5. “Just a Dream” by Nelly

When the students took their quizzes while listening to rap, they all completed their quizzes within the first four songs. None of the students heard any of the rap songs after track 4, “Where is the Love” by Black Eyed Peas.

Classical

1. “Canon in D” by Johann Pachelbel

2. “Fortuna Imperatrix Mundi: O Furtuna” by Carl Orff

3. ” Symphony No. 5 in C Minor, Op. 67: I. Allegro con Brio” by Ludwig Van Beethoven

4. “The Nutcracker - Ballet, Op. 71” by Peter Ilyich Tchaikovsky

5. “Suite in D: Round-O - the Prince of Denmark's March” by Jeremiah Clarke

6. “Toccata and Fugue in D Minor” by Johann Sebastian Bach

When the students took their quizzes while listening to classical music, they all completed their quizzes within the first four songs. None of the students heard any of the classical songs after track 4, “The Nutcracker - Ballet, Op. 71” by Peter Ilyich Tchaikovsky.

Data

The data included the student number, type of music, week, and class type. Students who were absent did not make up the quiz with music; therefore their score was left blank. Table 1 below represents the mean values of the quiz scores based on a 100 point scale, for each music type according to each week. Table 2 displays the mean values of the quizzes for each music type according to the class hour.

	1	2	3	4
None	65.00	85.58	73.00	49.00
Rock	73.86	81.00	80.21	68.27
Rap	76.25	89.13	71.88	68.48
Classical	86.96	90.48	76.00	65.22

Table 1

	1	2	3	6
None	73.00	85.58	65.00	49.00
Rock	73.86	68.27	80.21	81.00
Rap	68.48	71.88	89.13	76.25
Classical	90.48	86.96	65.22	76.00

Table 2

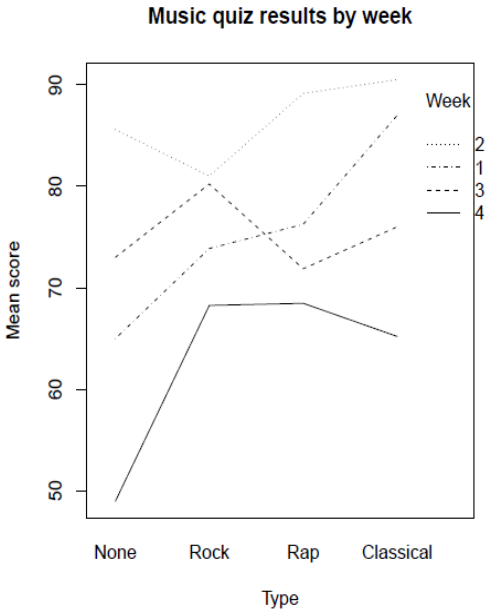


Table 1 Graph

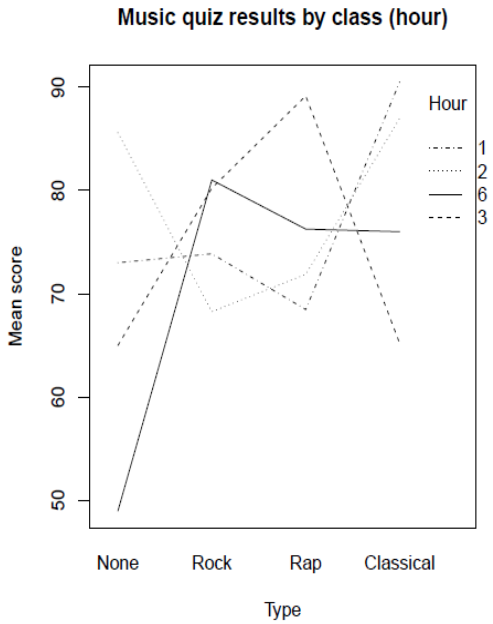
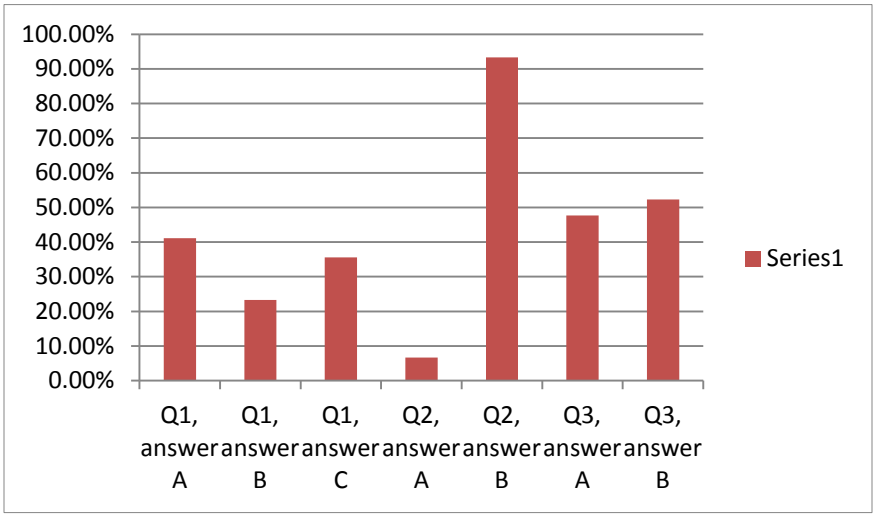


Table 2 Graph

These graphs strictly represent the mean values by week and by hour according to each type of music. Though these are great visual representations of the general trend of the data, it is difficult to draw conclusions when the data has separate comparisons as shown above. The data had to be analyzed based on all of the factors including hour, subject, week, etc.

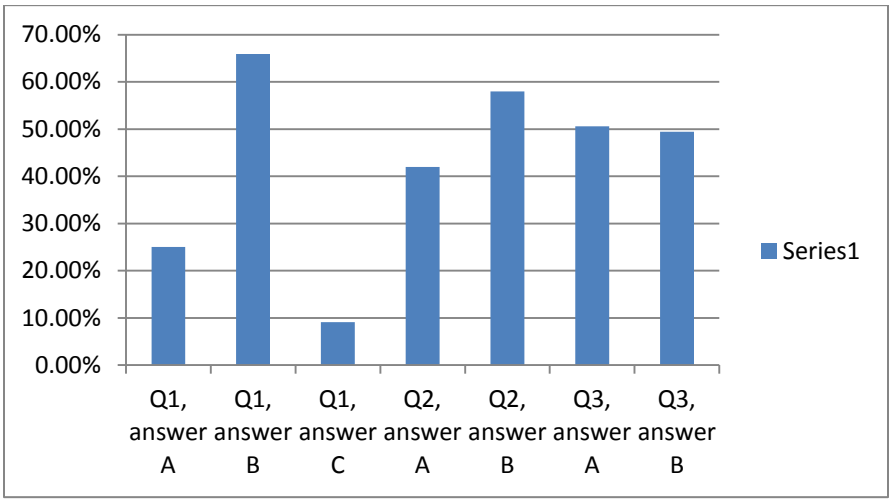
Following the quiz, the students answered three questions based on the music they heard and how they felt about the music. The questions inquired whether the student heard the songs before, if they usually listen to that type of music when doing homework and if they think that music would help them on their quiz. Refer to Appendix A for the exact follow-up questions. The following graphs display the results of the questions. In order for this data to be statistically relevant to the quiz scores, the questions would have to be analyzed strictly according to each individual student. For the purposes of this experiment, however, the questions are only used to speculate why the music affected the scores.

Classical Follow-up Questions



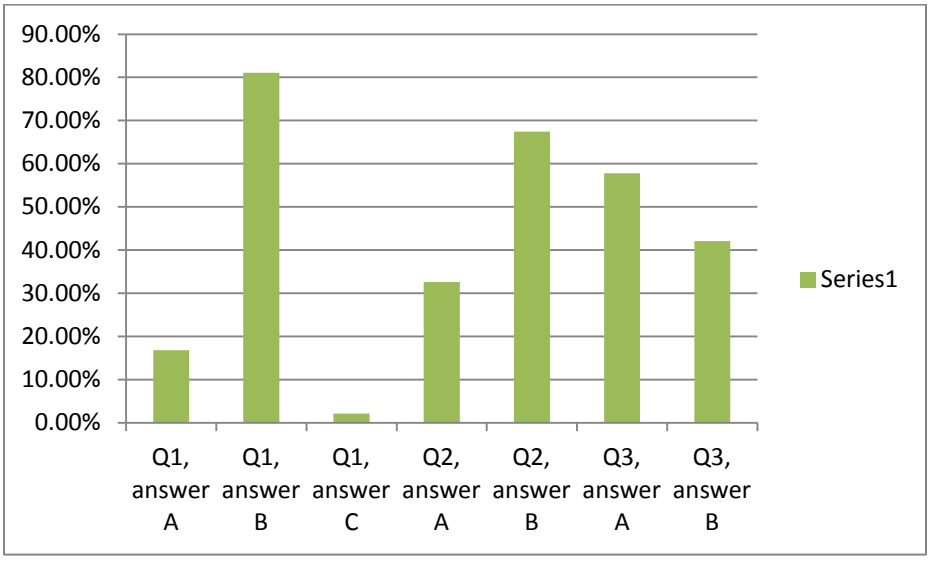
Graph

Rap Follow-up Questions



Graph 2

Rock Follow-up Questions



Graph 3

Analysis

Since there were so many contributing factors that affected the data, (week, class, difficulty of quiz, absences, etc.), a mixed effect linear model was used to fit the data, therefore taking into account the type, week, hour, type of student and music. This prevented the possibility of interaction between variables and assumes that all variables have an additive effect. For example, if rap music raised quiz scores when the quiz material was difficult but lowered the scores when the quiz material was easier, this would cause interaction between variables. The Latin Square technique and the mixed effect linear model helped untangle those interactions and analyzed the data as though the variables had an additive effect.

Random effects:

Groups	Name	Variance	Std.Dev.	
ID	(Intercept)	254.43	15.951	# variation between students Residual
		489.27	22.119	# variation within students

Number of obs: 380, groups: ID, 102

Fixed effects: # systematic differences between groups

	Estimate	Std. Error	t value	
(Intercept)	69.8766	4.8130	14.518	# baseline level
TypeRock	7.7524	3.1572	2.455	# offset for Rock music
TypeRap	7.0951	3.2314	2.196	
TypeClassical	11.1940	3.2098	3.487	
Week2	11.2319	3.2843	3.420	
Week3	0.6227	3.2564	0.191	
Week4	-12.2572	3.2723	-3.746	
Hour2	2.0526	5.5170	0.372	
Hour3	-1.7707	5.5706	-0.318	
Hour6	-6.7312	5.5506	-1.213	

Table 3

Since the experiment used the same students each week, there are some score trends within each student and between each student in every class. Some students are stronger than others and some students are able to focus better on certain days than others. As shown in Table 3 above, the standard deviation between students was about 16 points, which means that the students' scores varied about 16 points from student to student. Similarly, each student's score fluctuated about 22 points based on the standard deviation in Table 3.

Though these values represent points on a 100 point scale, the quizzes given were only four questions with possible scores of 0%, 25%, 50%, 75% and 100%. This means that the table values assume that the quiz can be scored continuously over 100 points and not in increments of 25. For example, a student's score would not be able to fluctuate by 22 points because each question is worth 25 points. However if the quiz was 100 questions or scored continuously, then the data in Table 3 would accurately represent the analysis of data.

Table 3 displays the intercept (baseline) value which represents the average score that would have occurred for week 1, 1st hour, without music. The rest of table 3 then lists the estimates and t-values relative to the baseline value. For example, rock music was an average of 7.7524 points more than the baseline value. The standard error column represents the uncertainty of the estimated values in number of points. The t-value in the last column gives a rough estimate of the significance of the data. Typically, t-values greater than 2 are considered significant, indicating that the music did have an effect on the quiz scores. A low t-score suggests that the music did not have any more effect on the quiz scores than normal background noise. Using these t-value estimates, the data would suggest that classical music had the most significant effect with a t-value of 3.487 and an increase in scores by about 11.2 points.

Since this linear model performs significance testing multiple times, it increases the range of errors for the t-values. This is why the t-values have room for interpretation. To reduce the percent error while analyzing, the Tukey Method was used to analyze the comparisons of the four music types. The Tukey Method minimizes the error to about 5% overall, giving a more accurate analysis of the data.

```
> confint(glht(mod,mcp(Type="Tukey")))

Simultaneous Confidence Intervals

Multiple Comparisons of Means: Tukey Contrasts

Quantile = 2.5683                95% family-wise confidence Level

Linear Hypotheses:
                              Estimate      lwr      upr
Rock - None == 0               7.7524  -0.3562 15.8610
Rap - None == 0                7.0951  -1.2041 15.3942
Classical - None == 0 11.1940   2.9502 19.4377
Rap - Rock == 0               -0.6573  -9.0449  7.7303
Classical - Rock == 0  3.4415  -4.8818 11.7649
Classical - Rap == 0   4.0989   -4.4285 12.6262
```

The Tukey method shows comparisons of the different kinds of music vs. no music as well as comparing the different types of music to each other. The lower and upper bound represent the range of point value differences from each comparison. The most significant difference is classical vs. none which shows an 11.1940 increase in points. The Classical vs. none music analysis was the only comparison that had a lower bound that was still greater than 0. This means that Classical music raised the student quiz scores by about 3 to 19 points. The other comparisons show some variation but not enough to show significance. This means that though rock and rap music showed some score improvement, only classical music showed significant improvement in the quiz scores when compared to no music. When comparing rap and rock music, rap music did not seem to improve the scores as much as rock music, however both were better than no music, though not significant according to the t-value. The results from the Tukey method analysis properly account for various interpretations of the linear model analysis process indicating that through multiple analysis processes, similar results were obtained.

Results

Based on the results of the linear model and the Tukey Method, it seems that Classical music has a positive relationship with math scores, while rap and rock have little effect on the scores. This may be somewhat surprising based on the students' opinions about Classical music. According to graph 1, 93% of the students do not listen to Classical music while doing their homework, and about half of the students thought it would not help their scores. Though this is just speculation, Classical music may have had more of an effect than rock or rap because there were no lyrics in the Classical music. Therefore the music may have helped block out the distractions in the classroom such as movement, noises, etc., but not distract them with lyrics to sing along to. Rock and Rap music had low t-scores indicating that the music may have been just as distracting

as the distractions found in a normal test taking environment. The data from this experiment reveals that Classical music had a positive relationship with math quiz scores, but there is always room for improvement in the experiment to increase accuracy and investigate other variables.

Conclusion

There are many variables that can be tested when investigating if music does affect math quiz performance. Though this experiment tested if rap, rock or classical music has a positive relationship with math quiz scores, there are many other factors in a classroom setting that affect the results. The mixed effect linear model and the Tukey method were able to statistically analyze the data while taking into account absences, differences in student abilities, subject, and week. Based on the results of this data, Classical music had a positive relationship with math quiz scores; however there is always room error and some speculation. In an ideal experimental situation, each student in the same classroom would have to listen to a different type of music on headphones while taking their quiz. Also, every student would have to be present for the lessons as well as the quiz day so that everyone has the same amount of instruction before taking the quiz. It would be even more interesting to follow the scores of each individual student and match their scores to their opinions about the music and their music preference. Since there are always more factors and variables to test when it comes to the effects of music on math test performance, more research is required to prove that Classical music does have a positive effect on math test performance.

Appendix A

Name_____ Hour_____

Accelerated Algebra II
Music Quiz Week #1
YOU MUST SHOW WORK TO RECEIVE CREDIT!!!

1. Convert 28^o to radians

a. $\frac{5040}{\pi}$
b. $\frac{7\pi}{45}$
c. $\frac{3\pi}{20}$
d. 28π

2. Convert $\frac{9\pi}{4}$ to degrees.

a. 1620^o
b. 810^o
c. 620^o
d. 405^o

3. Find the length of the arc if the radius is 6 inches and the central angle is $\frac{7\pi}{6}$.

a. 25.64 inches
b. 1260.0 inches
c. 26.0 inches
d. 22.0 inches

4. Find the length of the arc if the radius is 24 inches and the central angle is 255^o.

a. 6120 inches
b. 107 inches
c. 112 inches
d. 6620 inches

Name_____ Date_____

Algebra II

Music Quiz Week #1

YOU MUST SHOW WORK TO RECEIVE CREDIT!!!

Write an exponential function $y = ab^x$ for a graph that includes the given points.

1. (4, 8), (6, 32)

a. $y = 4(8)^x$
b. $y = 0.5(2)^x$
c. $y = 0.5(8)^x$
d. $y= 6(32)^x$

2. (-3, 24), (-2, 12)

a. $y = -2(0.5)^x$
b. $y = -2(12)^x$
c. $y = -3(24)^x$
d. $y = 3(0.5)^x$

3. (2, 18), (5, 60.75)

a. $y = 8(1.5)^x$
b. $y =2(18)^x$
c. $y = 4(1.5)^x$
d. $y = 5(60.75)^x$

4. Which of the following exponential functions DOES NOT represent exponential decay?

a. $y = 0.2(7.3)^x$
b. $y = 4(0.75)^x$
c. $y = \frac{1}{2}(\frac{1}{4})^x$
d. $y = 5(\frac{1}{2})^x$

Name_____ **Hour**_____

Accelerated Algebra II
Music Quiz Week #2
YOU MUST SHOW WORK TO RECEIVE CREDIT!!!

1. **Find the length of the arc if the radius is 6 inches and the central angle is $\frac{7\pi}{6}$.**
   a. **25.64 inches**
   b. **1260.0 inches**
   c. **26.0 inches**
   d. **22.0 inches**

2. **Find the length of the arc if the radius is 24 inches and the central angle is $\frac{17\pi}{12}$.**
   a. **6120 inches**
   b. **107 inches**
   c. **112 inches**
   d. **6620 inches**

3. **Find the coordinates of the point where the terminal side of each angle intersects the unit circle (USE EXACT VALUES)!**

   300°
   a. $(\frac{1}{2},-\frac{\sqrt{3}}{2})$
   b. $(-\frac{1}{2},-\frac{\sqrt{3}}{2})$
   c. $(-\frac{1}{2},\frac{\sqrt{3}}{2})$
   d. $(\frac{\sqrt{2}}{2},-\frac{\sqrt{2}}{2})$

4. **Find the coordinates of the point where the terminal side of each angle intersects the unit circle (USE EXACT VALUES)!**

$\frac{3\pi}{4}$

a. $(-\frac{\sqrt{2}}{2},-\frac{\sqrt{2}}{2})$

b. $(-\frac{1}{2},-\frac{\sqrt{3}}{3})$

c. $(-\frac{\sqrt{2}}{2},\frac{\sqrt{2}}{2})$

d. $(\frac{\sqrt{2}}{2},-\frac{\sqrt{2}}{2})$

Name_____ Hour_____

Algebra II
Music Quiz #2
YOU MUST SHOW ALL OF YOUR WORK TO RECEIVE CREDIT!!!

Find the amount in a continuously compounded account for the given conditions.

1. Principal: $10,000
Annual interest rate: 2%
Time: 6 years

a. $33,201.17
b. $23,938.29
c. $11,274.97
d. $1,627,547,914

2. Principal: $65,000
Annual interest rate: 5.5%
Time: 7 years

a. $95,524.93
b. $3.41 x 10^{21}
c. $3,054,549.11
d. $76,932.37

Describe how the following functions will be translated.

3. $y = 2(3)^{x-4} + 6$

a. left 4 units, up 6 units
b. left 4 units, down 6 units
c. right 4 units, up 6 units
d. right 4 units, down 6 units

4. $y = 0.5(7)^{x+10} - 8$

a. left 8 units, down 10 units
b. left 10 units, down 8 units
c. right 10 units, down 8 units
d. right 10 units, up 8 units

Name_____ Hour_____

Accelerated Algebra II
Music Quiz #3
YOU MUST SHOW ALL OF YOUR WORK TO RECEIVE CREDIT!!!

Find the amplitude and period of the following functions:

1. $y = \frac{-1}{2}\cos\frac{1}{4}\theta + 3$

a. Amplitude: $\frac{-1}{2}$
Period: 8π

b. Amplitude: $\frac{1}{4}$
Period: 4π

c. Amplitude: $\frac{-1}{2}$
Period: $\frac{\pi}{2}$

d. Amplitude: $\frac{1}{2}$
Period: 8π

2. $y = -2\sin\frac{1}{2}\theta + 6$

a. Amplitude: 6
Period: 2π

b. Amplitude: 2
Period: π

c. Amplitude: -2
Period: 4π

d. Amplitude: 2
Period: 4π

3. Describe how the following function is translated.

y = sin2(x-$\frac{\pi}{3}$) - $\frac{3}{2}$

a. Left $\frac{\pi}{3}$ units
Down $\frac{3}{2}$ units

b. Left $\frac{\pi}{3}$ units
Up $\frac{3}{2}$ units

c. Right $\frac{\pi}{3}$ units
Down $\frac{3}{2}$ units

d. Right $\frac{\pi}{3}$ units
Up $\frac{3}{2}$ units

4. Describe how the following function is translated.

y = 3cos(x+$\frac{\pi}{6}$) – 2

a. Left $\frac{\pi}{6}$ units
Down 2 units

b. Left $\frac{\pi}{6}$ units
Up 2units

c. Right $\frac{\pi}{6}$ units
Down 2 units

d. Right $\frac{\pi}{6}$ units
Up 2 units

Name_____ Hour_____

Algebra II
Music Quiz #3
YOU MUST SHOW ALL OF YOUR WORK TO RECEIVE CREDIT!!!

Write each expression as a single logarithm.

1. log 8 + log 3

a. log 11

c. log $\frac{8}{3}$

b. log 24

d. log 32

2. log 4 + log 2 – log 5

a. log $\frac{6}{5}$

c. log $\frac{8}{5}$

b. log 40

d. log $\frac{2}{5}$

Expand each logarithm

3. $\log_b \frac{x^2}{2y}$

a. $2\log_b x – (\log_b 2 + \log_b y)$

c. $2\log_b x – (\log_b 2 - \log_b y)$

b. $4\log_b x + (\log_b 2 + \log_b y)$

d. $2\log_b x + (\log_b 2 + \log_b y)$

4. $\log_b (4mn)^5$

a. $4(\log_b 5 + \log_b m + \log_b n)$

c. $5(\log_b 4 - \log_b m - \log_b n)$

b. $5(\log_b 4 + \log_b m + \log_b n)$

d. $4(\log_b 4 - \log_b m + \log_b n)$

Name_____ Hour_____

Accelerated Algebra II
Music Quiz #4
YOU MUST SHOW ALL OF YOUR WORK TO RECEIVE CREDIT!!!

1. In ΔDEF, angle D is a right angle. Find the other side if f = 1 and d = 2. Round to the nearest tenth.

a. e = 1.2

c. e = 1.5

b. e = 2.3

d. e = 1.7

In ΔDEF, angle D is a right angle where d = 13, e = 5 f = 12.

2. Find sec(E)

a. sec(E) = $\frac{12}{13}$

c. sec(E) = $\frac{13}{12}$

b. sec(E) = $\frac{5}{13}$

d. sec(E) = $\frac{13}{5}$

3. Find cot(E)

a. cot(E) = $\frac{12}{5}$

c. cot(E) = $\frac{12}{13}$

b. cot(E) = $\frac{5}{12}$

d. cot(E) = $\frac{13}{5}$

4. A kite string makes a 62^{o} angle with the horizontal, and 300 ft. of string is let out. The string is held 6 ft. off the ground. How high is the kite?

a. 270.9 ft.

c. 140.84 ft.

b. 146.84 ft.

d. 264.9 ft.

Name_____ Hour_____

Algebra II
Music Quiz #4
YOU MUST SHOW ALL OF YOUR WORK TO RECEIVE CREDIT!!!

1. Solve ln 3x = 6

a. 3.347 **c. 134.476**

b. 0.183 **d. 403.476**

2. Solve ln (4x – 1) = 36

a. 4.311×10^{15} **c. 1.173×10^{15}**

b. 1.078×10^{15} **d. 1.078**

Write each expression as a single natural logarithm

3. 2 ln 8 – 3 ln 4

a. ln 1 **c. – ln2**

b. 6 ln 2 **d. – ln 4**

4. 4 ln 8 + ln 10

a. 4 ln 80 **c. 4 ln 18**

b. ln 40960000 **d. ln 40,960**

Follow-up Questionnaire
Classical

1. Which songs did you recognize?
    a. Some songs
    b. All of the Songs
    c. None of the songs

2. Do you usually listen to classical music while you do your homework?
    a. Yes
    b. No

3. Do you think that classical background music helps you concentrate better?
    a. Yes
    b. No

Follow-up Questionnaire
Rap

1. Which songs did you recognize?
    a. Some songs
    b. All of the Songs
    c. None of the songs

2. Do you usually listen to rap music while you do your homework?
    a. Yes
    b. No

3. Do you think that rap background music helps you concentrate better?
    a. Yes
    b. No

Follow-up Questionnaire
Rock

1. Which songs did you recognize?
    a. Some songs
    b. All of the Songs
    c. None of the songs

2. Do you usually listen to rock music while you do your homework?
    a. Yes
    b. No

3. Do you think that rock background music helps you concentrate better?
    a. Yes
    b. No

Hello Parents and Students!

This semester I will be doing research for my thesis entitled "The Effect of Background Music on Math Test Performance of High School Students". Many students enjoy listening to music while they are doing their homework so I would like to investigate this possible positive correlation! Since I will be teaching your student's algebra II class, they are a perfect candidate to participate in this study. This research will be conducted over four weeks (01/25/13 to 02/15/13). Once a week for four weeks, the students will be given a short quiz on the material we covered in class during that week. During three of these quizzes, I will be playing rock, rap, or classical music in the background. These songs will of course be school appropriate.

The students will have an unlimited amount of time to complete the quizzes; however they should only last about ten minutes. Since some students may find this music distracting, the quizzes will be graded for participation and completion instead of accuracy so that the scores do not affect their grades. However if you feel that you do not want your student to take the quiz with music in the background, then they may complete their quiz in another quiet room. If your student typically listens to music while they do their homework, then they may enjoy and benefit from the background music. However, even if they find the music distracting, they are given an infinite amount of time to complete the quiz and will only be graded on completion.

My analysis and presentation of their scores will, of course, be anonymous. Their answers will be transferred onto an anonymous scantron. No other information will be given on the scantron other than their answer selections. Only Mrs. Verlinde, my thesis mentor, and I will have access to this data, and all files will be secured and protected.

I ask that you and your student please fill out the last page of this consent form so that your student may participate in my thesis research. Remember that participation is voluntary and that not participating will not affect their grades or relationship with the researcher, me or the school. If you have any further questions regarding this research, please feel free to contact me or my thesis mentor through email. This will be a great way for your student to become involved in researching a new teaching strategy and your student's participation would be greatly appreciated!

Thanks!
Sarah Maas (semaas@oakland.edu)

Thesis Mentor:
Jerrold Grossman (grossman@oakland.edu), (248) 370-3443

For questions regarding the rights of human subjects in research, you may contact the Oakland University Institutional Review Board at 248-370-2762.

_____
STUDENT NAME

I, _____ allow my son/daughter _____, to participate in the thesis project, “The Effect of Background Music on Math Test Performance of High School Students” by listening to rap, rock or classical music while taking their quizzes.

_____ _____
Parent Signature Date

I, _____ agree to participate in the thesis project, “The Effect of Background Music on Math Test Performance of High School Students” by listening to rap, rock or classical music while I take my quizzes.

_____ _____
Student Signature Date

Works Cited

Bach, J.S. (1873). Toccata and Fugue in D Minor, BWV 565: Toccata. On *100 Best Classics*. EMI Records. (2004).

Beethoven. L.V. (1801). Piano Sonata No. 14 in C-Sharp Minor, Op. 27, No. 2 "Moonlight": I. Adagio Sostenuto - Excerpt. On *100 Best Classics*. EMI Records. (2004).

Black Eyed Peas (2003). Where is the Love. On *Elephunk*. Interscope.

Clarke, J. (circa 1700). Suite in D: Round-O - the Prince of Denmark's March (Trumpet Voluntary). On *100 Best Classics*. EMI Records. (2004).

Davidson, Charles W., and Lou Anne Powell. "The Effects of Easy-Listening Background Music on the On-Task-Performance of Fifth Grade Children." Journal of Educational Research. 80.1 (1986): 29-33.

Fiasco, L. (2011). Out of My Head. On *Laser*. 1st and 15th, Atlantic.

Foran, Lucille M. "Listening to Music: Helping Children Regulate Their Emotions and Improve Learning in the Classroom." Educational Horizons. 88.1 (2009): 51-58.

Fun (2011). We Are Young. On *Some Nights*. Atlantic.

Hedayat, A. "348. Note: Self Orthogonal Latin Square Designs and their Importance." *Biometrics* 29.2 (1973): 393-6. Print.

Hetland, Lois. "Listening to Music Enhances Spatial-Temporal Reasoning: Evidence for The "Mozart Effect." Journal of Aesthetic Education. 34.3-4 (2000): 105-48.

Johnson, Christopher M., and Jenny E. Memmott. "Examination of Relationships between Participation in School Music Programs of Differing Quality and Standardized Test Results." *Journal of Research in Music Education* 54.4 (2006): 293-307. Print.

Journey (1981). Don't Stop Believing. On *Arrival of the Best*. Columbia.

Kelstrom, Joyce M. “The Untapped Power of Music: Its Role in the Curriculum and Its

Jovi, B. (2000). It’s My Life. On *Crush.* Island.

Effect on Academic Achievement.” NAASP Bulletin. 82.597 (1998): 34-43.

Muse (2009). Uprising. On *The Resistance*. Warner Bros.

Nelly (2010). Just a Dream. On *5.0*. Universal Motown.

Orff, C. (1936). Fortuna Imperatrix Mundi: O Fortuna. Carmina Burana.
Pachelbell, J. (1919) Canon in D.

Queen (1977). We Will Rock You. On *News of the World*. Elektra.

Rida, F. (2012). Good Feeling. On *Wild One.* Atlantic, Poe Boy.

Schmidt, Charles P. “Relations among Motivation, Performance Achievement, and Music Experience Variables in Secondary Instrumental Music Students.” *Journal of Research in Music Education* 53.2 (2005): 134-47. Print.

Smith, W. (1985). Fresh Prince of Bel-Air. On *The Fresh Prince of Bel-Air.* Word Up, Jive.

Vaughn, Kathryn. “Music and Mathematics: Modest Support for the Oft-Claimed Relationship.” Journal of Aesthetic Education. 34.3-4 (2000): 149-66.

Tchaikovsky, P. (1892). The Nutcracker - Ballet, Op. 71 (Highlights), No. 12 - Divertissement (Act II): V. Danse Des Mirlitons (Dance of the Reed Pipes). On *100 Best Classics*. EMI Records. (2004).

Tchaikovsky, P. (1812).1812 Overture: Op. 49 (Conclusion). On *100 Best Classics*. EMI Records. (2004).

Mentor's Statement

Sarah Maas asked me to be her mentor for her Honors College Thesis about two (or maybe it was three) years ago. She plans ahead! She already had a clear plan in mind as to what she wanted to do. It tied in with her education and career goals, and it was something she found interesting. The main mathematical content was the statistical analysis of the data she planned to collect to study the effect of background music on students' performance on a mathematical task, namely taking a quiz on recently studied material. She carefully worked out the details of how she would conduct the experiment over a four-week period, and it appears that everything went according to plan. With the help of my colleague Professor Robert Kushler, a statistician, she analyzed the data and drew appropriate conclusions. I think it was a worthwhile and rewarding exercise all around. Her thesis is well written and communicates clearly what she found, as well as the relevant background information.

We met several times over the couple of years to discuss her plans. The most burdensome thing for both of us, was having to deal with the Oakland University Institutional Review Board (IRB). Because her experiment involved human subjects (the students in the classes she was teaching as part of her secondary education internship), it was necessary to carefully devise plans to insure that the human subjects (and in this case their parents, since they were minor children) gave informed consent to participate and that no harm would come to them as a result of their participation. We both had to go through several hours of on-line training provided by the IRB, and then Sarah had to fill out a lengthy application for approval. After several iterations, approval was granted and her experiment went forward.

I enjoyed the opportunity to be part of this Honors College experience.

Professor Jerrold W. Grossman
Department of Mathematics and Statistics