Instrumental Music and ACT Scores

Jerry Price

Master of Public Administration
Capstone Project

Martin School of Public Policy and Administration
University of Kentucky

Faculty Advisor
Dr. Eugenia F. Toma

November 12, 2010

TABLE OF CONTENTS

Introduction

Allocation of dwindling resources force public administrators to make choices and instrumental music program budgets can be cut or even eliminated by state agencies or school districts. Whether or not this is good policy will be examined by the collection and analysis of school level data. Public school instrumental music programs are expensive to operate and maintain, involve specialized, highly-qualified instructors and require an inventory of instruments to ensure that students with low incomes will be able to participate. Families in high income situations may be able to afford private instrumental music lessons for their students and may be indifferent to public funding of instrumental music programs.

In many instances insufficient funding is allocated for music programs and alternative sources of revenue must be found to support the programs and fundraising activities may provide a solution (Young 1981). Program funding may also be influenced by external pressures. Abril and Gault (2006) studied school music programs in California over a five year period from 1999-2000 through 2003-2004 and reported a 50% decline in student involvement in music programs and a 26.7% decline in music educators. Abril and Gault speculated that the decline in music participation could be attributed to the current California budget crisis and the implementation of the No Child Left Behind Act.

Concern about these cuts presupposes that music programs have value, which like other education programs, must be demonstrated. Music education can be an important developmental tool that could be utilized in student academic achievement and holistic education. Participation in instrumental music programs may have an effect on academic development and standardized test scores. Using school-level data provided by the Kentucky Department of Education, this capstone paper examines evidence about the relationship between student participation in instrumental music programs and ACT scores

The school-level data and estimations presented here, even controlling for other factors, cannot provide causal evidence for or against direct effects of music education on ACT scores. However, given a positive statistical relationship between instrumental music participation and higher scores, school districts may want to weigh this factor when considering the allocation of scarce public funds.

Literature Review

Finding valid evidence for the relationship between instrumental music and scores on standardized tests is difficult for several reasons. The attributes of the population being examined are diverse; other factors increase or decrease test scores; and differing funding levels might matter. Current literature demonstrates that socio-economic factors, including parental education, are most important in contributing to student success and standardized test scores; and other known factors may play a role. Another confounding issue involves selection. Who participates in instrumental music programs? Are some students more likely than others to participate and would their ACT scores ultimately be higher due to higher innate intelligence, or are lower ACT scores caused by randomly selected socio-economic categorization?

It is known throughout academic literature that socioeconomic status (SES) is the most widely used contextual variable in education research. Generally, children from higher socioeconomic backgrounds have higher test scores. The effects of socioeconomic status are not only direct, but indirect. Parental education, for example, typically affects the type of employment of the parents, affects wages earned, and all these influence the choice of neighborhood in which the family lives. Both the parents and the neighborhood then influence the quality of the school.

There is however, another body of literature examining the relationship between musical training and academic outcomes. According to Fitzpatrick (2004), musical training may influence student test scores across socioeconomic categories. Robitaille and O'Neal (1981) used a sample of students from Albuquerque, NM that consisted of testing 5,154 fifth-graders completing the Comprehensive Tests of Basic Skills (CTBS) in March 1979. In 1980 an

additional 5,299 fifth-graders were tested. In all areas of comparison, students enrolled in instrumental music programs scored higher on CTBS testing than did the total fifth-grade group. The music students were a self selected group, but the results of the testing revealed that the longer students were participating in instrumental music the better they achieved on the CTBS test.

The results of the Albuquerque study not only showed that the instrumental music students tested in the study scored higher than the tested group as a whole, but those students who participated in two or more years of instrumental instruction in band programs scored 10 percentile points higher in reading and 12 percentile points higher in language than the total group of fifth-graders tested. Additionally, students that participated in two years of instrumental instruction in orchestra scored 16 percentile points higher in reading and 12 percentile points higher in language and 20 percentile points higher than the total fifth-grade group in language.

In a similar study, Fitzpatrick (2004) examined the relationships, at the student level, between music education and scores on the Ohio Proficiency Test (OPT). Fitzpatrick identified higher income students and lower income students by using the Free and Reduced Lunch Program to distinguish the two groups. Then she was able to identify the students who participated in instrumental music programs. This provided a set of four groups: students with high income and instrumental music; students with high income and no music; students with low income and instrumental music; and finally students with low income and no instrumental music.

High income was the most significant contributor to the probability of a high score on the OPT of the groups tested. However, while the high income variable held true for the fourth-graders tested and the sixth-graders tested, the ninth-grade results suggested that instrumental

music may have had an effect relationship on the low-income and instrumental group that surpassed the high-income and no music group in OPT testing results. Figure 1 and Figure 2 (See Appendix) are from the Fitzpatrick study and show the relationship between music and math and science scores over time. Figures 1 and 2 do not consider any other factors other than music participation, income and test scores. I will examine whether instrumental music among other factors correlated with it, increases test scores based on data collected from school level.

The researchers above, Fitzpatrick (2004) and Robitaille (1981), do not consider other variables that may have played a critical role in how the students were selected and the resulting higher test scores. Among some of the other variables that could affect ACT scores may be the family structure, racial identification, or significant others that might play an important role in encouraging higher academic goals. An ideal design would have treatment and control populations, with pre-test and post-testing to verify outcomes. All students observed in both studies, Fitzpatrick (2004) and Robitaille (1981) limited the number of student attributes to participation in music and test results.

Another study Gregory (1988) of elementary students found that third-grade students receiving music instruction through the "Leap into Music" curriculum made significant academic progress in Mathematics. Other researchers have shown improvements in academic achievements through the participation in instrumental music programs. Costa-Giomi (1999) showed significant early increases in general cognitive abilities and spatial abilities gained from piano instruction, but those gains were not sustained over time. Costa-Giomi found that after three years there were few sustained cognitive improvements among the tested group of students exposed to piano instruction.

> "Studies investigating connections between participation in music and general academic achievement have been ubiquitous in the literature. Most have demonstrated that participation in music parallels increased academic achievement (Perry, 1993). This relationship has been demonstrated with standardized tests in reading (Butzlaff, 2000), grade-point averages (Miranda, 2001; Zanutto, 1997), SAT scores (Butzlaff, 2000; Cobb, 1997; Miranda 2001), and ACT scores (Cobb, 1997; Miranda 2001). Some of the aforementioned studies have found that academic achievement did not improve with music participation. Others have shown that music participation did not affect academic achievement more than did other variables investigated, but significant academic gains were still noted (Andrews, 1997; Perry, 1993). None of the studies found that participation in music negatively influenced academic progress".

The resulting relationships displayed from the cognitive abilities and spatial abilities gained from piano instruction could have been caused by better students being attracted to music in the first place. Costa-Giomi further questioned whether the early increases in cognitive development might have been a result of the excitement of participation in the study or the additional attention given to the treatment group.

Vaughn (2000) conducted a meta-analysis of more than 4,000 initial references to try to understand the "conventional wisdom [that] music and mathematics are related". Of the 4,000 references Vaughn found six experimental training studies which were examined. In the general discussion, Vaughn (2000) asked three questions.

- Do individuals who voluntarily choose to study music (and these may be individuals with high musical ability) show higher mathematical achievement than those who do not choose music?
- Do individuals exposed to music curriculum in school (not voluntarily selected) show higher mathematical achievement as a consequence of this music instruction?
- Does background music heard while thinking about math problems serve to enhance mathematical ability at least during the music listening time?

The answers were as follows: Yes, students who choose music scored higher mathematical achievement than those students who did not choose to participate; Yes, students exposed to music curriculum showed higher mathematical achievement (a small casual relationship) as a

consequence of music instruction; and, a very small yes in improved mathematical ability enhanced by listening to music. Participation in the making of the music appears to have a stronger relationship than just listening, but even listening showed improved scores in this research.

Research based on predetermined and non-randomized populations, as presented in some of the studies above have treatment groups of students who were already participating in instrumental music. There was no control over who received the treatment and music participation was self selected. Activities other than music, not music, may have contributed to produce similar results.

Expected Effect of Music Education

Not all schools have instrumental music programs, and not all students have access to private lessons or a family member or significant other who supports instrumental music training. The examination and comparison between instrumental music students and non-music students needs a foundation on which to expect an effect, and controls for other variables that may affect ACT scores. When examining the problem statement "Does instrumental music increase predicted ACT scores?" both the decision by individual school districts to support instrumental music programs with resource allocation, and individual student choice to participate, could matter and could have an effect. The problem involves controlling for the many possible reasons students are initially attracted or select instrumental music instruction over other possible activities including alternatives such as sports, drama, or chorus.

Ideally, you would want to explain the alternatives and how they may have an impact on ACT scores. Alternative activities would take away from other lines of study. On the other hand

there is literature that claims music has an effect on neurological cognitive development. Hodges (2000) comments in his article *Implications of Music and Brain Research*, that musical experiences are multimodal. Playing a musical instrument requires the use of several neural systems to work simultaneously including auditory, visual, cognitive, affective, memory, and motor systems. It is beyond the scope of this research to solve the mystery of how the brain functions and develops.

The first step in an ideally designed research process would be to find a population of students who had never been exposed to music instruction. This population would not have been exposed to written music notation, musical intervals, beat, rhythmic patterns, or any other musical instruction. When a suitable sized sample of these students have been located, random treatment and control groups from that population would be selected for further study.

The treatment group would receive instrumental music instruction and the control group would not be exposed to any music instruction. Randomizing the selection of placement in both groups would eliminate any selection bias and therefore would preserve validity of the research design.

The criteria for selection into the research population for the ideal research design would include the following stages: (1) Collecting student level data from Kentucky school districts having active music programs within their curriculum; (2) verifiable instrumental music participation[1] would be demonstrated by a minimum of two years of instrumental classroom instruction as a qualifying attribute of treatment subjects.

[1] Verifiable attendance and participation records would help to defray bias that may exist in the question of the levels of instrumental music participation.

After the populations of instrumental music students have been selected, a random sample would be selected to compare to a random sample of non-instrumental music students to determine if there is an observable relationship in the mean ACT scores achieved by the two groups. The randomness of selection for observation would eliminate bias due to pre-existing preponderance of musical ability, family supported influences, teacher/instructor influences, socio-economic concerns, race, or residence factors.

Consider the following attributes of random selection: Both groups would include good musicians and poor musicians; both groups would include high academic achievers and low academic achievers; family attributes would be smoothed by randomly selecting treatment students strictly by chance; random selection would remove bias based on good or bad teachers. The selected populations would include students from a wide range of socio-economic backgrounds, race would not be a consideration, and, geographic locations (urban/rural) would not be a consideration for randomly selected groups.

The treatment group would be tracked through their secondary education and their ACT test results would be compared to a similar sized control group of non instrumental music students selected randomly to eliminate bias as suggested above. If the results of the comparison reveal that the group of randomly selected instrumental music students' collective average ACT scores is observed to be higher or lower than their randomly selected control counterparts, this would provide strong evidence of the relationship that might exist between participation in instrumental music instruction and higher ACT scores.

Collection and examination of the data compiled from the ideal research design would look for statistically significant differences in the mean ACT scores recorded by the treatment

group (μ_1) defined as those students given instrumental instruction and the scores recorded by the control group (μ_2) defined as those students whose instrumental music instruction was withheld. The mean scores from all students would be given as μ_o. If it is discovered that $\mu_1 > \mu_2$, the null hypothesis and alternative hypothesis of the hypothetical ideal research design would read as follows, tested at the 0.05 level of significance:

Hypothesis 1:

There is no statistically significant relationship between instrumental music participation and the average ACT scores of all students, $\mu_o - \mu_1 \approx 0$

Hypothesis 2:

There is no significant relationship between average student ACT scores with instrumental music participation and the average student ACT scores of students not participating in instrumental music, $\mu_1 - \mu_2 \approx 0$.

Such an ideal research design would still not answer the questions of whether or not other variables contribute to the results affecting the outcomes. Even with random sampling and use of treatment and control groups there would remain unknown factors that may or may not have an effect on ACT scores. Substitution of another discipline other than instrumental music may produce similar results.

Methods

The data I use for this research was provided by the Kentucky Department of Education (KDE) and contains the average ACT scores for each Kentucky high school in the 2008-2009 academic year. As mandated by Senate Bill 130, beginning in the 2007-2008 school year, all Kentucky public school students are required to take the Educational Planning and Assessment System (EPAS) tests from ACT. Eighth grade students will take EXPLORE, tenth grade students will take the PLAN, and eleventh grade students will take the ACT. The data I use includes PLAN scores, from the 2007-2008 academic year as a variable to try to explain some of the effects of student scores from the same population over time.

The three step process designed by ACT (EXPLORE, PLAN, ACT) administered over multiple years, records a comparison of scores that can be observed with the same population over time. The average ACT school level test scores, which were collected from the 2008-2009 junior class, of all participating Kentucky high school students, were used in this analysis and represent the dependent variable.

The KDE data set includes 226 public high schools in Kentucky (225 when one school with missing data was dropped) and variables were chosen to control for socio-economic factors, race, prior ability, and participation in instrumental music. The answers to an ACT pre-test questionnaire were examined to compile the data and it must be stated that the information provided by the students is self reported, so it may not be completely accurate. A more rigorously controlled data set might produce different results.[2]

[2] The self-reporting bias extends to the question of instrumental music participation where it is conceivable that a student who participated in only two months of fourth-grade orchestra class would answer yes to the pre-test question about instrumental music participation.

Percentages or averages were calculated for the variables examined for each independent variable at the school level. The ACT data set was provided by the Kentucky Department of Education and a questionnaire that the students complete before the ACT provided the raw data for the variables. Regression analysis was performed to control for possible factors which may be responsible for variations in test scores between instrumental and non instrumental populations.

This project will compare student ACT test results of Kentucky students at the school level and the percentage of the student population at each school who participated in instrumental music programs. The testing of Kentucky students follows an EXPLORE, PLAN, and ACT sequence. EXPLORE tests eight-graders and will not be used in this analysis. PLAN[3] tests will act as a control variable which shows academic improvements over time of the same population of students and shows academic achievement at an earlier time prior to the ACT test. Examination of test scores at the school level can provide information on whether students participating in instrumental music programs score higher than students who do not participate in instrumental music. A linear regression model will be utilized in estimating how important each factor may be in the testing results. The model is shown below.

$$\text{ACT SCORES} = \beta_0 + \beta_1 (\text{ACT PLAN}) + \beta_2 (\text{FRL}) + \beta_3 (\%\ \text{MUSIC}) + \beta_4 (\%\ \text{BLACK}) + \beta_5 (\text{AP SCIENCE}) + \beta_6 (\text{AP MATH}) + \beta_6 (\text{AP ENGLISH}) + \varepsilon$$

The ACT score, the dependent variable, is the school average. As the model suggests, explanatory variables include the student instrumental music program participation by school, the percentage of black students by school, the family income of participating students by school

[3] The ACT package used in the Commonwealth of Kentucky requires a three test sequence for all students. The three part series include EXPLORE, PLAN, and ACT.

(FRL), and participation in AP science, AP math, and AP English courses. The term ε represents the error term. ACT SCORES are averaged at the school level.

Family income is measured by the percentage of students who qualify for the Free and Reduced Lunch (FRL) relative to the statewide rate. According to the *Kentucky District Data Profiles School Year 2007-2008, Research Report No. 360* (Seiler, et.al, 2009) more than fifty-five percent of all Kentucky high school students are the recipients of Free and Reduced Lunch (FRL) benefits. Families earning less than $40,793 ($0 to $40,793) qualify for the federally funded FRL program[4]. The data from the pre-ACT test questionnaire relating to family income were self-reported by the students. It should also be noted that using FRL as an interpreting measure for poverty is not exact, but acts as an imperfect predictor of where a student may be on the SES spectrum of income and/or economic opportunity.

These explanatory variables were not intended to represent an exhaustible and conclusive list of possible factors that might lead to higher ACT scores at the school level. For instance there is no measure of parental support which could influence participation in instrumental programs and also influence the propensity and expectation for higher ACT test scores. Nor is there a measure of teacher quality or more generally, school quality, both of which would be expected to affect ACT scores.

The remaining explanatory variables are from the pre-ACT Student Information booklet completed by all Kentucky students tested. These include: average PLAN scores at the school level; income (high or low); ethnicity (coded as percentage African-American); participation in AP English, AP mathematics, and AP natural science; and participation in instrumental music

[4] Federal Register/Vol. 74, No. 58/ Friday, March 27, 2009/Notices (page 13412)
Accessed: June 1, 2010, http://www.fns.usda.gov/cnd/governance/notices/iegs/IEGs09-10.pdf

programs. All AP participation variables are expected to be positively related to ACT scores, just as high income usually increases ACT scores. The expectation is that instrumental music is associated with higher ACT scores.

Table 1 shows descriptive statistics for the 225 schools in the data set. Schools vary considerably on all characteristics. Instrumental music averages 15% participation, but the standard deviation is 7%, and the range is none at all to half. Representative of Kentucky, the average percentage of African-American students is 8% and the average school is 52% low income, with a small number of schools making these averages higher than the individual state average.

Table 1: Descriptive Statistics (225 schools in Kentucky)

Variables	Mean	Std. Dev.	Minimum	Maximum
Average ACT	18.08	1.59	14.03	25.03
Average PLAN	16.31	1.13	13.41	21.50
Percent Music	15%	7%	0%	50%
Percent Low Income	52%	17%	10%	84%
Ethnicity (Black)	8%	13%	0%	78%
Percent AP Science	23%	13%	2%	73%
Percent AP Math	27%	13%	0%	71%
Percent AP English	33%	15%	2%	79%

Results

The results from estimating an OLS regression with the average ACT score as the dependent variable are found in Table 2. The magnitude of the regression coefficient shows the estimated effect of a change of 1.0 or one unit in the explanatory variable. The t-statistics are reported below the coefficients.

Table 2: Regression Analysis of Act Scores

Dependent: Average ACT scores at the school Level		
Regression Statistics		
R Square	0.8765	
Observations	N = 225	
Variable	*Coefficients*	
Average PLAN SCORES	1.1120	
	(21.48)	***
% MUSIC	1.2265	
	(2.26)	***
% FRL	-1.8602	
	(-4.60)	***
% BLACK	0.0663	
	(0.20)	
% AP SCIENCE	0.4148	
	(0.82)	
% AP MATH	-0.2391	
	(-0.49)	
% AP ENGLISH	0.2494	
	(0.64)	
		*** - significant at 1%

As would be expected for a baseline ability measure, the composite PLAN scores at each school was the largest and most statistically significant predictor of the mean ACT scores at each school. Since the average PLAN score was taken by the same students who participated in the

ACT test it makes sense that the PLAN scores would be a predictor of ACT scores. An increase of one point in PLAN score predicts a .011 increase in ACT score.

The low income variable shows a negative relationship between the percentage of low income students and the mean ACT scores at the school level. The regression estimates that if there is a one percentage point increase of lower income in a given school the average ACT score for that school will be lower by about .018 points. The percentage low income can be very high and shows significant change when the PLAN scores are not included in the model.

In order to examine the same data over time the PLAN score was included as an explanatory variable. As was expected the ability measure was the most significant of all explanatory variables with a t-statistic of 21.48. To examine the other explanatory variables without the PLAN score a second regression was conducted and examined below.

When the PLAN scores are excluded from the regression (see Table 3), similar results are obtained. The R^2 in the model without the PLAN does not demonstrate the predictive accuracy of the analysis, yet the observed results support the predictive outcomes in this model. Low income has a significant negative predicted affect on ACT. The % black variable is observed to have a significant negative predicted affect on ACT scores with PLAN excluded. The instrumental music variable is observed to have a positive predicted affect on ACT scores from the school level data in both regression analyses.

Table 3: Regression Analysis Without PLAN SCORES

Dependent: Average ACT scores at the school Level	
Regression Statistics	
R Square	0.613983878
Observations	N = 225

Coefficients	*t Stat*	
% Music	2.566227852	
	(2.6996)	***
% FRL	-7.714983409	
	(-14.6504)	***
% BLACKK	-1.30943755	
	(-2.3316)	***
% AP SCIENCEI	1.552446995	
	(1.7543)	***
% AP MATH	0.102190494	
	(0.1177)	
%AP ENGLISH	1.017441713	
	(1.4804)	***
		*** - significant at 1%

From the regressions above, an expected increase of 10% in the music participation would have a predicted effect of about 0.10 times 1.2265 (including the PLAN variable), or .12 points on the ACT. The predicted effect, excluding the PLAN variable, doubles to 2.6996, or .27 points on the ACT and there are increases in significance of many of the other explanatory variables. With the PLAN scores excluded from the regression, the ability measure is not calculated and therefore increases in the other variables are observed. It should be noted that the positive relationship between instrumental music participation to predicted increased ACT scores and a negative predictive relationship between FRL and predicted ACT scores holds in both models.

Income measured as the percentage of students below $40,000 in household income (FRL) has a statistically significant estimated effect on ACT scores, lowering scores as expected. Instrumental music does have a statistically significant estimated effect on ACT scores in this model. None of the other factors considered have statistically significant estimated effects. The overall regression predicts a high percentage of the variance in ACT scores; the r square is over 87%; the high R^2 results mainly from the ability measure, PLAN scores.

Conclusions and Recommendations

This research examines the ability of instrumental music education to predict changes in ACT scores at the average level for schools, controlling for other factors including ability measures of the students and poverty levels, as well as, other standard controls such as ethnicity, science, math, and English achievement. The estimates show that, net of other factors, instrumental music increases the estimated ACT. This could result from a causal relationship, or from unmeasured ability associated with music, or with unmeasured funding or school factors associated with larger music programs. Therefore, it is impossible to infer causality from this research alone. However, some factor associated with instrumental music is increasing ACT scores net of overall ability and poverty.

Other independent variables include: PLAN score which is a measure of students' test scores before the ACT; AP English, mathematics, and natural science participation, none of which are associated with ACT scores after controlling for PLAN score; and percentage African-American, which is also uncorrelated with ACT scores controlling for PLAN scores.

The factors contributing to the initial participation in instrumental music are infinite. The same can be said about ACT scores. Whether student resources are internal (FRL, parental support,

etc) or external (good/bad teachers, schools, parental support, etc), students with less resources are at a statistical disadvantage than those students that have access to sufficient resources.

The ideal method of examining this causality question would be a panel of individual students over time with significant controls for ability and educational factors. An experiment of ideal design could provide supportive or conflicting results. An ideal design is not possible here, but the predictive ability of instrumental music participation suggests that further research with a larger, individual data set would be useful in order to estimate whether something about instrumental music participation is the explanation.

Appendix

Figure 1: Test scores by free and reduced price lunch and instrumental music status

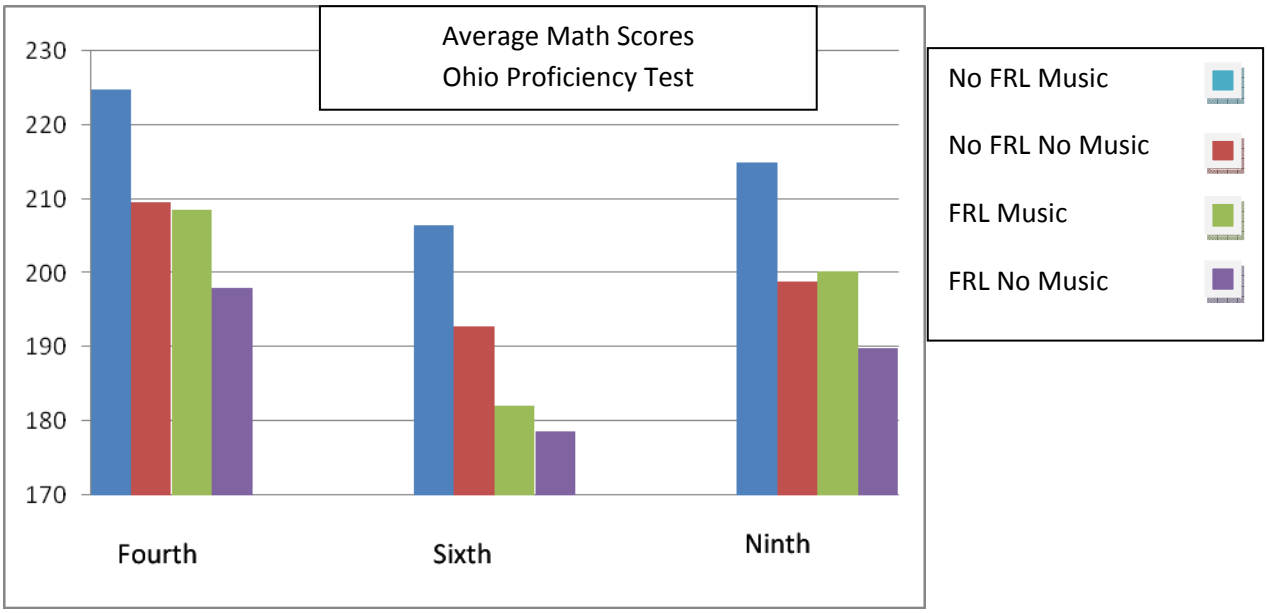
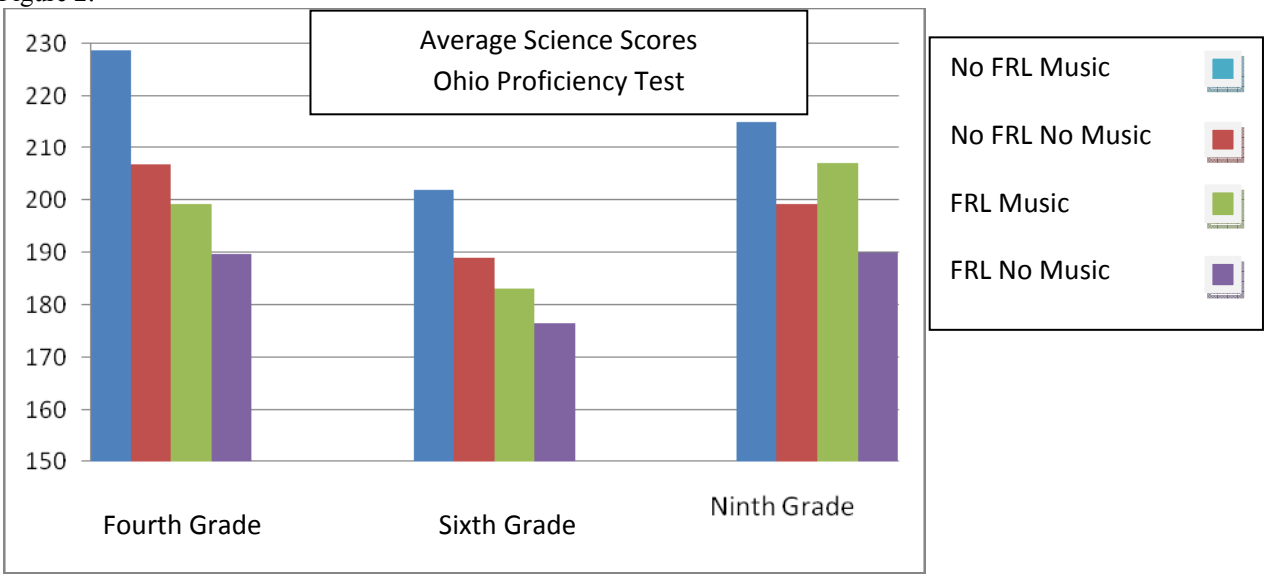


Figure 2:



The charts depicted in Figure 1 and Figure 2 were recreated using data from Fitzpatrick, Kate R. The Effect of Instrumental Music Participation and Socioeconomic Status on Ohio Fourth, Sixth, and Ninth-Grade Proficiency Test Performance. MENC: The National Association for Music Education. (2006) Master's Thesis August 2004.

References

Abril, Carlos R. and Gault, Brent M. "The State of Music in the Elementary School: The Principal's Perspective." Journal of Research in Music Education, Vol. 54, No. 1 (Spring 2006): 6-20.

Costa-Giomi, Eugenia. "The Effects of Three Years of Piano Instruction on Children's Cognitive Development." Journal of Research in Music Education, Vol. 47, No. 3 (Autumn 1999): 198-212.

Fitzpatrick, Kate R. "The Effects of Instrumental Music Participation and Socioeconomic Status on Ohio Fourth, Sixth, and Ninth-Grade Proficiency Test Performance." MENC: The National Association for Music Education (2006): Masters Thesis August 2004.

Hodges, Donald A. "Implications of Music and Brain Research." MENC: The National Association for Music Education (2000): 17-22.

Johnson, Christopher M. and Memmott, Jenny E. "Examination of Relationships between Participation in School Music Programs of Differing Quality and Standardized Tests." Journal of Research in Music Education, Vol. 54, No. 4 (Winter 2006): 293-307.

Kentucky Department of Education. "ACT Assessments." (March 2010).

Robitaille, Joseph P. and O'Neal, Sandra. "Why Instrumental Music in Elementary Schools?" Phi Delta Kappa Vol. 63, No. 3 (1981): 213.

Seiler, Marcia, et. al. "Kentucky District Data Profiles School Year 2007-2008, Research Report No. 360." Office of Educational Accountability, Legislative Research Commission (2009).

United States Department of Agriculture. "Federal Register/Vol. 74, No 58." (2009): 13412.

Vaughn, Kathryn. "Music and Mathmatics: Modest Support for the Oft-Claimed Relationship." Journal of Aesthetic Education (Autumn-Winter 2000): 149-166.

Young, Amanda. "Win the Funding Game." Music Educators Journal, Vol. 68, No. 3 (November 1981): 43-47.