IN-SCHOOL ARTS EDUCATION AND ACADEMIC ACHIEVEMENT: EXAMINING THE LONGITUDINAL ASSOCIATIONS USING HIERARCHICAL LINEAR MODELING AND FIXED EFFECTS TECHNIQUES

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ABSTRACT OF DISSERTATION

In-School Arts Education and Academic Achievement: Examining the Longitudinal Associations using Hierarchical Linear Modeling and Fixed Effects Techniques

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The primary aim of this research was to estimate the longitudinal associations of in-school arts education and academic achievement and growth, using hierarchical linear modeling and child fixed effects techniques. Data were drawn from two national studies: The Early Childhood Longitudinal Study and the National Education Longitudinal Study. Findings support previous claims of the academic benefits of arts education. Across data sets, research designs, and achievement outcomes, students who received any type of arts education at least once a week academically outperformed students who received neither art nor music education. The magnitude of the associations of arts education and academic achievement were consistent across achievement outcomes, which suggests that arts education contributes to overall academic achievement rather than subject specific knowledge and skills. Exploratory analyses revealed that the associations of arts education and academic achievement were strongest for females and for children who displayed negative learning-related skills (i.e. not following directions, not keeping belongings organized, not completing tasks).

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General Introduction

Whether in-school arts education contributes to achievement in reading and mathematics is a perennial debate in education policy. In the climate of reform and accountability, educators are faced with budgetary and curriculum constraints that lead to reductions in art and music programs (Abril & Gault, 2006; Parsad & Spiegelman, 2012; Sabol, 2013). Decisions to cut arts programs are often based in the assumption that time-on-task is the only thing that matters for long-term achievement in mathematics and language arts. However, decisions to cut arts programs are made in the absence of evidence that arts education is a distraction from academic goals. Indeed, some findings indicate that arts education is positively associated with academic achievement, even though arts education is not an intervention that targets the skills measured by standardized achievement assessments.

The debate over the value of arts education persists, in part, because arts education researchers have relied heavily on the use of cross-sectional research designs to compare the achievement of students who receive arts education to the achievement of students who do not. The problem with this approach is that there are many extraneous factors which contribute to whether students have access to and receive arts education. When cross-sectional designs are used to estimate between-student differences in achievement at a single point in time, it is difficult to determine whether pre-existing student differences (i.e. socioeconomic status, prior achievement, artistic talent) account for the positive associations of arts education and academic achievement. Therefore, it is still largely unknown whether and how arts education contributes to student learning.

In the present research, I use hierarchical linear modeling (HLM) and child fixed effects techniques to model the longitudinal associations of arts education and academic achievement. I also probe for potential moderators of the associations of arts education and academic achievement to determine whether the associations are stronger for some student populations than others. Data were drawn from two national longitudinal studies: The Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K) and the National Education Longitudinal Study of 1988 (NELS:88). The use of longitudinal data allowed for the temporal ordering of the independent and dependent variables and the prediction of initial achievement levels and rates of growth.

Hypotheses were informed by motivation theory, specifically achievement goal theory and cognitive evaluation theory. Per cognitive evaluation theory, characteristics of instructional contexts can either facilitate or forestall optimal student motivation. When students are allowed freedom in determining how to complete tasks, feel competent in their ability to do so, and are socially supported, they are happier, more persistent, and self-determined (Ryan et al., 1995).

Any instructional methods can be designed to satisfy student needs for autonomy, competence, and relatedness. However, direct instruction in language arts and mathematics can be experienced as controlling because performance goals (i.e. performing well on a test) are often emphasized (Deci et al., 1999, 2000; Harlen & Crick, 2003). In contrast, instruction in the arts often allows for a great deal of open-ended interpretation and self-expression. It also creates varied opportunities for under-performing students to experience success, and allows students to explore new ideas and experience failure without serious consequences (i.e. failing a test). Therefore, arts education has been theorized to contribute to student achievement by way of enhanced motivation and engagement (Dege et al., 2014; Fleming et al., 2015; Green & Kindseth, 2011; Gulatt, 2008; Winner et al., 2013).

Although it is important to examine the mechanisms that underlie the associations of arts education and academic achievement, the present research was not designed for this purpose. This research was designed to test the associations of arts education and academic achievement in adherence to rigorous methodological standards. Although they are general, findings from this research are relevant to education policy. If arts education reliably predicts longitudinal achievement and growth in traditionally tested subjects, then researchers have reason to question the efficacy of a strengthening trend in education policy: The narrowing of instruction to focus on mathematics and language arts.

Methodological Limitations of Past Research

Meta-analyses of both published and unpublished studies indicate that the associations of arts education and academic achievement are modest and reliable. Vaughn (2000) found that formal music training had an average effect size of $r = .15$ with mathematics achievement. Winner and Cooper (2000) found that training in any art form had an average effect size of $r = .19$ with reading achievement and $r = .10$ with mathematics achievement. However, the authors of these meta-analysis are quick to point out that the research designs used by arts education researchers do not allow for causal inferences. Most of the studies used in the meta-analyses were retrospective group comparisons that provide average effects that are not good representations of the true effects of arts education.

Studies conducted after the meta-analyses were published provide additional evidence of the positive associations of formal arts education and achievement in reading and mathematics (Catterall et al., 2012; Fitzpatrick, 2006; Melnick et al, 2011; Smithrim, 2005; Southgate & Roscigno, 2009; Wandell et al, 2008). Catterall et al. (2012) used data drawn from the ECLS-K and NELS:88 to compare students who received years of arts education and students who received little to no arts education on measures of academic achievement. The authors used all measures of arts education available in the two data sets—any art form, in-school, out-of-school, and overtime—and created a continuous composite measure for each study. (This was done by awarding students one point for each report of arts education). Students who scored in the top 25th percentile of the continuous arts education measures were identified as high-arts. Students who scored in the bottom 25th percentile of the continuous arts education measures were identified as low-arts.

Through a series of t-tests, Catterall et al. (2012) found that high-arts students outperformed low-arts students on science and writing assessments in 8th grade (ECLS-K) and were higher achieving in college (NELS:88). However, the authors discarded meaningful variation and drastically reduced their sample sizes by excluding students who did not score in the top and bottom 25th percentile of the continuous arts education measures. Moreover, the authors did not statistically adjust for the effects of confounding variables. The available data allows for much more comprehensive statistical analysis.

Taking a step in the direction of methodological rigor, Southgate and Roscigno (2009) used lagged dependent variable techniques to examine the associations of music education and achievement in reading and mathematics, adjusting for prior achievement. The authors drew data from the ECLS-K and NELS:88. In the ECLS-K analyses, predictors were drawn from the kindergarten assessment and outcomes were drawn from the 1st-grade assessment. In the NELS:88 analyses, predictors were drawn from the 8th-grade assessment and achievement outcomes were drawn from the 12th-grade assessment. Across data sets, the authors found that music education positively predicted achievement in reading and mathematics. These findings persisted after adjusting for the effects of gender, race, socioeconomic status, family composition characteristics, and prior achievement.

The findings from Southgate and Roscigno's (2009) study are more convincing than the findings from Catterall et al.'s (2012) study because the former authors adjusted for the effects of confounding variables. However, these studies share a common limitation: They use arts education variables to predict achievement at a single point in time. Only between-student variation can be modeled when predicting achievement at a single point in time, which poses many challenges. To reliably model between-student variation, one must statistically adjust for any systematic differences between compared students (Allison, 2015). However, attempting to statistically adjust for all factors that determine whether students receive arts education would cost precision (Westfall & Yarkoni, 2016) because many variables which lead students to engage with the arts are latent variables, such as artistic talent. In sum, between-student designs are unequipped to model the associations of arts education and academic achievement.

Many threats to internal validity can be reduced when longitudinal achievement data are available because both initial achievement levels and rates of growth can be modeled (Allison, 2005; Rabe-Hesketh & Skrondal, 2012; Singer & Willett, 2003). Achievement data are traditionally collected repeatedly over time. Therefore, it is surprising that only one researcher (Miksza, 2007), to the best of my knowledge, has used longitudinal techniques to model growth in achievement as a function of arts education. (Miksza's study is described in detail in the Research Objectives section).

In-School Arts Education

In addition to the methodological limitations just described, past arts education research is limited by a focus on the effects of out-of-school music education. The use of formal out-of-school arts education measures is problematic for two reasons. First, the treatment being evaluated is distinct from the treatment being promoted. Discussions of arts education research include implications for education policy (i.e. schools should have art programs). However, few studies have examined arts education as it realistically occurs in the standard school classroom. Second, out-of-school arts training is almost exclusively a self-selected treatment. As stated previously, it is difficult to identify and adjust for all the factors which contribute to whether parents decide to enroll their children in formal arts lessons (i.e. financial resources, parental education, child interest in the arts).

Compared to formal out-of-school arts education measures, the use of in-school arts education measures may reduce the threat of selection bias in the estimation of the associations of arts education and academic achievement. This is because selection appears to play a smaller role in determining whether students receive in-school arts education than in determining whether students receive out-of-school arts education. Using data drawn from the ECLS-K, Miksza and Gault (2014) found that family background characteristics were significant predictors of both in-school and out-of-school arts education. However, family background characteristics accounted for more variation in out-of-school arts education than in in-school arts education. Similar findings were reported by Southgate and Roscigno (2009) who used data drawn from the ECLS-K and NELS:88. In sum, it is possible that some parents select schools and teachers for their children because those schools and teachers value arts education. However, it is unlikely that every child who receives in-school arts education is, or has a parent who is, intrinsically interested in the arts.

Art vs Music

The reliance on music and multi-arts measures of arts education is also a limitation of past arts education research. Multi-arts studies are those which do not distinguish between different types of arts education (i.e. music, art, drama, and dance). They are prevalent and are often designed to capture the cumulative effects of receiving more than one type of arts education. Many scholars have examined the distinct impact of music education on academic achievement, but, few have examined the distinct impact of visual arts education. Moreover, virtually none have explored the relative impact of different types of arts education and the cumulative impact of receiving more than one type. From a motivational perspective, there is little reason to assume that art and music education will have differing effects on academic achievement. However, it may be variety in the curriculum that enhances student engagement and achievement. Therefore, it is plausible that receiving multiple types of arts education (i.e. both art and music) contributes more to achievement than receiving only one type of arts education. Examining the relative and cumulative effects of different art forms may clarify whether it is arts education in general that fosters student engagement and learning, or whether some types of arts education (i.e. music) are more cognitively beneficial than others.

Moderation

A final limitation of the arts education literature is that few researchers have probed for potential moderators of the associations of arts education and academic achievement. There is a small amount of inconsistent evidence that socioeconomic status moderates the associations of arts education and academic achievement (Catterall et al., 2012; Fitzpatrick, 2006; Miksza & Gault, 2007). However, to the best of my knowledge, socioeconomic status is the only variable used in tests of moderation by past arts education researchers. Probing for additional potential moderators of the associations of arts education and academic achievement may lead to a better understanding of how arts education contributes to achievement and for whom the associations are the strongest.

Research Objectives

The primary aim of the present research was to estimate the longitudinal associations of in-school arts education (art, music, and both art and music) and academic achievement and growth, using data drawn from two national studies: The ECLS-K and the NELS:88. In addition to making these methodological contributions, this research fills gaps in the arts education literature by focusing on the effects of in-school arts education, exploring the relative contributions of art and music education, and probing for potential moderators of the associations of arts education and academic achievement.

Study 1: NELS:88 Hierarchical Linear Models

Study 1 is a replication and extension of a longitudinal study conducted by Miksza (2007). Miksza used data drawn from the NELS:88 to model within- and between-student variation in reading, mathematics, science, and history achievement, using HLM techniques. Students who reported engaging in music activities at all three data collection time points (8^{th}-grade, 10^{th}-grade, and 12^{th}-grade) were assigned to a music education category. Students who reported not engaging in any music activities throughout the course of the study were assigned to a no music education category. Findings indicate that adolescents who continuously received music education had higher initial achievement scores and greater rates of growth from 8^{th}-grade to 12^{th}-grade than adolescents who did not receive music education.

Miksza's (2007) study makes a unique contribution to the arts education literature by moving beyond the prediction of achievement at a single point in time to modeling growth in achievement over a four-year period. To the best of my knowledge, Miksza is the first and only researcher to model growth in achievement as a function of arts education. However, Miksza's study is not without limitations. First, the analytic sample was limited to high-music and no-music students. This approach unnecessarily discards variation and observations which jeopardizes the precision of the effect estimates. Moreover, high school students often choose their schedules, and students who consistently choose to take music classes may differ in many important ways from students who consistently choose not to take music classes. Therefore, the differences in initial status and rates of growth between high-music and non-music students may result from preexisting differences rather than music education itself.

A second limitation of Miksza's study is that school-level confounds, and school-level nesting, were not addressed. Schools that offer arts education may be systematically different from schools that do not offer arts education and omitting school-level confounds will positively bias effect estimates (Allison, 2005). Additionally, when the nesting of children in schools is ignored in analyses, student observations are treated as though they were sampled randomly from the general population. Children in the same schools have many characteristics in common and treating them as independent observations will negatively bias standard error estimates (Rabe-Hesketh & Skrondal, 2012).

Therefore, in the present replication, I used 8^{th}-grade measures of in-school arts education as the key predictors of academic achievement (the latter waves only contained measures of out-of-school arts education). This resulted in a sample that was twice as large—and inclusive—as the sample used in Miksza's (2007) study. I used three-level HLM techniques to account for variation in academic achievement at the student level and the school level. I also adjusted for the effects of confounding variables at the student level (gender, race, socioeconomic status) and the school level (percent free lunch, percent minority, starting teacher salary, school type, and region).

All predictors were drawn from the 8^{th}-grade assessment. IRT achievement scale scores in reading, mathematics, science, and history were drawn from the 8^{th}-grade, 10^{th}-grade, and 12^{th}-grade assessments. Covariates at the child level and the school level predicted the intercept (i.e. initial achievement scores) and slope (i.e. linear change in achievement over time) parameters. Interactions of arts education and student and school characteristics were estimated in additional exploratory models.

Study 2: ECLS-K Hierarchical Linear Models

Study 2 is a replication and extension of Study 1. For this replication, data were drawn from the ECLS-K. School and family characteristics were drawn from the kindergarten assessment. Measures of in-school arts education and achievement in reading and mathematics were drawn from the kindergarten, 1st-grade, 3rd-grade, and 5th-grade assessments. HLM procedures, identical to those used in Study 1, were used in Study 2 to model variation in achievement as a function of arts education. The only difference in analyses is that a time-varying measure of in-school arts education was used in Study 2 as the key predictor of achievement in reading and mathematics. Time-varying covariates predict the intercept and slope parameters as well as achievement at each assessment time point. This allows for more precise estimation of the associations of arts education and academic achievement than the time-invariant predictor used in Study 1.

Study 3: ECLS-K Fixed Effects Models

The greatest internal validity threats to past findings are selection and omitted variable biases. In Study 3, child fixed effects models were used to address these threats. Child fixed effects models are uniquely suited to address omitted variable bias because they condition out stable between-child variation to focus solely on the analysis of within-child variation. Within-child designs control for the effects of all stable child characteristics including those which are difficult or impossible to observe (Allison, 2005; Rabe-Hesketh & Skrondal, 2012). This includes traditionally measured characteristics such as gender, race, and parental education, and less frequently measured characteristics such as parental interest in the arts, stable personality traits, and many genetic factors.

Fixed effects techniques were not applicable with the NELS:88 data because time-varying measures of in-school arts education were not available. The ECLS-K data contained the required time-varying measures for fixed effects analysis as well as measures which enabled the construction of a continuous arts education composite measure. Therefore, two time-varying measures of in-school arts education were used as predictors in Study 3: A continuous measure (total number of minutes per week of art and music education) and a categorical measure (type of arts education received). All variables included in the child fixed effects analyses were drawn from the kindergarten, 1st-grade, 3rd-grade, and 5th-grade waves.

Overarching Hypotheses

Considering previous research and theory, I hypothesized that a) students who receive any type of arts education academically outperform students who receive neither art nor music education, b) the effects of receiving both art and music education reflect the cumulative effects of each art form (i.e. effect size of only art + effect size of only music = effect size of both art and music), and c) the effects of each art form are consistent across academic subjects.

I did not formulate a hypothesis regarding the relative magnitude of the associations of art versus music education. Given the dearth of published studies that examine the associations of visual arts education and academic achievement, I suspected that the effects of music education would be easier to detect. My secondary goals to probe for potential moderators of the associations of arts education and academic achievement were exploratory. Therefore, I did not formulate hypotheses regarding the significance or direction of the arts education and student and school characteristic interaction effects.

From a methodological standpoint, I predicted that the magnitude of the effects of arts education would be the most notable in Study 1 and the least notable in Study 3. This is because the time-varying measure of arts education used in Study 2 allows for more precise estimation of the effects of arts education than the time-invariant measure used in Study 1. The fixed effects design applied in Study 3 is better suited to adjust for the effects of unmeasured confounding variables than the HLM techniques applied in Studies 1 and 2. Therefore, the ordering of the studies by methodological rigor should be reflected in decreasing effect sizes.

Arts Education and Academic Achievement: A Three-Level HLM Approach, is the first paper in the series (p. 14). It contains Studies 1 and 2. Arts Education and Academic Achievement: A Child Fixed Effects Approach, is the second paper in the series (p. 53). It contains Study 3.

Arts Education and Academic Achievement: A Three-Level HLM Approach

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Abstract

The aim of this research was to estimate the longitudinal associations of in-school arts education and academic achievement, using three-level HLM techniques and data drawn from two national studies: The NELS:88 and the ECLS-K. In the NELS:88 models, a time-invariant measure of 8^{th}-grade arts education (art, music, and both art and music, at least once a week) was used to predict initial status and rates of growth in mathematics, reading, science, and history achievement, from 8^{th}-grade to 12^{th}-grade. In the ECLS-K models, a time-varying measure of arts education was used to predict initial status and rates of growth in mathematics and reading achievement, from kindergarten to 5^{th}-grade. Across data sets and achievement outcomes, students who received music education or both art and music education academically outperformed students who received only art education or neither art nor music education. Additional exploratory analyses revealed that gender moderated the associations of arts education and mathematics achievement. Female gender was negatively correlated with mathematics achievement in both data sets. However, receiving only art education or both art and music education closed the gap in mathematics achievement between males and females.

Key Words: art, music, achievement, NELS:88, ECLS-K

Whether in-school arts education contributes to achievement in reading and mathematics is a perennial debate in education policy. In the climate of reform and accountability, educators are faced with budgetary and curriculum constraints that lead to reductions in art and music programs (Abril & Gault, 2006; Parsad & Spiegelman, 2012; Sabol, 2013). Decisions to cut arts programs are often based in the assumption that time-on-task is the only thing that matters for long-term achievement in mathematics and language arts. However, decisions to cut arts programs are made in the absence of evidence that arts education is a distraction from academic goals. Indeed, some findings indicate that arts education is positively associated with academic achievement even though arts education does not target the skills measured by standardized achievement assessments.

The debate over the value of arts education persists, in part, because arts education researchers have relied heavily on the use of cross-sectional research designs to compare the achievement of students who receive arts education to the achievement of students who do not. The problem with this approach is that there are many extraneous factors which contribute to whether students have access to and receive arts education. When cross-sectional designs are used to model between-student variation in achievement at a single point in time, it difficult to determine whether pre-existing student differences (i.e. socioeconomic status, prior achievement, artistic talent, etc.) account for the positive associations of arts education and academic achievement. Therefore, it is still largely unknown whether and how arts education contributes to student learning.

The aim of the present research was to model the longitudinal associations of in-school arts education (art, music, and both art and music, at least once a week) and academic achievement using three-level hierarchical linear modeling (HLM) techniques. Data were drawn from two national studies: The Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K) and the National Education Longitudinal Study of 1988 (NELS:88). The use of longitudinal data allowed for the temporal ordering of the independent and dependent variables and the prediction of initial achievement levels and rates of growth.

Hypotheses were informed by motivation theory, specifically achievement goal theory and cognitive evaluation theory. Per cognitive evaluation theory, characteristics of instructional contexts can either facilitate or forestall optimal student motivation. When students are allowed freedom in determining how to complete tasks, feel competent in their ability to do so, and are socially supported, they are happier, more persistent, and self-determined (Ryan et al., 1995).

Any instructional methods can be designed to satisfy student needs for autonomy, competence, and relatedness. However, direct instruction in language arts and mathematics can be experienced as controlling because performance goals (i.e. performing well on a test) are often emphasized (Deci et al., 1999, 2000; Harlen & Crick, 2003). In contrast, instruction in the arts allows for a great deal of open-ended interpretation and self-expression. It also creates non-academic opportunities for under-performing students to experience success, and allows students to explore new ideas and experience failure without serious consequences (i.e. failing a test). Therefore, arts education has been theorized to contribute to student achievement by way of enhanced motivation and engagement (Dege et al., 2014; Fleming et al., 2015; Green & Kindseth, 2011; Gullatt, 2008; Winner et al., 2013).

Although it is important to examine the mechanisms that underlie the associations of arts education and academic achievement, the present research was not designed for this purpose. This research was designed to test the associations of arts education and academic achievement in adherence to rigorous methodological standards. Although they are general, findings from this research are relevant to education policy. If arts education reliably predicts longitudinal achievement and growth in traditionally tested subjects, then researchers have reason to question the efficacy of a strengthening trend in education policy: The narrowing of instruction to focus on mathematics and language arts.

Past Research Using the ECLS-K and NELS:88 Data

The ECLS-K and NELS:88 are two longitudinal studies designed by the National Center for Education Statistics (NCES). These studies followed nationally representative samples of students over multiyear periods and collected extensive data on curriculum characteristics and student achievement. The ECLS-K and NELS:88 data sets have been used by past researchers to examine the associations of arts education and academic achievement. However, past arts education researchers have not used the analytical techniques best suited to the task of analyzing nested education data (i.e. HLM, multilevel modeling, etc.).

For example, Catterall et al. (2012) used data drawn from the ECLS-K and NELS:88 to compare students who received years of arts education and students who received little to no arts education on measures of academic achievement. The authors used all measures of arts education available in the two data sets—any art form, in-school, out-of-school, and overtime—and created a continuous composite measure for each data set. (This was done by awarding students one point for each report of arts education). Students who scored in the top 25th percentile of the continuous arts education measures were identified as high-arts. Students who scored in the bottom 25th percentile of the continuous arts education measures were identified as low-arts. Through a series of t-tests, the authors found that high-arts students outperformed low-arts students on science and writing assessments in 8th grade (ECLS-K) and were higher achieving in college (NELS:88). However, the authors discarded meaningful variation and drastically reduced their sample sizes by excluding students who did not score in the top and bottom 25th percentile of the continuous arts education measures. Moreover, the authors did not statistically adjust for the effects of confounding variables. The available data allows for much more comprehensive statistical analysis.

Taking a step in the direction of methodological rigor, Southgate and Roscigno (2009) used lagged dependent variable techniques to examine the associations of music education and achievement in reading and mathematics, adjusting for prior achievement. The authors drew data from the ECLS-K and NELS:88. In the ECLS-K analyses, predictors were drawn from the kindergarten assessment and outcomes were drawn from the 1st-grade assessment. In the NELS:88 analyses, predictors were drawn from the 8th-grade assessment and achievement outcomes were drawn from the 12th-grade assessment. Across data sets, the authors found that music education positively predicted achievement in reading and mathematics. These findings persisted after adjusting for the effects of gender, race, socioeconomic status, family composition characteristics, and prior achievement.

The findings from Southgate and Roscigno's (2009) study are more convincing than the findings from Catterall et al.'s (2012) study because the former authors adjusted for the effects of confounding variables. However, these studies share a common limitation: They estimate the associations of arts education and achievement at a single point in time. Only between-student variation can be modeled when predicting achievement at a single point in time, which poses many challenges. To reliably model between-student variation, any systematic differences between compared students must be adjusted for in analysis (Allison, 2015). It is virtually impossible to identify and statistically adjust for all factors which contribute to whether or not students receive arts education. Attempting to do so would cost precision (Westfall & Yarkoni, 2016) because many variables which lead students to engage with the arts are latent variables, such as artistic talent. In sum, cross-sectional research designs are unequipped to model the associations of arts education and academic achievement.

One alternative is to model within-child variation in achievement. Within-child variation, as a function of arts education, can be reliably modeled when achievement outcomes are measured repeatedly over time (Rabe-Hesketh & Skrondal, 2012; Singer & Willett, 2003). For example, Miksza (2007) used data drawn from the NELS:88 to model within- and between-child variation in reading, mathematics, science, and history achievement, using hierarchical linear modeling (HLM) techniques. The author identified students who reported engaging in music activities at all three data collection time points (8^{th}-grade, 10^{th}-grade, and 12^{th}-grade) and assigned them to a music education category. Students who reported not engaging in any music activities throughout the course of the study were assigned to a no music education category. Miksza then compared the achievement trajectories of students who were music educated to the achievement trajectories of students who were not, adjusting for the effects of family socioeconomic status. Adolescents who were continuously engaged in music education had higher initial achievement scores and greater rates of growth from 8^{th}-grade to 12^{th}-grade than adolescents who did not receive music education (Miksza, 2007).

Miksza (2007) makes a unique contribution to the arts education literature by moving beyond the prediction of achievement at a single point in time to modeling growth in achievement over a four-year period. To the best of my knowledge, it is the only study of its kind. However, like Catterall et al. (2012), Miksza only included high-music and no-music students in the analytic sample. Many students—who took a single music class out of fleeting interest, to spend time with a friend, or to fill an empty slot in their schedule—were excluded. This approach unnecessarily discards variation and observations which jeopardizes the precision of the effect estimates. Moreover, high school students often choose their schedules, and students who consistently choose to take music classes may differ in many important ways from students who consistently choose not to take music classes. Therefore, the differences in initial status and rates of growth between high-music and non-music students may result from preexisting differences rather than music education.

A final limitation that the reviewed ECLS-K and NELS:88 studies share is that school-level confounds, and school-level nesting, were not addressed. Schools that offer arts education may be systematically different from schools that do not offer arts education and omitting school-level confounds will positively bias effect estimates (Allison, 2005). Additionally, when the nesting of children in schools is ignored in analyses, student observations are treated as though they were sampled randomly from the general population. Children in the same schools have many characteristics in common and treating them as independent observations will negatively bias standard error estimates (Rabe-Hesketh & Skrondal, 2012). Therefore, it is important to account for variation at the student level and the school level when modeling the associations of arts education and academic achievement.

Objectives

The aim of the present research was to estimate the associations of in-school arts education (art, music, and both art and music) and academic achievement and growth, using data drawn from the ECLS-K and the NELS:88. I focused on in-school arts education as opposed to out-of-school arts education in this research to produce findings that are relevant to education policy. Moreover, many arts education scholars have focused on the associations of music education and academic achievement and virtually none have examined the effects of visual art as a standalone art form. Therefore, I examined the relative impact of art and music education to fill a gap in the existing literature.

Random intercept hierarchical linear models were applied in all primary analysis to adjust for the effects of confounding variables at the student level (gender, race, and family socioeconomic status) and the school level (percent minority, percent free lunch, starting teacher salary, school type, and region). For Study 1, a time-invariant in-school arts education predictor was drawn from the 8^{th}-grade assessment of the NELS:88, and achievement outcomes were drawn from the 8th-grade, 10th-grade, and 12th-grade assessments. For Study 2, a time-varying in-school arts education predictor was drawn from the kindergarten, 1st-grade, 3rd-grade, and 5th-grade assessments of the ECLS-K, and achievement outcomes were drawn from the same waves. In secondary exploratory models, a series of two-way interactions were estimated to probe for potential moderators of the associations of arts education and academic achievement. Accordingly, the present research was designed to answer the following questions:

1. What is the relation between in-school arts education in 8th-grade and adolescents' rate of growth in reading, mathematics, science, and history achievement from 8th-grade to 12th-grade?
2. Do student and school characteristics moderate the associations of 8th-grade arts education and academic achievement from 8th-grade to 12th-grade?
3. What is the relation between in-school arts education in kindergarten, 1st-grade, 3rd-grade, and 5th-grade and children's rates of growth in reading and mathematics achievement from kindergarten to 5th-grade?
4. Do student and school characteristics moderate the associations of kindergarten, 1st-grade, 3rd-grade, and 5th-grade arts education and academic achievement from kindergarten to 5th-grade?

Considering previous research, I hypothesized that students who receive any type of arts education academically outperform students who receive neither art nor music education. I did not formulate a hypothesis regarding the relative magnitude of the associations of art versus music education. Given the dearth of published studies that examine the associations of visual arts education and academic achievement, I suspected that the effects of music education would be easier to detect. I also tentatively hypothesized that the effects of receiving both art and music education would reflect the cumulative effects of each art form (i.e. effect size of only art + effect size of only music = effect size of both art and music). My secondary goals were exploratory, and I did not formulate hypotheses regarding the significance or direction of the interactions of arts education and student and school characteristics.

Study 1

Methods

Data Source and Sample

For Study 1, three waves of data were drawn from the NELS:88. The NELS:88 was designed by the NCES and followed a nationally representative sample of 8th-grade students over a six-year period (until two years after high school). The NELS:88 sampling and survey design is described in detail elsewhere (Tourangeau et al., 2009). In brief, the NELS:88 used a multilevel stratified cluster sampling frame to obtain a nationally representative sample and collected extensive data on student achievement, school and curriculum characteristics, and family demographics.

All measures of school and student characteristics were drawn from the 8th-grade wave of the NELS:88. Achievement data were drawn from the 8th-grade, 10th-grade, and 12th-grade NELS:88 assessments. Measures of in-school arts education were only available in the NELS:88 at the time of the 8th-grade assessment. Therefore, a time-invariant arts education predictor was used in the NELS:88 analyses.

All students with available baseline demographic and arts education data were included in analyses. The analytical sample for Study 1 consisted of 20,810 adolescents from 1,000 schools (52% female and 70% white).

Measures

Arts Education

The NELS:88 measured in-school arts education through adolescent self-reports in 8^{th}-grade only. Adolescents indicated whether they had art class (and separately, music class) at least once a week (1 = *yes*, 2 = *no*). A set of dummy variables were constructed to reflect four arts education categories: only art at least once a week, only music at least once a week, both art and music at least once a week, and neither art nor music at least once a week. Students who received neither art nor music education were treated as the reference category.

Academic Achievement

Direct cognitive assessments were administered by the NCES to measure academic achievement for NELS:88 in 8^{th}-grade, 10^{th}-grade, and 12^{th}-grade. Item response theory was used to calculate academic achievement scale scores in reading, mathematics, science, and history. IRT scores are ideal outcome measures for use in modeling longitudinal growth because they place individuals on a continuous ability scale by calculating the probability of correct answers using the observed pattern of right, wrong, and omitted responses. This enables the measurement of growth in achievement over time even though the tests administered at each time point were not identical.

Student and School Characteristics

Measures of student-level and school-level characteristics were drawn from the 8th-grade assessment. These measures included gender, race, family socioeconomic status, percent free lunch in school, percent minority in school, starting teacher salary, school type, and region. A description of the student-level and school-level characteristics are presented in Table 1.

Statistical Analysis

The aim of Study 1 was to examine the impact of 8th-grade arts education on adolescents' academic trajectories. Therefore, growth curve models were estimated using hierarchical linear modeling (HLM) techniques. HLM techniques support the examination of predictors that underlie initial achievement levels and growth in achievement over time. This powerful analytical tool can model within-student growth in achievement (Level 1), variation in achievement between students clustered in the same school (Level 2), and variation in achievement between schools (Level 3), simultaneously (Rabe-Hesketh & Skrondal, 2012). The HLM models applied in Study 1 have a three-level nested structure to account for the effects of time at Level 1; gender, race, and family socioeconomic status at Level 2; and percent minority, percent free lunch eligibility, starting teacher salary, school type, and region at Level 3.

A time-varying measure of in-school arts education was not available in the NELS:88 data. Therefore, all predictors were drawn from the eighth-grade assessment. IRT achievement scale scores in reading, mathematics, science, and history were drawn from the 8th-grade, 10th-grade, and 12th-grade assessments. Covariates at the student level and the school level predicted the intercept (i.e. initial achievement scores) and slope (i.e. linear change in achievement over time) parameters.

Table 1

Description of NELS:88 Sample and Baseline Measures of Student-Level and School-Level Characteristics (N = 20,810)

Variable	Description	Proportion/M(SD)
Student Characteristics		
African American	0 = no, 1 = yes	.108
Hispanic	0 = no, 1 = yes	.121
Asian	0 = no, 1 = yes	.061
American Indian	0 = no, 1 = yes	.012
White (reference)	0 = no, 1 = yes	.698
Female	0 = male, 1 = female	.517
Socioeconomic status (a)	Continuous	-0.038(0.797)
School Characteristics		
% free lunch eligibility	0 = 0%	.177
	1 = 1 to 5%	.136
	2 = 6 to 10%	.102
	3 = 11 to 20%	.164
	4 = 21 to 30%	.135
	5 = 31 to 50%	.153
	6 = 51 to 75%	.090
	7 = 76 to 100%	.043
% minority	0 = 0%	.130
	1 = 1 to 5%	.227
	2 = 6 to 10%	.116
	3 = 11 to 20%	.133
	4 = 21 to 40%	.150
	5 = 41 to 60%	.087
	6 = 61 to 90%	.090
	7 = 91 to 100%	.067
Starting teacher salary	0 = $12k or less	.064
	1 = >$12k to $14k	.057
	2 = >$14k to $16k	.167
	3 = >$16k to $18k	.296
	4 = >$18k to $20k	.254
	5 = >$20k to $22k	.107
	6 = >$22k	.055
Public school	0 = no, 1 = yes	.789
Urban	0 = no, 1 = yes	.299
Rural	0 = no, 1 = yes	.284
Suburban (reference)	0 = no, 1 = yes	.417

Notes: (a) Composite scale of parental education, occupation, and income. The NELS:88 baseline data were collected in 1988.

Preliminary analysis of the NELS:88 data involved the plotting of achievement trajectories and the examination of across-wave and intraclass correlations. This was done to determine whether there was enough within- and between-student variation in achievement to warrant the use of HLM techniques. Additionally, to determine whether students clustered in the same schools received similar amounts of arts education and had similar levels of academic achievement, within- and between-school variation in in-school arts education and academic achievement was inspected.

HLM techniques were then used to estimate the associations of in-school arts education and academic achievement and growth, from 8^{th}-grade to 12^{th}-grade. In a final exploratory step, a series of two-way interactions of arts education and student-level and school-level characteristics were estimated. Interactions were the products of the original variable values. These interactions were estimated to probe for potential moderators of the associations of arts education and academic achievement.

The time metrics used in this research were wave and wave-squared. The optimal time metric for longitudinal research is often participant age at the time of the assessment (Singer & Willett, 2003). However, complete age data were not available in the public use NELS:88 data files. Wave was coded as follows: 0 = *baseline*, 1 = *1^{st} follow-up*, 2 = *2^{nd} follow-up*, and a wave-squared variable was included to account for non-linearity in achievement gains over time.

Most predictors included in analyses were categorical. The continuous predictors included in analyses had meaningful zero values. Therefore, all predictors were left unstandardized. Models were estimated using both standardized and unstandardized achievement outcomes. The effects of arts education produced by the models with standardized and unstandardized outcomes were consistent in pattern, direction, and significance. Therefore, to facilitate the interpretation of effect sizes across data sets and academic subjects, models with standardized achievement outcomes are presented in the main text. Models with unstandardized achievement outcomes can be found in the supplemental materials (Appendix A). The standardized coefficients can be interpreted as the proportion of a standard deviation (SD) in the achievement outcome that is associated with a one unit increase in the independent variable when all other predictors are equal to zero.

The mixed procedure in Stata 14 was used to fit the multilevel models. This software permits the estimation of models with multiple random intercepts and allows for the application of sampling weights. The use of child-level weights was considered for this study because the NELS:88 used a multilevel stratified cluster sampling frame and provided sample weights. However, many of the variables used to construct the child weights were included as covariates in the present models (i.e. gender, race, socioeconomic status). Following the advice of Salon (2013), models were estimated with and without weights. The effects of arts education produced by the weighted and unweighted models varied inconsistently in magnitude. (The weighted models sometimes produced larger and sometimes produced smaller effects than the unweighted models). However, the effects of arts education produced by the weighted and unweighted models were consistent in pattern and direction. Results from the unweighted models are presented in the main text. Results from the weighted models are available in the supplemental materials (Appendix B).

Results

Descriptive Statistics

In 8^{th}-grade, 34% of adolescents reported having neither art nor music class at least once a week, and 28% of adolescents reported having both art and music class at least once a week (Table 2). Fewer adolescents reported having only music class (20%) and having only art class (17%). School-level intraclass correlations revealed that the proportions of students who received both art and music education were balanced within- and between-schools (*rho* = .536). Variation in receiving only art (*rho* = .203), only music (*rho* = .202), and neither art nor music education (*rho* = .316) was greater within schools than between schools.

Table 2
Description of Key Measures (NELS:88)

Variable	N	M or Proportion	SD
Time-Varying Outcomes			
Reading Achievement			
8th-grade	20,220	27.129	8.673
10th-grade	14,116	31.282	9.980
12th-grade	11,334	33.976	10.056
Mathematics Achievement			
8th-grade	20,220	36.351	12.145
10th-grade	14,116	44.807	13.971
12th-grade	11,334	49.857	14.408
Science Achievement			
8th-grade	20,220	18.779	4.907
10th-grade	14,116	21.986	6.095
12th-grade	11,334	23.932	6.234
History Achievement			
8th-grade	20,220	29.578	4.614
10th-grade	14,116	31.746	5.204
12th-grade	11,334	35.206	5.373
Time-Invariant 8th-Grade Arts Education Predictors			
Art	20,810	.174	---
Music	20,810	.204	---
Both	20,810	.279	---
Neither (reference)	20,810	.343	---

Note: Academic achievement scale scores calculated using item response theory. Art = art class at least once a week. Music = music class at least once a week. Both = both art and music class at least once a week. Neither = neither art nor music class at least once a week.

Average scores and standard deviations in reading, mathematics, science, and history achievement increased over time (Table 2). The strongest across-wave correlations were found between 10th-grade and 12th-grade and the weakest across-wave correlations were found between 8th-grade and 12th-grade. The across-wave correlations of mathematics achievement (r = .838 to r = .923) were the strongest, followed by reading (r = .740 to r = .817), science (r = .706 to r = .807), and history (r = .717 to r = .782). Plots of achievement trajectories revealed linear trends with substantial heterogeneity at both the student and the school levels. Student-level intraclass correlations revealed that between-student differences accounted for the majority of variation in reading (*rho* = .711), mathematics (*rho* = .719), science (*rho* = .633), and history (*rho* = .586). Additionally, school-level intraclass correlations indicated that achievement in all four subjects varied more within schools than between schools (*rho* = .186 to *rho* = .240).

Primary Analysis

Results from the hierarchical linear models are displayed in Tables 3 and 4. The positive coefficients for wave indicate that achievement scores increased as students progressed to later grades. The negative coefficients for wave squared indicate that the rate of growth decelerated over time. This pattern was consistent across all achievement outcomes except for history, in which case the rate of growth accelerated overtime.

All the student-level and school-level characteristics included in the multilevel models were significant predictors of academic achievement from 8th-grade to 12th-grade. The coefficients of the racial dummy variables were removed from the tables to conserve space. These missing portions of the tables can be found in the supplemental materials (Appendix C). Using white as the reference category, the African-American, Hispanic, and American Indian variables were negatively associated with achievement in all four academic subjects. Asian race was positively associated with achievement in mathematics, science, and history, but, it was not a significant predictor of achievement in reading.

Female gender was positively associated with achievement in reading and negatively associated with achievement in mathematics, science, and history. Achievement in all four academic subjects was positively associated with socioeconomic status and starting teacher salary and negatively associated with percent free lunch eligibility, percent minority, and attending a public school. Compared to suburban region, rural region was positively associated with achievement in mathematics, science, and history, but, it was not a significant predictor of achievement in reading.

Compared to receiving neither art nor music education, receiving music education or both art and music education in 8^{th}-grade positively predicted initial achievement levels in all four academic subjects. Students who received only music education had the highest initial achievement levels, followed by students who received both art and music education. Students who received only art education or neither art nor music education had the lowest initial achievement levels. The music and both art and music education categories positively predicted rates of growth in mathematics, science, and history, and the art education category positively predicted rates of growth in science and history. The plots in Figure 1 display interactions of arts education and time in the prediction of achievement in all four academic subjects.

Table 3

In-School Arts Education in 8th-Grade Predicting Achievement in Mathematics and Reading From 8th-Grade to 12th-Grade (NELS:88)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	0.630***	0.630***	0.619***	0.439***	0.439***	0.439***
	(0.007)	(0.007)	(0.008)	(0.010)	(0.010)	(0.010)
Wave squared	-0.106***	-0.106***	-0.106***	-0.067***	-0.067***	-0.067***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
Female	-0.058***	-0.070***	-0.070***	0.182***	0.170***	0.170***
	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.011)
Socioeconomic status	0.402***	0.394***	0.394***	0.399***	0.392***	0.392***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
% free lunch in school	-0.033***	-0.034***	-0.034***	-0.019***	-0.019***	-0.019***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
% minority in school	-0.022***	-0.020***	-0.020***	-0.018***	-0.016**	-0.016**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Starting teacher salary	0.052***	0.055***	0.055***	0.021**	0.023***	0.023***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Public school	-0.209***	-0.214***	-0.215***	-0.218***	-0.225***	-0.225***
	(0.030)	(0.030)	(0.030)	(0.027)	(0.028)	(0.028)
Urban region	0.032	0.028	0.028	0.032	0.029	0.029
	(0.022)	(0.022)	(0.022)	(0.020)	(0.020)	(0.020)
Rural region	0.067**	0.063**	0.063**	0.037	0.032	0.032
	(0.022)	(0.022)	(0.022)	(0.020)	(0.020)	(0.020)
Art		0.019	0.016		0.026	0.026
		(0.016)	(0.016)		(0.017)	(0.017)
Music		0.159***	0.146***		0.162***	0.160***
		(0.015)	(0.015)		(0.016)	(0.017)
Both		0.062***	0.046**		0.058***	0.059***
		(0.016)	(0.016)		(0.016)	(0.017)

Table 3 Cont.

Art*Wave			0.004			0.000
			(0.006)			(0.008)
Music*Wave			0.019***			0.003
			(0.006)			(0.008)
Both*Wave			0.024***			-0.001
			(0.005)			(0.007)
Overall constant	-0.203***	-0.255***	-0.247***	-0.139***	-0.190***	-0.190***
	(0.026)	(0.028)	(0.028)	(0.024)	(0.027)	(0.027)
SD in school constant	0.209	0.209	0.209	0.169	0.169	0.169
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
SD in student constant	0.668	0.666	0.666	0.689	0.687	0.687
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)

Notes: Racial category dummy variables were included in these models, with white omitted as the reference category. They were removed from the tables to conserve space. No. of observations = 45,670. No. of adolescents = 20,810. No. of schools = 1,000. Average no. of observations per school = 46. Standardized coefficients with standard errors in parentheses.
* p<0.05, ** p<0.01, *** p<0.001

Table 4
In-School Arts Education in 8th-Grade Predicting Achievement in Science and History From 8th-Grade to 12th-Grade (NELS:88)

	Science			History		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	0.568***	0.568***	0.542***	0.227***	0.226***	0.212***
	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.011)
Wave squared	-0.096***	-0.096***	-0.096***	0.124***	0.124***	0.123***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Female	-0.211***	-0.221***	-0.222***	-0.127***	-0.138***	-0.139***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Socioeconomic status	0.374***	0.368***	0.368***	0.376***	0.369***	0.369***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
% free lunch in school	-0.026***	-0.026***	-0.026***	-0.024***	-0.024***	-0.024***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
% minority in school	-0.027***	-0.025***	-0.025***	-0.020***	-0.018***	-0.018***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Starting teacher salary	0.030***	0.032***	0.032***	0.027***	0.029***	0.029***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Public school	-0.107***	-0.107***	-0.108***	-0.198***	-0.202***	-0.202***
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
Urban region	0.024	0.020	0.020	0.018	0.015	0.015
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Rural region	0.095***	0.091***	0.092***	0.049*	0.045*	0.045*
	(0.021)	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
Art		0.030	0.001		0.007	-0.013
		(0.016)	(0.017)		(0.016)	(0.017)
Music		0.138***	0.116***		0.135***	0.119***
		(0.015)	(0.016)		(0.015)	(0.016)
Both		0.072***	0.041*		0.053***	0.042*
		(0.016)	(0.017)		(0.016)	(0.017)
Art*Wave			0.042***			0.031***
			(0.009)			(0.009)

Table 4 Cont.

Music*Wave			0.031***			0.023**
			(0.008)			(0.008)
Both*Wave			0.045***			0.017*
			(0.008)			(0.007)
Overall constant	-0.083***	-0.140***	-0.121***	-0.082**	-0.124***	-0.114***
	(0.025)	(0.027)	(0.028)	(0.025)	(0.028)	(0.028)
SD in school constant	0.199	0.197	0.197	0.200	0.199	0.199
	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)
SD in student constant	0.614	0.612	0.612	0.625	0.623	0.623
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)

Notes: Racial category dummy variables were included in these models, with white omitted as the reference category. They were removed from the tables to conserve space. No. of observations = 45,670. No. of adolescents = 20,810. No. of schools = 1,000. Average no. of observations per school = 46. Standard errors are in parentheses.

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

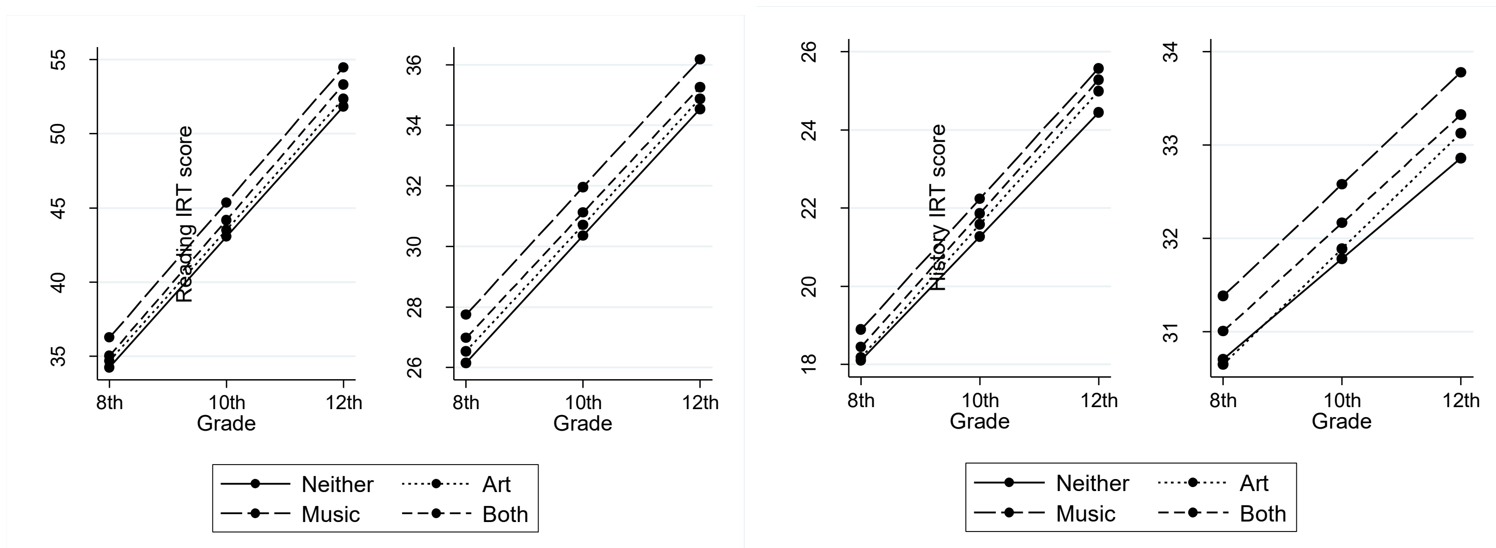

Figure 1: *Predicted Achievement in Mathematics, Reading, Science, and History from 8th-Grade to 12th-Grade by Type of Arts Education (NELS:88).* Neither = neither art nor music class at least once a week. Art = only art class at least once a week. Music = only music class at least once a week. Both = both art and music class at least once a week.

Exploratory Analyses

Table 5

Coefficients of Two-Way Interactions of Arts Education and Student-Level and School-Level Characteristics In the Prediction of Academic Achievement From 8th-Grade to 12th-Grade (NELS:88)

Arts Education Category	Female	% Minority	Rural
Outcome: Mathematics			
Art	0.083**	-0.007	-0.006
	(0.030)	(0.007)	(0.035)
Music	0.018	-0.009	0.049
	(0.028)	(0.007)	(0.032)
Both	0.120***	-0.024**	0.085*
	(0.026)	(0.007)	(0.034)
Outcome: Reading			
Art	0.073*	-0.010	-0.007
	(0.032)	(0.008)	(0.037)
Music	0.036	-0.015*	0.039
	(0.030)	(0.008)	(0.033)
Both	0.131***	-0.023**	0.096**
	(0.028)	(0.008)	(0.035)
Outcome: Science			
Art	0.070*	-0.012	-0.005
	(0.030)	(0.007)	(0.035)
Music	0.008	-0.020**	0.027
	(0.028)	(0.007)	(0.031)
Both	0.083**	-0.027***	0.070*
	(0.026)	(0.007)	(0.034)
Outcome: History			
Art	0.054	-0.009	-0.018
	(0.030)	(0.007)	(0.035)
Music	0.018	-0.021**	0.060
	(0.028)	(0.007)	(0.031)
Both	0.089***	-0.034***	0.074*
	(0.026)	(0.007)	(0.034)

Notes: All the variables in the main models were included in these models. Only the interaction coefficients are presented to conserve space. Standard errors are in parentheses. Patterns that were consistent across at least three achievement subjects are presented.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 5 displays coefficients of interactions between arts education and student-level and school-level characteristics. Gender, percent minority in school, and rural region appeared to moderate the associations of arts education and academic achievement. The associations of receiving both art and music education and achievement in all four academic subjects were strongest for students who were female, from schools with low minority concentration, and from rural regions. Additionally, the associations of receiving only art education and achievement in all academic subjects except history were strongest for female students. The associations of receiving only music education and achievement in all academic subjects except for mathematics were strongest for students from schools with low minority concentration.

Study 2

Methods

Data Source and Sample

For Study 2, four waves of data were drawn from the ECLS-K. The ECLS-K was designed by the NCES, and it followed a nationally representative sample of kindergarten students over a nine-year period (until eighth-grade). The ECLS-K sampling and survey design is described in detail elsewhere (Curtin et al., 2002). Like the NELS:88, the ECLS-K used a multilevel stratified cluster sampling frame to obtain a nationally representative sample and collected extensive data on student achievement, school and curriculum characteristics, and family demographics.

All measures of school and student characteristics were drawn from the kindergarten assessments. Measures of in-school arts education were available in the kindergarten, 1st-grade, 3rd-grade, and 5th-grade data. Therefore, in-school arts education and achievement measures were drawn from these waves. As in Study 1, all students with available baseline data were included in analysis. This resulted in an ECLS-K analytic sample size of 13,873 children from 1,895 schools (49% female, 63% white).

Measures

Arts Education

The ECLS-K measured in-school arts education through teacher self-reports in kindergarten, 1st-grade, 3rd-grade, and 5th-grade. Primary classroom teachers indicated how many times per week they taught art (and separately, music) in their classroom (1 = *never*, 2 = *less than once a week*, 3 = *one to two times per week*, 4 = *three to four times per week*, and 5 = *daily*). As in Study 1, a set of dummy variables were constructed to reflect four arts education categories: only art at least once a week, only music at least once a week, both art and music at least once a week, and neither art nor music at least once a week. Students who received neither art nor music education were again treated as the reference category.

Academic Achievement

Direct cognitive assessments were administered by the NCES to measure academic achievement for the ECLS-K, and item response theory was used to calculate academic achievement scale scores in reading and mathematics. As stated previously, the use of item response theory enables the measurement of growth in achievement over time even though the tests administered at each time point were not identical.

Student and School Characteristics

Measures of student-level and school-level characteristics were drawn from the kindergarten assessment. As in Study 1, these measures included gender, race, family socioeconomic status, percent free lunch in school, percent minority in school, starting teacher salary, school type, and region. A description of the student-level and school-level characteristics are presented in Table 6.

Statistical Analysis

The aim of Study 2 was to replicate and extend the analyses of Study 1 using data drawn from the ECLS-K. School and family characteristics were drawn from the kindergarten assessment and measures of in-school arts education and achievement in reading and mathematics were drawn from the kindergarten, 1st-grade, 3rd-grade, and 5th-grade assessments. Growth curve models were estimated using HLM techniques. The HLM models had a three-level nested structure—identical to that of Study 1—to account for the effects of time at Level 1; gender, race, and family socioeconomic status at Level 2; and percent minority, percent free lunch eligibility, starting teacher salary, school type, and region at Level 3. (See Study 1 Statistical Analysis for details on time metrics, preliminary analyses, standardization, weighting, and software).

Results

Descriptive Statistics

As shown in Table 7, nearly all kindergarten teachers reported using both art and music in the classroom at least once a week (93.4%). However, the proportion of teachers who reported using neither art nor music education increased from kindergarten (1.3%) to 5th-grade (23.7%). Weak across-wave correlations were found for music (r = .036 to r = .262), art (r = -.005 to r = .189), both art and music (r = .030 to r = .297), and neither art nor music (r = .018 to r = .180). Student-level intraclass correlations ranging from *rho* = .002 to *rho* = .125 indicate that within-student change accounted for the clear majority of variation in all four art types. School-level intraclass correlations revealed that variation in all four art types was greater within schools than between schools (*rho* = .256 to *rho* = .356).

Table 6

Description of ECLS-K Samples and Baseline Measures of Student-Level and School-Level Characteristics (N = 13,873)

Variable	Description	Proportion/M(SD)
Student Characteristics		
African American	0 = no, 1 = yes	.125
Hispanic	0 = no, 1 = yes	.140
Asian	0 = no, 1 = yes	.062
American Indian	0 = no, 1 = yes	.021
Other	0 = no, 1 = yes	.126
White (reference)	0 = no, 1 = yes	.627
Female	0 = male, 1 = female	.493
Socioeconomic status (a)	Continuous	0.038(0.786)
School Characteristics		
% free lunch eligibility	Continuous	29.30(27.66)
% minority	0 = <10%	.379
	1 = 10 to <25%	.204
	2 = 25 to <50%	.166
	3 = 50 to <75%	.093
	4 = >75%	.158
Starting teacher salary	0 = <$15k	.022
	1 = $15k to $20k	.150
	2 = >$20k to $25k	.439
	3 = >$25k to $30k	.292
	4 = >$30k	.097
Public school	0 = no, 1 = yes	.780
Urban	0 = no, 1 = yes	.371
Rural	0 = no, 1 = yes	.242
Suburban (reference)	0 = no, 1 = yes	.387

Notes: (a) Composite scale of parental education and income. The ECLS-K baseline data were collected in 1999.

Achievement scores in reading and mathematics increased substantially over time, most notably from kindergarten to 1st-grade and from 1st-grade to 3rd-grade (Table 7). Correlations of reading achievement across waves ranged from $r = .531$ to $r = .846$, and correlations of mathematics achievement were slightly stronger ranging from $r = .668$ to $r = .867$. Plots of achievement trajectories revealed linear trends with substantial heterogeneity at both the student and the school level. Student-level intraclass correlations revealed that within-student change accounted for the clear majority of variation in reading achievement (*rho* = .053) and mathematics achievement (*rho* = .071). School-level intraclass correlations indicated that within-school variation in reading (*rho* = .255) and mathematics (*rho* = .268) achievement was greater than between-school variation in achievement.

Primary Analysis

Results from the hierarchical linear models are displayed in Table 8. The positive coefficients for wave indicate that achievement scores increased as students progressed to later grades. The negative coefficients for wave squared in the prediction of reading achievement indicate that the rate of growth decelerated over time.

Many of the student-level and school-level characteristics included in the models were significant predictors of achievement in reading and mathematics from kindergarten to 5^{th}-grade. The coefficients of the racial dummy variables were removed from the tables to conserve space. These missing portions of the tables can be found in the supplemental materials (Appendix C). Using white as the reference category, the African-American, Hispanic, and American Indian variables were negatively associated with achievement in reading and mathematics. Asian race was not significantly associated with achievement in either subject. The other race category was negatively associated with achievement in mathematics and was uncorrelated with achievement in reading.

Female gender was negatively associated with achievement in mathematics and positively associated with achievement in reading. Achievement in both academic subjects was positively associated with socioeconomic status and negatively associated with percent free lunch eligibility in school, percent minority in school, and rural region.

Starting teacher salary was positively associated with mathematics achievement and attending a public school was negatively associated with reading achievement.

Table 7
Description of Key Measures (ECLS-K)

Variable	N	M or Proportion	SD
Time-Varying Outcomes			
Reading Achievement			
Kindergarten	11,315	46.843	14.064
1st-grade	10,436	79.421	22.995
3rd-grade	8,266	129.264	27.536
5th-grade	6,883	151.363	25.936
Mathematics Achievement			
Kindergarten	11,315	37.305	11.988
1st-grade	10,436	63.419	17.526
3rd-grade	8,266	100.685	24.167
5th-grade	6,883	124.577	24.657
Time-Varying Arts Education Predictors			
Art			
Kindergarten	11,315	.031	---
1st-grade	10,436	.076	---
3rd-grade	8,266	.061	---
5th-grade	6,883	.063	---
Music			
Kindergarten	11,315	.021	---
1st-grade	10,436	.060	---
3rd-grade	8,266	.103	---
5th-grade	6,883	.138	---
Both			
Kindergarten	11,315	.934	---
1st-grade	10,436	.816	---
3rd-grade	8.266	.724	---
5th-grade	6,883	.562	---
Neither (reference category)			
Kindergarten	11,315	.013	---
1st-grade	10,436	.048	---
3rd-grade	8,266	.112	---
5th-grade	6,883	.237	---

Note: Academic achievement scale scores calculated using item response theory. Art = art used in classroom at least once a week. Music = music used in classroom at least once a week. Both = both art and music used in classroom at least once a week. Neither = neither art nor music used in classroom at least once a week.

Table 8

In-School Arts Education in Kindergarten, 1st-Grade, 3rd-Grade, and 5th-Grade Predicting Achievement in Mathematics and Reading From Kindergarten to 5th-Grade (ECLS-K)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	0.766***	0.769***	0.692***	0.890***	0.894***	0.816***
	(0.005)	(0.005)	(0.011)	(0.006)	(0.006)	(0.011)
Wave squared	0.002	0.003	0.008***	-0.038***	-0.037***	-0.032***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Female	-0.063***	-0.063***	-0.063***	0.070***	0.070***	0.070***
	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Socioeconomic status	0.166***	0.166***	0.166***	0.166***	0.165***	0.165***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
% minority in school	-0.002***	-0.001***	-0.001***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
% free lunch in school	-0.013**	-0.012*	-0.011*	-0.019***	-0.017***	-0.016***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Starting teacher salary	0.017*	0.017*	0.017*	0.008	0.007	0.007
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Public school	-0.001	-0.000	-0.002	-0.034*	-0.033*	-0.034*
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.016)
Urban region	0.004	0.003	0.003	0.003	0.002	0.002
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Rural region	-0.062***	-0.062***	-0.061***	-0.045***	-0.045**	-0.044**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Art		0.024*	-0.084***		0.007	-0.096***
		(0.011)	(0.024)		(0.012)	(0.025)
Music		0.063***	-0.044		0.057***	-0.068**
		(0.011)	(0.025)		(0.011)	(0.026)
Both		0.066***	-0.083***		0.066***	-0.084***
		(0.008)	(0.020)		(0.008)	(0.021)

Table 8 Cont.

Art*Wave			0.041***			0.037**
			(0.011)			(0.012)
Music*Wave			0.045***			0.054***
			(0.011)			(0.011)
Both*Wave			0.070***			0.070***
			(0.008)			(0.009)
Overall constant	-0.881***	-0.948***	-0.803***	-0.951***	-1.018***	-0.872***
	(0.017)	(0.019)	(0.026)	(0.016)	(0.018)	(0.026)
SD in school constant	0.119	0.119	0.120	0.116	0.116	0.115
	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
SD in student constant	0.332	0.332	0.342	0.295	0.295	0.295
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)

Notes: Racial category dummy variables were included in these models, with white omitted as the reference category. They were removed from the tables to conserve space. No. of observations = 31,615. No. of children = 13,873. No. of schools = 1,895. Average no. of observations per school = 17. Standard errors are in parentheses.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

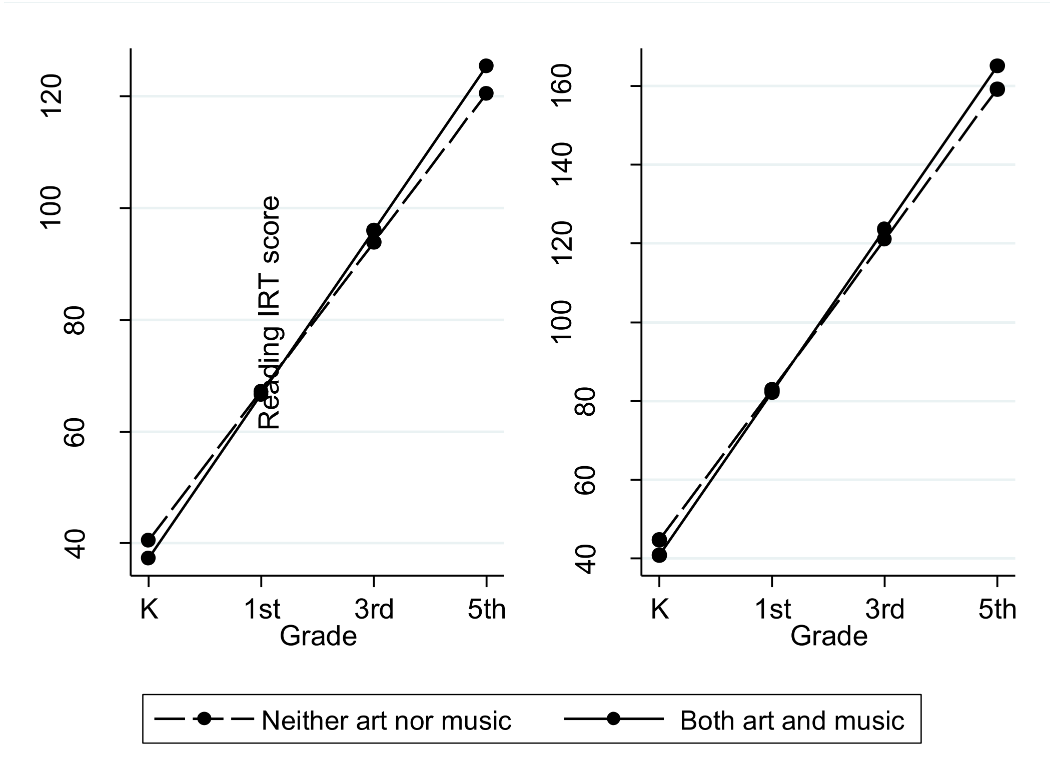

Figure 2: *Predicted Achievement in Mathematics and Reading from 1st-Grade to 5th-Grade by Type of Arts Education (ECLS-K).* The trajectories of students who received only one type of arts education were omitted for the sake of clarity.

Compared to receiving neither art nor music education, receiving any type of arts education negatively predicted initial achievement levels in reading and mathematics and positively predicted rates of growth from kindergarten to 5th-grade. Students who received neither art nor music education had the highest initial achievement levels in kindergarten. However, students who received both art and music education had the fastest rates of growth from kindergarten to 5th-grade. The plots in Figure 2 display interactions of arts education and time in the prediction of academic achievement from kindergarten to 5th-grade.

Exploratory Analysis

Table 9
Coefficients of Two-Way Interactions of Arts Education and Student-Level and School-Level Characteristics In the Prediction of Academic Achievement From Kindergarten to 5th-Grade (ECLS-K)

	Female	SES	% Free Lunch	% Minority	Teacher Salary	Public	Rural
Outcome: Mathematics							
Art	0.052*	-0.052***	0.001***	0.003	-0.029*	-0.050	0.068**
	(0.022)	(0.014)	(0.000)	(0.007)	(0.012)	(0.032)	(0.024)
Music	0.042*	0.007	-0.000	-0.005	-0.033**	-0.080*	0.069**
	(0.021)	(0.014)	(0.000)	(0.007)	(0.012)	(0.032)	(0.023)
Both	0.069***	-0.095***	0.002***	0.028***	-0.035***	-0.030	0.107***
	(0.014)	(0.009)	(0.000)	(0.005)	(0.008)	(0.024)	(0.016)
Outcome: Reading							
Art	-0.007	-0.023	0.000	-0.002	-0.016	-0.025	0.053*
	(0.023)	(0.015)	(0.000)	(0.007)	(0.013)	(0.033)	(0.026)
Music	0.015	0.020	-0.000	-0.015*	-0.048***	-0.068*	0.095***
	(0.021)	(0.014)	(0.000)	(0.007)	(0.013)	(0.033)	(0.024)
Both	-0.004	-0.070***	0.002***	0.033***	-0.004	0.062*	0.093***
	(0.015)	(0.010)	(0.000)	(0.005)	(0.009)	(0.025)	(0.017)

Notes: All the variables in the main models were included in these models. Only the interaction coefficients are presented to conserve space. Standard errors are in parentheses. Patterns that were consistent for both reading and mathematics achievement and patterns that were consistent across data sets are presented.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 9 displays coefficients of a series of two-way interactions between arts education and student-level and school-level characteristics. The associations of receiving both art and music education and achievement in mathematics were strongest for female students. The associations of receiving both art and music education and achievement in mathematics and reading were strongest for students from low socioeconomic family backgrounds, schools with high free lunch eligibility concentration, schools with high minority concentration, and rural regions. The associations of receiving only music education and achievement in mathematics and reading were strongest for students from rural regions, public schools, and schools with low starting teacher salaries. The associations of receiving only art education and achievement in mathematics were strongest for students from low socioeconomic backgrounds, rural regions, schools with high free lunch eligibility, and schools with low starting teacher salaries.

Discussion

The primary aim of this research was to estimate the longitudinal associations of in-school arts education and academic achievement and growth in childhood and adolescence. Data were drawn from two large national studies: The ECLS-K and NELS:88. Three-level HLM techniques were applied to adjust for the effects of time at Level 1, race, gender, and socioeconomic status at Level 2, and percent free lunch eligibility, percent minority, starting teacher salary, school type, and region at Level 3.

In Study 1, the NELS:88 analyses, a time-invariant arts education predictor was drawn from the 8th-grade assessment and was used to predict achievement in mathematics, reading, science, and history from 8th-grade to 12th-grade. Compared to the neither art nor music education category, the music education category was the most notable predictor of initial achievement levels. All three types of arts education positively predicted of rates of growth in science and history achievement. The music and both categories predicted rates of growth in mathematics achievement but not reading achievement.

In Study 2, the ECLS-K analyses, a time-varying measure of in-school arts education was used as the key predictor of achievement. Arts education measures were drawn from the kindergarten, 1^{st}-grade, 3^{rd}-grade, and 5^{th}-grade assessments and used to predict achievement in reading and mathematics from kindergarten to 5^{th}-grade. Compared to receiving neither art nor music education, receiving any type of arts education negatively predicted initial achievement levels and positively predicted rates of growth in reading and mathematics. Of the arts education categories, art education was the most notable predictor of initial achievement levels. The both art and music education category was the most notable predictor of rates of growth from kindergarten to 5^{th}-grade.

A secondary aim of this research was to probe for potential moderators of the associations of arts education and academic achievement and growth. To this end, a series of two-way interactions of arts education and student and school characteristics were estimated. Many of the interaction effects were inconsistent in significance and direction across data sets. However, one pattern was strikingly consistent: The effects of arts education were strongest for students from rural regions compared to suburban regions. In Study 1, this pattern was found for all achievement outcomes and arts education categories. In Study 2, rural region only moderated the effects of receiving both art and music education. However, the pattern was consistent across academic subjects.

The finding that rural region moderates the associations of arts education and academic achievement has not been reported previously. These associations were detected in exploratory analyses and should be interpreted with caution. However, the consistency in the patterns in the present research indicate that the associations may be meaningful. Further investigation is warranted to better understand whether and why the associations of arts education are strongest for students in rural regions.

Another consistent pattern across data sets was that gender moderated the associations of arts education and mathematics achievement. Female gender was negatively correlated with mathematics achievement in both data sets. However, receiving both art and music education closed the gap in mathematics achievement between males and females (Figure 3).

The finding that gender moderates the associations of arts education and achievement in mathematics has, again, not been reported previously. However, it is possible that arts education has a motivational influence on females which enhances their persistence. Dweck (1986) has suggested that females underperform in mathematics because they tend to adopt performance-goal orientations and recoil in the face of increasing challenge. Females may become more persistent in mathematics when provided safe opportunities to experiment with new ideas and experience failure—opportunities that arts education may be able to provide. However, this motivational explanation is speculative and considerably more research is needed to determine whether and why the associations of arts education and mathematics achievement are moderated by student gender.

Limitations and Future Directions

The present research makes unique contributions to the literature through the use of HLM techniques and the exploration of moderating variables. The associations reported here are closer approximations of the true effects of arts education than have been reported previously. It is worthy of note that substantive associations of arts education and academic achievement are detectable when tested in adherence to rigorous methodological standards.

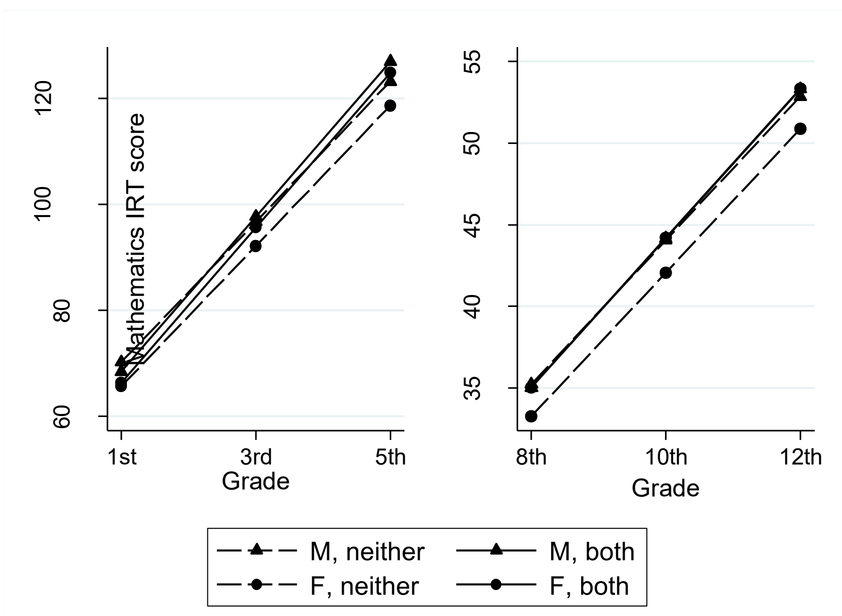

Figure 3: *Predicted Achievement in Mathematics from 1st-Grade to 5th-Grade (ECLS-K) and from 8th-Grade to 12th-Grade (NELS:88) by Type of Arts Education and Gender.* An interaction of arts education and wave was also included in the models used to generate these plots. M = male. F = female. Neither = neither art nor music education at least once a week. Both = both art and music education at least once a week.

An alternative explanation for the associations of arts education and academic achievement and growth is that higher achieving students attend higher quality schools that offer arts education. In Study 1, music education positively predicted initial achievement levels and the effect estimates were suspiciously large in magnitude (around .15 SD). This could be an indication that schools that offer music education are higher quality schools or that high achieving students choose to take music classes. Many student and school characteristics were included in the present analyses in an effort to adjusted for the effects of confounding variables. However, there may be additional unobserved factors that influence the associations of arts education and academic achievement.

Experimental research is warranted to estimate the causal effects of arts education. To facilitate experimental research, future longitudinal research should continue to probe for child and school characteristics that moderate the associations of arts education and academic achievement. If the sub-populations most likely to experience academic gains could be identified and purposively sampled, it would make the investment in experimental research more appealing.

To be clear, findings from this research are not meant to give traction to the notion that the primary purpose of in-school arts education is to enhance academic achievement. Engaging with the arts is valuable in and of itself. However, I argue that the intrinsic value of the arts is not diminished by acknowledging that intrinsic interest facilitates achievement. Arts education may enhance the quality of students' lived experiences in school, making learning more enjoyable and effective.

Arts Education and Academic Achievement: A Child Fixed Effects Approach

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Abstract

The aim of this study was to estimate the within-child associations of in-school arts education and achievement in reading and mathematics, using four waves of data (kindergarten, 1st-grade, 3rd-grade, and 5th-grade) from the Early Childhood Longitudinal Study. Robust fixed effects modeling techniques were applied to adjust for the effects of stable child characteristics. Arts education (min per week of art and music) positively predicted academic achievement and growth in reading and mathematics from kindergarten to 5th-grade. Children who received both art and music education academically outperformed children who received only one type of arts education and children who received neither type of arts education. The second highest performers were children who received only music education. A series of two-way interactions revealed that the associations of arts education and academic achievement were strongest for children from low-socioeconomic family backgrounds and children who displayed negative learning-related skills (i.e. not following directions, not completing tasks, not keeping belongings organized, etc.).

Key Words: art, music, achievement, fixed effects, ECLS-K

In-school arts education may play an important academic role in primary and secondary education because it enhances engagement, fosters creativity, and provides alternative perspectives from which to approach academic challenges (Gullatt, 2008; Winner & Vincent-Lancrin, 2013). However, despite a substantial body of theories supporting a link between arts education and academic achievement, there is surprisingly little rigorous research on this topic. Past arts education researchers have relied heavily on the use of cross-sectional research designs to compare the achievement of students who receive arts education to the achievement of students who receive little to no arts education. However, when self-reports of arts education are used to predict achievement at a single point in time it is difficult to determine whether preexisting student differences account for the positive associations of arts education and academic achievement (Murnane & Willett, 2010). For example, high-achieving students may self-select arts education or be assigned to teachers that use the arts in their classrooms.

The primary purpose of this study was to use robust within-child modeling techniques—which adjust for the effects of all stable child characteristics—to estimate the longitudinal associations of in-school arts education and achievement in reading and mathematics. Four waves of data (kindergarten, 1st-grade, 3rd-grade, and 5th-grade) containing measures of in-school arts education and achievement in reading and mathematics were drawn from the Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K). A continuous measure of arts education (min per week) and a categorical measure of arts education type (art, music, and both art and music) were used to predict student achievement and growth from kindergarten to 5th-grade.

A secondary exploratory aim of this study was to identify possible moderators of the longitudinal associations of in-school arts education and academic achievement. Past scholars have speculated that some student populations are particularly susceptible to the effects of arts education. However, who benefits from arts education and why are empirically underexplored questions.

One theory is that children from disadvantaged family backgrounds benefit uniquely from in-school arts education because they are the least likely to be exposed to arts education outside of school (Catterall et al., 2012). Other scholars theorize that children who feel disconnected from traditional schooling benefit uniquely from arts education because it enhances their engagement (Fleming et al, 2015; Rabkin & Redmond). Moreover, scholars have speculated that the effects of arts education are delayed and emerge gradually over the course of years (Smithrim & Upitis, 2005; Winner & Vincent-Lancrin, 2013). Therefore, in this study, I estimated a series of two-way interactions to provide preliminary evidence of whether the associations of in-school arts education and academic achievement vary as a function of time, family socioeconomic status, and student learning-related skills (i.e. classroom behaviors and conduct).

Past Research and Methodological Limitations

Meta-analyses of both published and unpublished correlational studies indicate that the associations of arts education and academic achievement are modest and reliable. Vaughn (2000) found that formal music training had an average effect size of $r = .15$ on mathematics achievement. Winner and Cooper (2000) found that training in any art form had a modest average effect size of $r = .19$ on reading achievement and $r = .10$ on mathematics achievement. However, the authors of these meta-analysis are quick to point out that the research designs used by arts education researchers do not allow for causal inferences.

Butzlaff (2000) conducted a meta-analysis of six experimental studies—which do allow for causal inferences—and found that formal music training had an average effect size of $r = .11$ on reading achievement. Although the average effect was significant, Butzlaff concluded that it was not robust because it was characterized by substantial heterogeneity (study effect sizes ranged from $r = -.34$ to $r = .64$). Together, these meta-analyses indicate that the estimates from experimental studies are weaker than the estimates from correlational studies, which is consistent with findings from education research in general (Cheung, 2016). This pattern suggests that correlational studies overestimate the effects of arts education and points to the need for more experimental research.

Studies conducted after these meta-analyses were published provide additional evidence of the positive associations of formal arts education and achievement in reading and mathematics (Catterall et al., 2012; Fitzpatrick, 2006; Melnick et al, 2011; Smithrim, 2005; Southgate & Roscigno, 2009; Wandell et al, 2008;). However, arts education researchers have continued to rely heavily on the use of cross-sectional research designs.

When researchers use self-report measures of arts education and compare children who receive arts education to children who do not on measures of academic achievement, selection bias is a severe threat. To reduce the threat of selection bias, some researchers have statistically controlled for observed child characteristics in multiple regression analysis. Other researchers have matched children who experience arts education with children who do not on a small number of demographic characteristics (i.e. gender, race, SES). These techniques are limited because they only account for the effects of variables that are measured and included in analyses. Moreover, if the control measures are imprecise or represent latent constructs, their inclusion in analysis will introduce bias (Westfall & Yarkoni, 2016).

One reliable way to adjust for the effects of all systematic differences between children who receive arts education and children who do not, is to randomly assign children to art treatment and control groups. However, it is difficult to determine whether past findings are reliable enough to warrant the investment in experimental research. In a comprehensive review of the arts education literature, Winner & Vincent-Lancrin (2013) proposed an intermediary step: The use of longitudinal research designs to model within-child variation in achievement. The authors make this recommendation because within-child designs inherently adjust for the effects of many child characteristics that are difficult or impossible to observe (Allison, 2005; Rabe-Hesketh & Skrondal, 2012).

Study Objectives

Arts and Achievement

The primary aim of the present study was to examine the longitudinal associations of in-school arts education and achievement in reading and mathematics, using a large nationally representative sample. A child fixed effects estimator was used to adjust for the effects of all stable child characteristics. Two measures of in-school arts education were used as predictors: A continuous measure (the total number of minutes per week of arts education received in class) and a categorical measure (the type of arts education received). The categorical measure was treated as four dummy variables: only art, only music, both art and music, and neither art nor music.

I focused on in-school arts education as opposed to out-of-school arts education to produce findings that are relevant to education policy. I examined the relative impact of different art forms (art, music, both art and music) to clarify whether it is arts education in general that fosters student engagement and learning, or whether some types of arts education (i.e. music) are more cognitively beneficial than others. Finally, I compared the relative magnitude of the effects of dichotomous and continuous arts education predictors to determine whether dichotomous measures overestimate the effects of arts education.

Considering previous research, I hypothesized that children who receive any type of arts education academically outperform children who receive neither art nor music education. I did not formulate a hypothesis regarding the relative magnitude of the associations of art versus music education. However, I predicted that the effects of receiving both art and music education would reflect the cumulative effects of each art form (i.e. effect size of only art + effect size of only music = effect size of both art and music).

Who Benefits?

The second aim of this study was to determine whether the associations of in-school arts education and academic achievement vary as a function of time, family socioeconomic status, and student learning-related skills. These analyses were exploratory and tentative hypotheses were based primarily in theory.

Variability as a Function of Time

Past researchers have estimated the associations of arts education and academic achievement using samples spanning wide age ranges (pre-school to young adulthood).

However, none have tested whether the effects of arts education vary by age group. Children develop different academic skills as they progress to later grades. Therefore, the effects of arts education on academic achievement may also vary over time. Moreover, some scholars speculate that the effects of arts education on academic achievement are delayed and emerge gradually over the course of years (Smithrim & Upitis, 2005; Winner & Vincent-Lancrin, 2013). Therefore, my first exploratory goal was to inspect grade-level interactions to provide preliminary evidence of whether the effects of in-school arts education vary over time. Given the absence of existing evidence and theory, I did not formulate hypotheses regarding the direction of these associations.

Variability as a Function of Socioeconomic Status

Many children and parents have limited access to arts education. Children from affluent family backgrounds are more likely to have art materials in their homes and to receive arts education outside of school than their less affluent counterparts (Miksza & Gault, 2014; Southgate & Roscigno, 2009). Therefore, children from less affluent family backgrounds may benefit the most from in-school arts education because they have few opportunities to engage with the arts outside of school.

In a multi-arts study, Catterall et al. (2012) found that the associations of arts education and academic achievement were only apparent for children from low-socioeconomic backgrounds. Fitzpatrick (2006) reported similar findings. However, Miksza (2007) found no significant interaction between music education (band, chorus, or orchestra) and socioeconomic status in the prediction of academic achievement. Therefore, my second exploratory goal was to inspect the interactions of arts education and socioeconomic status. Considering existing theory, I hypothesized that the associations of in-school arts education and academic achievement would be strongest for children from low-socioeconomic backgrounds.

Variability as a Function of Learning-Related Skills

Arts education has also been theorized to enhance engagement for children who are under-motivated or otherwise disengaged with school (Fleming, 2015; Rabkin & Redmond, 2004). Learning-related skills measure classroom behaviors and conduct (i.e. keeping belongings organized, following directions, persisting in completing tasks, etc.) and have been described as self-determination in the classroom context (Matthews et al., 2010). When a child displays negative learning-related skills it could be an indication that they are struggling academically, or rather, that they are under-stimulated and bored in school. In either instance, arts education may uniquely benefit children who struggle to comport in standard academic contexts.

For children who are under-stimulated in school, arts education may facilitate engagement because it introduces variety into the curriculum and creates opportunities for open-ended interpretation. Larson and Richards (1991), using time-sampling data, found that students who reported being bored in school perceived school as being monotonous and lacking variety. Moreover, the authors found that students experienced the least amount of boredom in non-academic classes such as shop, music, and gym.

On the other hand, children who are disengaged with school because they are struggling with academic material may benefit from arts education because it creates varied opportunities to experience success in the classroom. Discouraged children may find alternative solutions to academic challenges when allowed to investigate them from creative perspectives (Gullatt, 2008), and they may establish a sense of confidence in their artistic abilities which translates into academic contexts (Dege et al., 2014).

Therefore, my third and final exploratory goal was to examine interactions of arts education and learning-related skills. Considering existing theory, I hypothesized that the associations of in-school arts education and academic achievement would be strongest for children who displayed negative learning-related skills.

Methods

The ECLS-K Data Set

To facilitate the investigation of what educational practices promote student achievement, the National Center for Education Statistics (NCES) designed the ECLS-K. The ECLS-K used a multistage sampling frame to select a nationally representative sample of 21,387 kindergarten students from 1,280 schools across the United States (for a full description see Tourangeau, 2009). Through direct cognitive assessments, self-administered questionnaires, and interviews with children, parents, teachers, and administrators, the ECLS-K collected extensive data on school demographics and resources, curriculum characteristics, and student achievement. Data collection began in the fall of 1998 and repeated observations were collected in the spring of 1999, fall of 1999, spring of 2000, and again in the spring of 2002, 2004, and 2007.

For the present study, I drew data from the second, fourth, fifth, and sixth waves of data collection. The first, third, and final waves were excluded from analyses because the assessments administered at these time points did not include measures of in-school arts education. For the included waves, data collection occurred in the spring when child participants of the ECLS-K were in kindergarten, 1st-grade, 3rd-grade, and 5th-grade.

Attrition in the ECLS-K sample increased over the course of the study and approached 50% for some outcomes by the final wave of data collection. One advantage of fixed effects methods is that they allow for the inclusion of all available observations in analyses even if participants skipped a wave or dropped out of the study midway (Allison, 2005). Therefore, children with at least two available observations on each key variable were included in analyses which resulted in analytic sample size of 14,069 children. Demographic and school composition variables are described in Table 1. Key time-varying variables are described in Table 2.

Table 1
Description of Analytic Sample

Variable	Proportion/M	SD
Child characteristics		
Female	.496	---
Black	.115	---
Hispanic	.144	---
Asian	.054	---
American Indian	.018	---
Pacific Islander	.012	---
Other	.026	---
White	.630	---
Socioeconomic status (a)	0.057	0.791
School characteristics		
Percent minority		
Less than 10 %	.365	---
10 % to less than 25 %	.187	---
25 % to less than 50 %	.167	---
50 % to less than 75 %	.098	---
75 % or more	.183	---
Percent free lunch (b)	.266	.266
Public school	.782	---
Rural	.248	---
Urban	.355	---
Suburban	.397	---

Note. No. of children = 14, 069. (a) Continuous composite scale of household income and mother's and father's education level. (b) Continuous measure. The remaining variables are dichotomous (yes = 1; no = 2). Summed proportions may not equal one due to rounding.

Key Measures

Arts Education: Continuous

The ECLS-K measured in-school arts education through teacher self-reports. Primary classroom teachers indicated how many times per week they taught art in their classroom (1 = *never*, 2 = *less than once a week*, 3 = *one to two times per week*, 4 = *three to four times per week*, and 5 = *daily*). Following this, teachers reported the number of minutes they spent teaching art on a given day (1 = *1-30 min*, 2 = *31-60 min*, 3 = *61-90 min*, 4 = *91 min or more*). Music instruction was measured using identical instruments. To create a continuous measure of the amount of time spent on arts education, the *times per week* and *minutes per day* variables were recoded for interpretability (i.e. the response option *1-2 times per week* was assigned the value 1.5 and the response option *31-60 min* was assigned the value 45). Next, the recoded values were multiplied to generate a *minutes per week* variable for each art form. Many teachers reported dedicating instructional time to both art and music. Therefore, continuous variables for each distinct art form were not included in the models due to issues of collinearity. Rather, the minutes per week values for art and music were summed to generate a variable, *minutes per week of arts education*, which represents the number of minutes per week teachers reported spending on both art and music education.

Arts Education: Categorical

A set of dummy variables were also constructed to reflect four arts education categories: only art at least once a week, only music at least once a week, both art and music at least once a week, and neither art nor music at least once a week. Children who received neither art nor music education were used as the reference category.

Academic Achievement

The NCES administered direct cognitive assessments to measure achievement in reading and mathematics for the ECLS-K. The kindergarten and 1st-grade assessments measured basic reading skills such as letter and word recognition and basic math skills such as counting and number recognition. Subsequent assessments focused on more complex skills such as reading comprehension and mathematical computation. To make the assessments comparable across waves, the ECLS-K used item response theory to calculate academic achievement scale scores. This method places individuals on a continuous ability scale by calculating the probability of correct responses, based on the observed pattern of right, wrong, and omitted responses. This method adjusts for correct guesses and enables the measurement of growth in achievement even though the tests administered at each time point are not identical.

Learning-Related Skills

Classroom behaviors were measured through teacher reports. Teachers indicated how often children displayed the following behaviors: (a) "keeps belongings organized," (b) "shows eagerness to learn new things," (c) "works independently," (d) "easily adapts to changes in routine," (e) "persists in completing tasks," and (f) "pays attention well" (1 = *never*…4 = *very often*). The ECLS-K averaged the values for the six classroom behaviors to create an *approaches to learning* scale which has a Cronbach's alpha reliability coefficient, averaged across waves, of *a* = .90 (Pollack et al., 2005). The term learning-related skills is used in this study, rather than approaches to learning, because it is the term used most frequently in the education literature.

Analytic Approach

The greatest internal validity threats to past findings are selection and omitted variable biases. In this study, child fixed effects models were used to address these threats. Child fixed effects models are uniquely suited to address omitted variable bias because they condition out stable between-child differences to focus solely on the analysis of within-child variation. Within-child designs control for the effects of all stable child characteristics including those that are difficult or impossible to observe (Allison, 2005; Rabe-Hesketh & Skrondal, 2012). This includes traditionally measured characteristics such as gender, race, and parental education, and less frequently measured characteristics such as parental interest in the arts, stable personality traits, and many genetic factors.

Discarding between-child variation means that the effects of stable child characteristics cannot be estimated, which is a limitation of the design. However, the aim of this study was not to estimate the effects of characteristics such as race and gender on academic achievement. Rather, the aim of this study was to estimate the effects of in-school arts education on academic achievement while controlling for all stable child characteristics. A Hausman test revealed that the magnitude of the effects of key variables differed significantly when estimated in random and fixed effects models. (Effects were larger in magnitude in the random effects models, Appendix D0). Therefore, a fixed effects approach was determined the best fit for the data.

The most salient characteristic of child fixed effects models is their ability to condition out stable between-child variation by converting values for time-varying variables into deviation scores (Allison, 2005). This approach requires that the values of included variables change for some participants over time. Therefore, I first inspected across-wave correlations and child-level intraclass correlations. (If a variable has a child-level intraclass correlation of one, it represents a stable characteristic such as race.) This was done to determine the extent to which the values of in-school arts education, academic achievement, socioeconomic status, and learning-related skills varied within-child. Moreover, the child and school characteristics (presented in Table 1) with time-varying potential were inspected for within-child variation to determine whether their effects can be considered stable.

Next, I used child fixed effects models to estimate the effects of arts education on achievement in reading and mathematics from kindergarten to 5^{th}-grade. Interaction terms were subsequently included in the primary models to determine whether the effects of in-school arts education varied as a function of time, socioeconomic status, and learning-related skills. Interaction terms were the products of the variable values.

To facilitate the comparison of effect sizes of variables with different units of measurement, all of the continuous time-varying variables included in the fixed effects models were standardized to have means of zero and standard deviations of one. (Standardizing variables changes the representation of the effect size, but, has no impact on significance tests.) The only variables that were not standardized were the dummy variables for type of arts education (with neither art nor music omitted as the reference category). The precise ages of participants at each assessment time point were not available in the ECLS-K. Therefore, wave was used as the time metric (coded 0 = *baseline*, 1 = *1^{st}-grade follow-up*, 2 = *3^{rd}-grade follow-up*, 3 = *5^{th}-grade follow-up*. A wave-squared term was also included in analyses to account for nonlinearity in achievement gains.

The xtreg procedure in Stata 14 was used to estimate the child fixed effects models, with robust standard errors to adjust for clustering in the ECLS-K sample design. Effects were expected to be modest in magnitude because arts education is not an intervention that targets the academic skills measured by standardized assessments. However, a power analysis using the power procedure in Stata revealed that a sample of 783 children is enough to detect a correlation of .10 with .80 power. The sample used in the present study exceeded this requirement. Indeed, the present sample was large enough to detect a correlation as weak as .025.

Results

Descriptive Statistics

As shown in Table 2, achievement scores in reading and mathematics increased substantially over time, most notably from kindergarten to 1st-grade and from 1st-grade to 3rd-grade. The strongest across-wave correlations were found between 3rd-grade and 5th-grade and the weakest across-wave correlations were found between kindergarten and 5th-grade. This was true for all the time-varying variables described here. Correlations of reading achievement across waves ranged from $r = .53$ to $r = .84$, and correlations of mathematics achievement were slightly stronger ranging from $r = .67$ to $r = .86$. These moderate to strong across-wave associations indicate that children hold fairly stable positions in the achievement distribution from kindergarten to 5th-grade. However, within-child change accounted for the clear majority of variation in reading (*rho* = .05) and mathematics (*rho* = .07) achievement over time.

The amount of instructional time teachers reported spending on arts education decreased as grade level increased. Across-wave correlations of minutes per week of arts education were weak, ranging from *r* = -.04 to *r* = .16. A child-level intraclass correlation (*rho* = .02) revealed that most variation in minutes per week of arts education was attributed to within-child change as opposed to stable between-child differences. Examination of the categorical arts education variable revealed that the proportion of children who did not receive any type of arts education increased from kindergarten (1.2%) to 5th-grade (23.2%). Weak across-wave correlations were found for music (from *r* = .07 to *r* = .28), art (from *r* = .01 to *r* = .17), both art and music (from *r* = .05 to *r* = .31), and neither art nor music (*r* = .01 to *r* = .17). Intraclass correlations ranging from *rho* = .04 to *rho* = .14 indicated that within-child change accounted for a clear majority of variation in all four art types.

Learning-related skill sample means were fairly stable over time. However, across-wave correlations ranged from *r* = .42 to *r* = .55. A moderate child-level intraclass correlation (*rho* = .51) indicated that just under half of the variation in learning-related skills was attributed to within-child change.

The intraclass correlations of the time-varying student and school characteristics presented in Table 1 ranged from *rho* = .79 to *rho* = .98, which indicates a high level of stability in these characteristics over time. The student and school characteristics were included in preliminary models to determine whether their small amount of within-child variation contributed to the prediction of academic achievement. The only significant predictor was socioeconomic status (*rho* = .90). Therefore, it was retained for further analyses.

Table 2
Description of Key Time-Varying Measures

Variable	M/Proportion	SD	N
Mathematics achievement (a)			
Kindergarten	37.542	11.860	12,809
First grade	63.421	17.545	12,016
Third grade	101.446	23.994	9,551
Fifth grade	125.161	24.392	8,611
Reading achievement (a)			
Kindergarten	47.061	13.792	12,809
First grade	79.806	23.251	12,016
Third grade	130.064	27.137	9,551
Fifth grade	152.081	25.719	8,611
Minutes per week of arts education (b)			
Kindergarten	131.841	108.158	12,809
First grade	94.705	66.186	12,016
Third grade	87.534	60.798	9,551
Fifth grade	79.220	65.714	8,611
Type of arts education (c)			
Art only			
Kindergarten	.031	---	12,809
First grade	.076	---	12,016
Third grade	.060	---	9,551
Fifth grade	.053	---	8,611
Music only			
Kindergarten	.020	---	12,809
First grade	.055	---	12,016
Third grade	.103	---	9,551
Fifth grade	.140	---	8,611
Both art and music			
Kindergarten	.936	---	12,809
First grade	.820	---	12,016
Third grade	.725	---	9,551
Fifth grade	.576	---	8,611
Neither art nor music			
Kindergarten	.012	---	12,809
First grade	.049	---	12,016
Third grade	.111	---	9,551
Fifth grade	.232	---	8,611

Note: (a) Academic achievement scale scores calculated using item response theory. (b) Teacher reported number of min per week spent on arts education ranging from 0 to 1100. (c) art only at least once a week, music only at least once a week, both art and music at least once a week, neither art nor music at least once a week.

Art Predicting Academic Achievement

Results from the primary fixed effects models are presented in Table 3. The positive coefficients for wave indicate that achievement scores increased over time. The negative coefficient for wave-squared in the prediction of reading indicates that the rate of growth in this academic subject decelerated over time. In the prediction of mathematics achievement, the wave-squared coefficient was positive, indicating that the rate of growth accelerated slightly over time.

Table 3

Min Per Week and Type of Arts Education Predicting Achievement in Mathematics and Reading From Kindergarten to 5th Grade

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	0.771***	0.776***	0.774***	0.897***	0.904***	0.901***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Wave squared	0.003*	0.002	0.003**	-0.038***	-0.039***	-0.037***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Socioeconomic status	0.013*	0.013*	0.013*	0.009	0.008	0.008
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Learning-related skills	0.017***	0.017***	0.017***	0.035***	0.035***	0.035***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Min per week of arts		0.010***			0.014***	
		(0.002)			(0.002)	
Art only			0.014			0.014
			(0.010)			(0.010)
Music only			0.060***			0.051***
			(0.010)			(0.010)
Both art and music			0.058***			0.065***
			(0.007)			(0.007)
Constant	-1.030***	-1.034***	-1.086***	-1.077***	-1.082***	-1.140***
	(0.002)	(0.003)	(0.007)	(0.003)	(0.003)	(0.008)
Pseudo r-squared						
Within	0.917	0.917	0.917	0.909	0.909	0.909
Between	0.433	0.433	0.437	0.471	0.472	0.476
Overall	0.753	0.753	0.755	0.772	0.773	0.774

Note: No. of observations = 42,987. No. of children = 14,069. Standardized coefficients with robust standard errors in parentheses.

* p<0.05, ** p<0.01, *** p<0.001

Minutes per week of in-school arts education was positively associated with achievement in reading and mathematics. The effects were modest in magnitude with a one SD increase in arts education leading to a .010 SD increase in mathematics achievement and a .014 SD increase in reading achievement. The inclusion of socioeconomic status and learning-related skills did not influence the effect sizes of in-school arts education, or their significance levels. A one SD increase in socioeconomic status was associated with a .013 SD increase in mathematics achievement. Socioeconomic status was not a significant predictor of reading achievement. A one SD increase in learning-related skills was associated with a .017 SD increase in mathematics achievement and a .035 SD increase in reading achievement.

The effects of the arts education dummy variables—reflecting the type of arts education received—were more notable in magnitude than the effects of the continuous arts education variable. Compared to receiving neither art nor music education, receiving both art and music education at least once a week was associated with a .058 SD increase in mathematics achievement and a .065 SD increase in reading achievement. Receiving only music education at least once a week was associated with a .060 SD increase in mathematics achievement and a .051 SD increase in reading achievement. Compared to receiving neither art nor music education, the associations of receiving only art education and academic achievement did not reach conventional levels of significance. However, receiving only art education at least once a week was associated with a .014 SD increase in mathematics and reading achievement.

Variability as a Function of Time, SES, and Learning-Related Skills

To determine whether the effects of in-school arts education were moderated by time, socioeconomic status, and learning-related skills, interaction terms were added to the primary fixed effects models presented in Table 3. Interaction coefficients are presented in Tables 4 and 5. The coefficients for the interactions of minutes per week of arts education and time were positive. These positive interaction coefficients indicate that the associations of arts education and academic achievement strengthen over time. The negative coefficients for the interactions of minutes per week of arts education and socioeconomic status indicate that the associations of arts education and academic achievement were strongest for children from low socioeconomic family backgrounds. Similarly, the negative coefficients for the interactions of minutes per week of arts education and learning-related skills indicate that the associations of arts education and academic achievement were strongest for children who displayed negative learning-related skills.

The models that included the dummy variables for in-school arts education type revealed similar interaction patterns and provided additional information (Table 5). Children from low-socioeconomic family backgrounds and children who displayed negative learning-related skills illustrated the greatest achievement gains when they received both art and music education. The effects of music education on mathematics achievement were not moderated by socioeconomic status and learning-related skills. And the interaction coefficients for art type and time were consistently positive across the art education categories.

Table 4

Min Per Week of Arts Education Predicting Achievement in Mathematics and Reading from Kindergarten to 5th Grade (Including Interactions with Wave, SES, and Learning-Related Skills)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	0.773***	0.773***	0.774***	0.901***	0.902***	0.902***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Wave squared	0.003*	0.003*	0.003*	-0.038***	-0.038***	-0.038***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Socioeconomic status	0.013*	0.013*	0.013*	0.009	0.009	0.009
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Learning-Related Skills	0.017***	0.017***	0.017***	0.035***	0.035***	0.034***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Min per week	0.004	0.005*	0.006**	0.008***	0.010***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Wave*min per week	0.007***	0.007***	0.006***	0.006***	0.005**	0.005*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
SES*min per week		-0.016***	-0.013***		-0.022***	-0.018***
		(0.002)	(0.002)		(0.002)	(0.002)
LRS*min per week			-0.016***			-0.017***
			(0.002)			(0.002)
Constant	-1.031***	-1.031***	-1.031***	-1.080***	-1.080***	-1.080***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Pseudo r-squared						
Within	0.917	0.918	0.918	0.909	0.910	0.910
Between	0.434	0.435	0.434	0.473	0.473	0.472
Overall	0.754	0.754	0.754	0.773	0.774	0.774

Note: No. of observations = 42,987. No. of children = 14,069. Min per week = teacher reported min per week of art and music education. SES = socioeconomic status. LRS = learning-related skills. Standardized coefficients with robust standard errors in parentheses.

* p<0.05, ** p<0.01, *** p<0.001

Table 5

Type of Arts Education Predicting Achievement in Mathematics and Reading from Kindergarten to 5th Grade (Including Interactions with Wave, SES, and Learning-Related Skills)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	0.700***	0.701***	0.700***	0.823***	0.824***	0.823***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)
Wave squared	0.008***	0.008***	0.008***	-0.032***	-0.032***	-0.032***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Socioeconomic status	0.013*	0.085***	0.073***	0.008	0.078***	0.068***
	(0.006)	(0.009)	(0.009)	(0.006)	(0.009)	(0.009)
Learning-related skills	0.017***	0.017***	0.068***	0.035***	0.035***	0.076***
	(0.002)	(0.002)	(0.006)	(0.003)	(0.003)	(0.007)
Art	-0.090***	-0.104***	-0.111***	-0.100***	-0.113***	-0.119***
	(0.021)	(0.022)	(0.022)	(0.023)	(0.023)	(0.024)
Music	-0.052*	-0.058*	-0.064**	-0.064**	-0.072**	-0.076**
	(0.022)	(0.023)	(0.023)	(0.024)	(0.025)	(0.025)
Both	-0.088***	-0.102***	-0.107***	-0.089***	-0.103***	-0.106***
	(0.017)	(0.018)	(0.018)	(0.019)	(0.019)	(0.019)
Wave*art	0.037***	0.039***	0.041***	0.042***	0.044***	0.046***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Wave*music	0.047***	0.045***	0.046***	0.048***	0.047***	0.048***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Wave*both	0.067***	0.066***	0.067***	0.071***	0.070***	0.071***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
SES*art		-0.041***	-0.030**		-0.038***	-0.030**
		(0.010)	(0.010)		(0.010)	(0.010)
SES*music		-0.018	-0.017		-0.023*	-0.021*
		(0.010)	(0.010)		(0.010)	(0.010)
SES*both		-0.087***	-0.073***		-0.083***	-0.072***
		(0.007)	(0.007)		(0.007)	(0.007)

Table 5 Cont.

LRS*art			-0.045***			-0.031**
			(0.010)			(0.010)
LRS*music			-0.003			-0.006
			(0.009)			(0.010)
LRS*both			-0.062***			-0.050***
			(0.006)			(0.007)
Pseudo r-squared						
Within	0.918	0.918	0.919	0.910	0.910	0.910
Between	0.437	0.440	0.438	0.477	0.480	0.479
Overall	0.755	0.756	0.756	0.775	0.776	0.776

Note: Constants were removed from the table to conserve space. No. of observations = 42,987. No. of children = 14,069. Art = art only at least once a week. Music = music only at least once a week. Both = art and music at least once a week. SES = socioeconomic status. LRS = learning-related skills. Robust standard errors are in parentheses.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Interaction plots generated from the final models in Tables 4 and 5 are presented to facilitate interpretation. Figure 1 displays predicted achievement trajectories in mathematics and reading as a function of arts education and learning-related skills. Children who displayed positive learning-related skills and received neither art nor music education had higher initial achievement scores in 1st-grade. However, by the time of the 5th-grade assessment, these students lost their academic advantage to students who received both art and music education. Children who displayed negative learning related skills and received neither art nor music education had the lowest predicted initial status and rates of growth.

To clarify these patterns, Figures 2 and 3 illustrate the similar notable contrast in the effects of receiving both art and music education on the achievement of children from high-socioeconomic backgrounds and children from low-socioeconomic backgrounds. Children from high-socioeconomic backgrounds who received neither art nor music education had an academic advantage in kindergarten, but, this advantage disappeared by 5th-grade (Figure 2). An opposite pattern was found for children from low-socioeconomic backgrounds (Figure 3). Children who received both art and music education and children who received neither art nor music education had similar initial achievement scores in kindergarten. However, an achievement gap emerged between children who received arts education and children who did not, and this gap widened as children progressed to later grades.

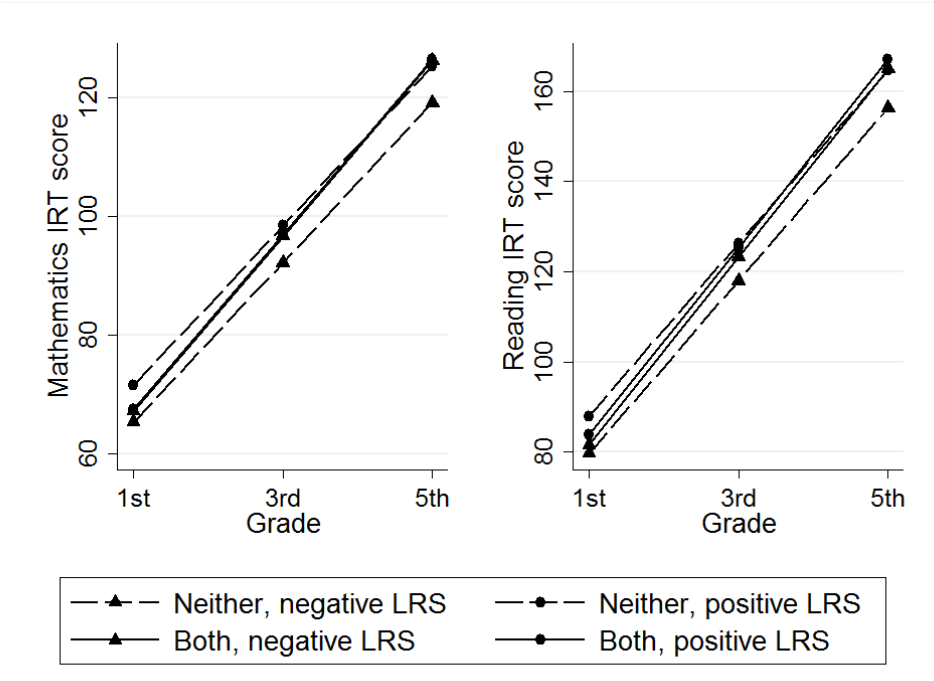

Figure 1: *Predicted Achievement from 1st- to 5th-Grade by Level of Arts Education and Learning-Related Skills.* LRS = learning-related skills. Positive = one SD above the mean. Negative = one SD below the mean. Only 1st- through 5th-grade observations are plotted because there was little change between categories from kindergarten and 1st-grade. Both = both art and music at least once a week. Neither = neither art nor music at least once a week.

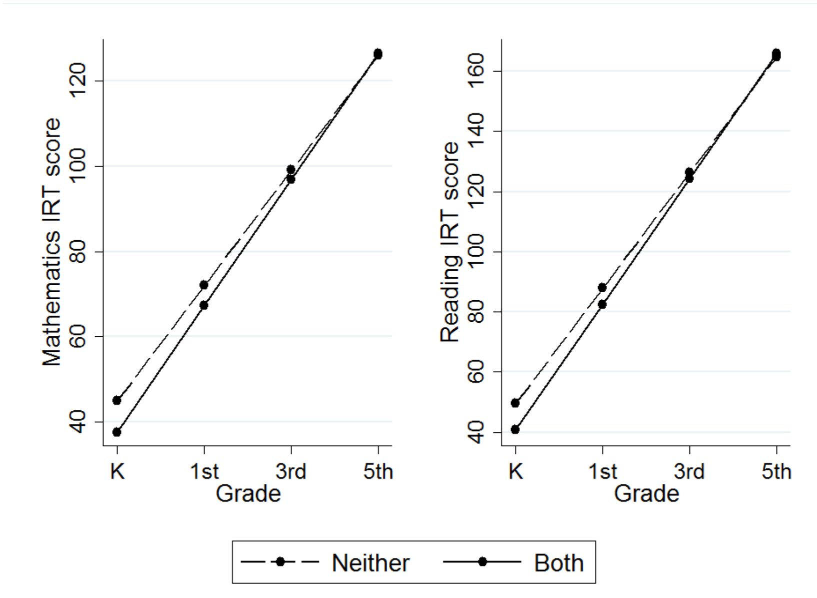

Figure 2: *Predicted Academic Achievement of Children from High-SES family backgrounds by Type of Arts Education.* High-SES = one SD above the mean. Both = both art and music at least once a week. Neither = neither art nor music at least once a week.

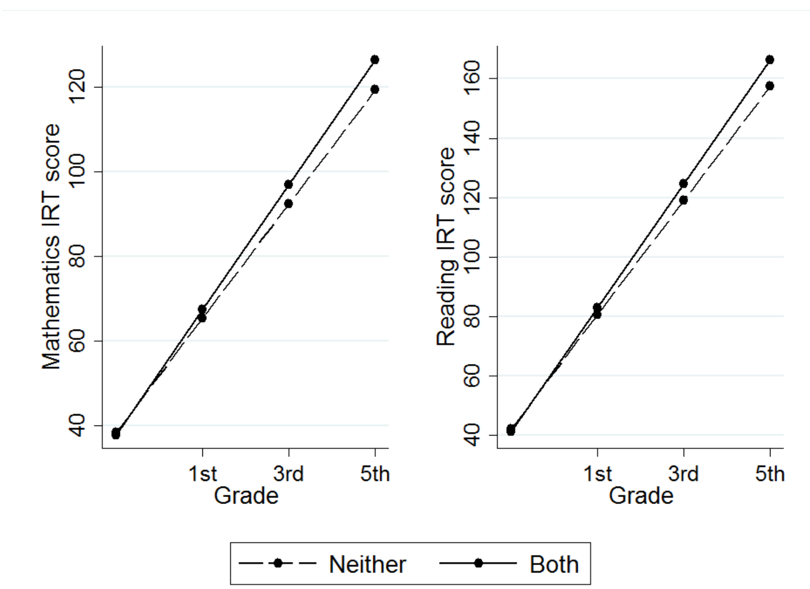

Figure 3: *Predicted Academic Achievement of Children from Low-SES family backgrounds by Type of Arts Education.* Low-SES = one SD below the mean. Both =

both art and music at least once a week. Neither = neither art nor music at least once a week.

Discussion

The primary aim of this study was to estimate the longitudinal associations of in-school arts education and achievement in reading and mathematics, using robust fixed effects modeling techniques and a large nationally representative sample. Two measures of in-school arts education were used as predictors: A continuous measure (minutes per week of arts education) and a categorical measure (type of arts education). The dummy variables for type of arts education were stronger predictors of academic achievement than the continuous min-per-week predictor. This suggests that dichotomous measures—that create starker contrasts—might overstate the effects of arts education.

The main effects of min per week of arts education on achievement in reading and mathematics were positive and modest within a fixed effects framework. The use of dummy variables as predictors revealed that art and music education had distinct and possibly cumulative effects. Children who received any type of arts education at least once a week (art, music, or both art and music) outperformed children who received neither art nor music education at least once a week. Children who received only music education outperformed children who received only arts education. Receiving both art and music education was the strongest predictor of reading achievement, suggesting a cumulative effect. In the prediction of mathematics achievement, the effect of receiving only music education was slightly stronger than the effect of receiving both art and music education. However, this was likely because the effects of music education on mathematics achievement were not moderated by child characteristics.

The secondary aim of this study was to provide preliminary evidence of whether the effects of in-school arts education varied as a function of time, family socioeconomic status, and student learning-related skills. Interactions of time and arts education were positive which indicate that the effects of in-school arts education on academic achievement increased in strength and significance as children progressed to later grades. These findings have not been reported in previous literature and should be interpreted with caution. However, these interactions might indicate that in-school arts education contributes little to the acquisition of rudimentary academic skills such as number, letter, and word recognition, and contributes more to the acquisition of higher-order cognitive skills such as problem solving and comprehension. If this is the case, the cognitive assessments administered in 3rd-grade and 5th-grade may have better captured the impact of arts education than the assessments administered in kindergarten and 1st-grade.

An alternative explanation for the variability in the effects of in-school arts education as a function of time is that teachers of different grade levels use the arts in different ways. Teachers of kindergarten and 1st-grade students might use the arts in their classrooms to teach direction following skills and to signal and ease transitions. Teachers of 3rd- and 5th-grade students, on the other hand, might integrate the arts into academic lessons with the intention to cultivate critical thinking and problem-solving skills. However, this study was unable to distinguish between different types of arts instruction and further investigation is warranted to determine how arts education at different stages of development contributes to student achievement.

Socioeconomic status and learning-related skills were weakly correlated in this study. However, their interactions with in-school arts education were strikingly similar.

The associations of in-school arts education and academic achievement were strongest for children from low-socioeconomic backgrounds and for children who displayed negative learning-related skills. Moreover, the interaction effects were particularly salient for children who received both art and music education.

I argue that the associations detected in the present study are notably substantive. Given the ability of child fixed effects models to address selection and omitted variable biases, findings from this study provide reasonably strong causal evidence (Allison, 2005; Rabe-Hesketh & Skrondal, 2012). Some may argue that the effects of the continuous arts education variable are so small they are negligible. However, by the time of the 5^{th}-grade assessment, children who displayed negative learning-related skills and received at least three hours of arts education a week had a mathematics achievement score that was .101 SD higher than children who displayed negative learning-related skills and received twenty minutes or less of arts education a week. By the time of the 5th-grade assessment, the difference between high-arts and low-arts children who displayed negative learning-related skills was even larger in magnitude when predicting reading achievement (.142 SD). One year of schooling has been associated with an approximate .200 SD increase in achievement (Hansen et al., 2004). Therefore—particularly because arts education is not an intervention that targets the skills measured by standardized achievement assessments—the effect sizes reported here have considerable magnitude.

Limitations

Although the present study makes unique contributions to the existing literature through the application of longitudinal modeling techniques and the examination of theoretically relevant moderating variables, it is not without limitations. Fixed effects models adjust for the effects of stable time-invariant characteristics. However, there are time-varying selection factors that were not accounted for in the present study. For example, time-varying measures of teacher salary were not available in the ECLS-K data. It is plausible that changes in teacher salary are associated with changes in arts education practices as well as changes in student achievement.

A plausible alternative explanation for the associations of arts education and academic achievement is that measures of in-school arts education are proxies for teacher quality. In this study, in-school arts education varied more within-schools than between-schools which suggests that in-school arts education is a teacher, rather than school, characteristic. Teachers who dedicate instructional time to the arts may value creativity and thematic learning more generally. Therefore, the estimated effect of arts education on academic achievement may reflect teacher quality. This scenario is particularly compromising if high-performing children were assigned to teachers who used the arts in their classrooms.

However, across-wave and intraclass correlations of arts education were weak and a pooled OLS regression revealed that child-level and school-level demographic characteristics accounted for a very small proportion of variance in in-school arts education. Therefore, in the present study, there was little evidence that selection played a large role in determining whether children received arts education in school.

Implications and Future Directions

The lowest performing schools in the United States house the most disadvantaged student populations (Suporitz, 2009). In the climate of reform and accountability, these low-performing schools are subject to budgetary and curriculum constraints which often lead to cutbacks in in-school arts education (Abril & Gault, 2006; Parsad & Spiegelman, 2012; Sabol, 2013). The associations of arts education and academic achievement in the present study were strongest for children from low-socioeconomic backgrounds. Therefore, it appears that the child populations most affected by cutbacks in arts education are the same populations that benefit the most from arts education.

Scholars should continue to explore the moderating potential of socioeconomic status and behavioral variables such as learning-related skills. If future studies find that children from low-socioeconomic backgrounds and children who have trouble comporting in standard academic classrooms benefit uniquely from in-school arts education, numerous implications for classroom practice and education policy could be drawn.

Future studies should also continue to examine the relative impact of different types of arts education, including types other than art and music (i.e. dance, drama, etc.). The inclusion of a visual art education variable in this study was useful, as many of the interaction effects detected were notable for this category. Therefore, future scholars should not underestimate the potential contribution of non-music forms of arts education. For some student populations, such as those from low socioeconomic backgrounds and who display negative learning-related skills, multi-arts education may lead to substantive achievement gains.

General Discussion

The primary aim of this research was to model the longitudinal associations of in-school arts education and academic achievement using three-level hierarchical linear modeling and child fixed effects techniques. These techniques were used to address the primary methodological limitation of past arts education research: The use of cross-sectional research designs. The present research also fills gaps in the arts education literature by focusing on the effects of in-school arts education, exploring the relative contributions of art and music education, and probing for potential moderators of the associations of arts education and academic achievement.

Data were drawn from two national studies: The ECLS-K and NELS:88. In Study 1, measures of in-school arts education from the NELS:88 8^{th}-grade assessment were used to predict initial status and rates of growth in achievement from 8^{th}-grade to 12^{th}-grade. In Study 2, a time-varying measure of in-school arts education from the ECLS-K was used to predict initial status and rates of growth in achievement from kindergarten to 5^{th}-grade. In Studies 1 and 2, three-level HLM techniques were used to account for variation, and adjust for the effects of confounding variables, at the student level (gender, race, socioeconomic status) and the school level (percent free lunch, percent minority, starting teacher salary, school type, and region).

The greatest internal validity threats to past findings are selection and omitted variable biases. Therefore, child fixed effects models were used to address these threats in Study 3. Two time-varying measures of in-school arts education from the ECLS-K were used as predictors of achievement from kindergarten to 5^{th}-grade: A continuous measure (total number of minutes of art and music education per week) and a categorical measure (the type of arts education received).

Findings from the present research support previous claims of the academic benefits of arts education. Across data sets, research designs, and achievement outcomes, students who received any type of arts education at least once a week had faster rates of growth than students who received neither art nor music education. This was the case in every model except the model predicting reading achievement in Study 1. The magnitude of the effect sizes of each art form were consistent across achievement outcomes, which suggests that arts education contributes to overall academic achievement rather than subject specific knowledge and skills.

The main effects for visual arts education were insignificant in nearly every model. However, visual art and music education had comparable positive associations with rates of growth in many models. Additionally, when examining only the slope parameters, it appears that receiving both art and music education was associated with the greatest academic gains (i.e. students who received both art and music education often had faster rates of growth than students who received only one type of arts education and neither type of arts education).

In Study 1, compared to receiving neither art nor music education, receiving music education was the most notable predictor of initial achievement levels. All three types of arts education positively predicted of rates of growth in science and history achievement. The music and both categories predicted rates of growth in mathematics achievement but not reading achievement.

In Study 2, compared to receiving neither art nor music education, receiving any type of arts education negatively predicted initial achievement levels and positively predicted rates of growth in reading and mathematics. Of the arts education categories, music education was the least notable predictor of initial achievement levels. The both art and music education category was the most notable predictor of rates of growth from kindergarten to 5th-grade.

To reiterate, students who received neither art nor music education had an academic advantage in kindergarten. This could indicate that arts education contributes little to the acquisition of rudimentary mathematics and reading skills such as number and word recognition. If this is the case, the cognitive assessments administered in kindergarten may not have been suited to capture the academic benefits of arts education. Conversely, it is possible that focusing instructional time on tested subjects in kindergarten gives students an achievement boost in early childhood. However, as is the case with other early childhood interventions (Puma, 2012), the associated academic advantages were lost by 3rd-grade.

The results from Study 2 are very similar to the results from Study 3. This could indicate that the fixed effects models effectively adjusted for the effects of the individual and school characteristics included in the multilevel models. It could also indicate that selection did not play a large role in determining whether students received arts education in elementary school. Either way, the consistent patterns reinforce the reliability of the findings.

A secondary aim of this research was to probe for potential moderators of the associations of arts education and academic achievement. Findings indicate that arts education is moderated by many student and school characteristics. Two patterns were consistent across data sets and achievement outcomes. First, the associations of arts education and mathematics achievement were strongest for female students. Compared to receiving neither art nor music education, receiving both art and music education closed the mathematics achievement gap between males and females. Second, the associations of arts education and achievement across academic subjects were strongest for students from rural regions. This was true for all arts education categories and achievement outcomes in Study 1 and for the both art and music education category and achievement in reading and mathematics in Study 2. In Study 3, interactions of arts education and learning-related skills revealed that the associations of arts education and academic achievement were strongest for students who displayed negative learning-related skills.

Limitations and Future Directions

Many of the goals of this research were exploratory. Findings regarding moderation are preliminary and should be interpreted with caution. Further research is needed to understand whether and why the effects of arts education are moderated by student and school characteristics. If reliable moderators are identified, it would make the investment in experimental research more appealing because the sub-populations most likely to experience academic gains could be purposively sampled.

An alternative explanation for the associations of arts education and academic achievement and growth in Study 1 is that higher quality schools offer arts education and higher achieving students choose to take arts classes. In Study 1, music education positively predicted initial achievement levels in 8th-grade. The effect estimates were suspiciously large in magnitude, ranging from .12 SD to .16 SD. Many student and school characteristics were included in the present analyses in an effort to adjusted for the effects of confounding variables. However, there are additional factors, not included in analyses, that might influence the associations of music education and academic achievement in adolescence, such as school finance characteristics and artistic talent.

An alternative explanation for the associations of arts education and academic achievement and growth in Studies 2 and 3 is that measures of in-school arts education are proxies for teacher quality. Teacher reports of classroom arts education were used in Studies 2 and 3. The values of these teacher reports varied more within-schools than between-schools which suggests that in-school arts education is a teacher, rather than school, characteristic. Teachers who dedicate instructional time to the arts may value creativity and thematic learning more generally. Therefore, the estimated associations of arts education with academic achievement may reflect qualities of the instructional context not directly related to arts education. This scenario is particularly compromising if high-performing children were assigned to teachers who used the arts in their classrooms.

The fixed effects techniques used in Study 3 adjust for the effects of many unobserved variables. Therefore, findings from this study provide reasonably strong causal evidence (Allison, 2005; Rabe-Hesketh & Skrondal, 2012). However, the approach does not account for the effects of unobserved time-varying selection factors such as teacher salary. Changes in teacher salary may be associated with both changes in instructional practices and student achievement.

However, it is noteworthy that substantive associations of arts education and academic achievement are detectable when tested in adherence to rigorous methodological standards. Arts education is not an intervention that targets the skills measured by standardized achievement assessments. Therefore, further examination of why arts education contributes to achievement in tested subjects is needed.

Practitioners often rely on the assumption that increasing time-on-task in reading and mathematics will enhance achievement. However, it is plausible that too much time on task is detrimental to student motivation and persistence, and cutting arts programs to increase time-on-task may not improve long-term academic achievement. Findings from this research—that arts education predicts longitudinal achievement and growth in traditionally tested subjects—give researchers reason to question the efficacy of the strengthening trend in education policy to narrow instruction to focus on mathematics and language arts.

Experimental research is warranted to empirically identify the mechanisms that reinforce the positive associations. Motivation is highly susceptible to changes in instructional contexts (Dweck, 2007; Deci et al., 1999). Therefore, short-term experiments may be suited to capture the motivational effects of arts education. Researchers engaging in experimental arts education research should consider measuring motivational outcomes such as student achievement goal orientations, engagement, and satisfaction. Arts education researchers interested in achievement outcomes should consider conducting longitudinal analyses because the effects of arts education may emerge gradually over the course of years or only in response to cumulative exposure.

This study duration issue poses challenges for researchers who wish to test motivational mediation models. To facilitate this type of investigation, I recommend that researchers who design national longitudinal studies collect data on student motivation, engagement, and satisfaction. This would enable researchers to examine and identify curriculum characteristics (such as arts education) that contribute to student motivation and engagement as well as academic achievement.

To be clear, findings from this research are not meant to give traction to the argument that the primary purpose of in-school arts education is to enhance academic achievement. Engaging with the arts is valuable in and of itself. However, I argue that the intrinsic value of the arts is not diminished by acknowledging that intrinsic interest facilitates achievement. Arts education may enhance the quality of students' lived experiences in school, making learning more enjoyable and effective.

Supplemental Materials

Appendix A: HLM Models with Unstandardized Achievement Outcomes

Table 3: Unstandardized Outcomes
In-School Arts Education in 8th-Grade Predicting Achievement in Mathematics and Reading From 8th-Grade to 12th-Grade (NELS:88)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	9.101***	9.099***	8.941***	4.330***	4.328***	4.325***
	(0.103)	(0.103)	(0.111)	(0.095)	(0.095)	(0.103)
Wave squared	-1.528***	-1.528***	-1.532***	-0.661***	-0.661***	-0.661***
	(0.051)	(0.051)	(0.051)	(0.047)	(0.047)	(0.047)
Female	-0.833***	-1.014***	-1.016***	1.796***	1.676***	1.676***
	(0.146)	(0.147)	(0.147)	(0.107)	(0.107)	(0.107)
Socioeconomic status	5.809***	5.699***	5.700***	3.934***	3.861***	3.861***
	(0.114)	(0.114)	(0.114)	(0.082)	(0.082)	(0.082)
% free lunch in school	-0.482***	-0.486***	-0.486***	-0.189***	-0.191***	-0.191***
	(0.077)	(0.077)	(0.077)	(0.048)	(0.048)	(0.048)
% minority in school	-0.312***	-0.286***	-0.285***	-0.173***	-0.157**	-0.157**
	(0.076)	(0.076)	(0.076)	(0.048)	(0.048)	(0.048)
Starting teacher salary	0.757***	0.790***	0.789***	0.204**	0.226***	0.226***
	(0.108)	(0.108)	(0.108)	(0.068)	(0.068)	(0.068)
Public school	-3.017***	-3.095***	-3.107***	-2.149***	-2.221***	-2.221***
	(0.433)	(0.436)	(0.436)	(0.271)	(0.274)	(0.274)
Urban region	0.462	0.408	0.407	0.319	0.281	0.281
	(0.316)	(0.316)	(0.316)	(0.198)	(0.197)	(0.197)
Rural region	0.972**	0.905**	0.904**	0.365	0.318	0.317
	(0.321)	(0.321)	(0.321)	(0.200)	(0.200)	(0.200)
Art		0.270	0.236		0.255	0.254
		(0.226)	(0.234)		(0.163)	(0.172)
Music		2.300***	2.109***		1.599***	1.577***
		(0.214)	(0.222)		(0.155)	(0.164)
Both		0.898***	0.670**		0.574***	0.582***

Table 3 Cont.

		(0.231)	(0.237)		(0.162)	(0.169)
Art*Wave			0.052			0.001
			(0.090)			(0.083)
Music*Wave			0.280***			0.030
			(0.084)			(0.077)
Both*Wave			0.345***			-0.011
			(0.078)			(0.072)
Overall constant	39.378***	38.628***	38.751***	28.741***	28.238***	28.240***
	(0.373)	(0.406)	(0.407)	(0.238)	(0.263)	(0.265)

Notes: Racial category dummy variables were included in these models, with white omitted as the reference category. They were removed from the tables to conserve space. No. of observations = 45,670. No. of adolescents = 20,810. No. of schools = 1,000. Coefficients are point estimates. Standard errors are in parentheses.
* p<0.05, ** p<0.01, *** p<0.001

Table 4: Unstandardized Outcomes
In-School Arts Education in 8th-Grade Predicting Achievement in Science and History From 8th-Grade to 12th-Grade (NELS:88)

	Science			History		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	3.428***	3.427***	3.270***	1.241***	1.240***	1.160***
	(0.062)	(0.062)	(0.067)	(0.054)	(0.054)	(0.058)
Wave squared	-0.578***	-0.578***	-0.579***	0.676***	0.676***	0.676***
	(0.031)	(0.031)	(0.031)	(0.027)	(0.027)	(0.027)
Female	-1.272***	-1.335***	-1.337***	-0.697***	-0.758***	-0.759***
	(0.061)	(0.061)	(0.061)	(0.055)	(0.056)	(0.056)
Socioeconomic status	2.255***	2.218***	2.218***	2.057***	2.021***	2.021***
	(0.047)	(0.047)	(0.047)	(0.043)	(0.043)	(0.043)
% free lunch in school	-0.156***	-0.158***	-0.158***	-0.130***	-0.132***	-0.132***
	(0.031)	(0.031)	(0.031)	(0.028)	(0.028)	(0.028)
% minority in school	-0.166***	-0.152***	-0.152***	-0.108***	-0.100***	-0.099***
	(0.031)	(0.031)	(0.031)	(0.028)	(0.028)	(0.028)
Starting teacher salary	0.180***	0.192***	0.192***	0.149***	0.160***	0.160***
	(0.044)	(0.044)	(0.043)	(0.040)	(0.040)	(0.040)
Public school	-0.644***	-0.645***	-0.653***	-1.085***	-1.107***	-1.109***
	(0.175)	(0.176)	(0.176)	(0.160)	(0.161)	(0.161)
Urban region	0.144	0.121	0.120	0.099	0.083	0.082
	(0.128)	(0.127)	(0.127)	(0.117)	(0.117)	(0.117)
Rural region	0.573***	0.552***	0.552***	0.268*	0.246*	0.246*
	(0.130)	(0.129)	(0.129)	(0.118)	(0.118)	(0.118)
Art		0.178	0.004		0.040	-0.073
		(0.094)	(0.101)		(0.085)	(0.091)
Music		0.832***	0.702***		0.738***	0.652***
		(0.089)	(0.096)		(0.081)	(0.086)
Both		0.433***	0.248*		0.293***	0.232*
		(0.095)	(0.100)		(0.087)	(0.091)
Art*Wave			0.256***			0.167***
			(0.054)			(0.047)

Table 4 Cont.

Music*Wave			0.189***			0.125**
			(0.050)			(0.044)
Both*Wave			0.271***			0.091*
			(0.047)			(0.041)
Overall constant	20.548***	20.201***	20.316***	31.198***	30.964***	31.019***
	(0.152)	(0.165)	(0.166)	(0.138)	(0.151)	(0.152)

Notes: Racial category dummy variables were included in these models, with white omitted as the reference category. They were removed from the tables to conserve space. No. of observations = 45,670. No. of adolescents = 20,810. No. of schools = 1,000. Coefficients are point estimates. Standard errors are in parentheses.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 8: Unstandardized Outcomes

In-School Arts Education in Kindergarten, 1st-Grade, 3rd-Grade, and 5th-Grade Predicting Achievement in Mathematics and Reading From Kindergarten to 5th-Grade (ECLS-K)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	29.553***	29.670***	26.674***	41.574***	41.762***	38.155***
	(0.205)	(0.206)	(0.409)	(0.264)	(0.266)	(0.521)
Wave squared	0.093	0.120	0.328***	-1.758***	-1.735***	-1.497***
	(0.068)	(0.069)	(0.073)	(0.088)	(0.089)	(0.094)
Female	-2.412***	-2.425***	-2.425***	3.279***	3.264***	3.266***
	(0.263)	(0.263)	(0.262)	(0.300)	(0.300)	(0.300)
Socioeconomic status	6.414***	6.405***	6.399***	7.737***	7.727***	7.725***
	(0.203)	(0.203)	(0.202)	(0.233)	(0.232)	(0.232)
% free lunch in school	-0.060***	-0.057***	-0.057***	-0.079***	-0.076***	-0.075***
	(0.010)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)
% minority in school	-0.505**	-0.455*	-0.430*	-0.874***	-0.799***	-0.769***
	(0.195)	(0.195)	(0.195)	(0.227)	(0.226)	(0.226)
Starting teacher salary	0.674*	0.659*	0.661*	0.362	0.344	0.343
	(0.269)	(0.270)	(0.270)	(0.315)	(0.314)	(0.313)
Public school	-0.047	-0.002	-0.061	-1.585*	-1.540*	-1.612*
	(0.663)	(0.665)	(0.666)	(0.775)	(0.773)	(0.771)
Urban region	0.156	0.114	0.098	0.151	0.113	0.099
	(0.476)	(0.477)	(0.478)	(0.557)	(0.555)	(0.554)
Rural region	-2.391***	-2.373***	-2.340***	-2.124***	-2.086**	-2.048**
	(0.549)	(0.550)	(0.551)	(0.642)	(0.640)	(0.638)
Art		0.941*	-3.255***		0.341	-4.494***
		(0.430)	(0.933)		(0.548)	(1.188)
Music		2.442***	-1.711		2.650***	-3.185**
		(0.406)	(0.970)		(0.517)	(1.235)
Both		2.561***	-3.185***		3.076***	-3.903***
		(0.303)	(0.760)		(0.385)	(0.966)
Art*Wave			1.581***			1.742**
			(0.437)			(0.555)

Table 8 Cont.

Music*Wave			1.753***			2.527***
			(0.411)			(0.524)
Both*Wave			2.686***			3.251***
			(0.319)			(0.405)
Overall constant	40.616***	38.013***	43.625***	48.804***	45.676***	52.501***
	(0.658)	(0.727)	(1.003)	(0.770)	(0.862)	(1.228)

Notes: Racial category dummy variables were included in these models, with white omitted as the reference category. They were removed from the tables to conserve space. No. of observations = 31,615. No. of children = 13,873. No. of schools = 1,895. Average no. of observations per school = 17. Coefficients are point estimates. Standard errors are in parentheses.
* p<0.05, ** p<0.01, *** p<0.001

Appendix B: Weighted HLM Models

Table 3: Weighted
In-School Arts Education in 8th-Grade Predicting Achievement in Mathematics and Reading From 8th-Grade to 12th-Grade (NELS:88)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	0.607***	0.607***	0.600***	0.407***	0.407***	0.413***
	(0.012)	(0.012)	(0.013)	(0.018)	(0.018)	(0.020)
Wave squared	-0.102***	-0.102***	-0.102***	-0.059***	-0.059***	-0.059***
	(0.005)	(0.005)	(0.005)	(0.009)	(0.009)	(0.009)
Female	-0.063***	-0.076***	-0.076***	0.182***	0.169***	0.169***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Socioeconomic status	0.426***	0.418***	0.419***	0.419***	0.412***	0.412***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
% free lunch in school	-0.028***	-0.028***	-0.028***	-0.016**	-0.016**	-0.016**
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
% minority in school	-0.021***	-0.019**	-0.019**	-0.016**	-0.014*	-0.014*
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Starting teacher salary	0.056***	0.058***	0.058***	0.026**	0.028***	0.028***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Public school	-0.270***	-0.274***	-0.274***	-0.256***	-0.259***	-0.259***
	(0.036)	(0.036)	(0.036)	(0.033)	(0.033)	(0.033)
Urban region	0.040	0.036	0.036	0.051*	0.047*	0.047*
	(0.025)	(0.026)	(0.026)	(0.024)	(0.024)	(0.024)
Rural region	0.067**	0.061**	0.061**	0.040	0.034	0.034
	(0.024)	(0.023)	(0.023)	(0.021)	(0.021)	(0.021)
Art		0.035	0.048*		0.037	0.054*
		(0.020)	(0.021)		(0.021)	(0.023)
Music		0.161***	0.140***		0.160***	0.152***
		(0.018)	(0.019)		(0.019)	(0.021)
Both		0.077***	0.061**		0.080***	0.093***
		(0.020)	(0.021)		(0.021)	(0.023)
Art*Wave			-0.015			-0.019

Table 3 Cont.

			(0.013)			(0.014)
Music*Wave			0.024*			0.009
			(0.010)			(0.013)
Both*Wave			0.018			-0.015
			(0.011)			(0.013)
Overall constant	-0.121***	-0.182***	-0.176***	-0.089**	-0.152***	-0.157***
	(0.032)	(0.035)	(0.035)	(0.030)	(0.033)	(0.034)

Notes: Racial category dummy variables were included in these models, with white omitted as the reference category. They were removed from the tables to conserve space. No. of observations = 45,670. No. of adolescents = 20,810. No. of schools = 1,000. Standard errors are in parentheses.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 4: Weighted

In-School Arts Education in 8th-Grade Predicting Achievement in Science and History From 8th-Grade to 12th-Grade (NELS:88)

	Science			History		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	0.535***	0.535***	0.517***	0.214***	0.214***	0.196***
	(0.019)	(0.019)	(0.020)	(0.019)	(0.019)	(0.021)
Wave squared	-0.089***	-0.089***	-0.090***	0.120***	0.120***	0.119***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Female	-0.238***	-0.249***	-0.250***	-0.143***	-0.155***	-0.155***
	(0.014)	(0.014)	(0.014)	(0.013)	(0.013)	(0.013)
Socioeconomic status	0.393***	0.386***	0.386***	0.389***	0.382***	0.382***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
% free lunch in school	-0.023***	-0.024***	-0.023***	-0.022***	-0.022***	-0.022***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
% minority in school	-0.028***	-0.025***	-0.026***	-0.019**	-0.017**	-0.017**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Starting teacher salary	0.036***	0.038***	0.038***	0.035***	0.036***	0.036***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Public school	-0.166***	-0.165***	-0.165***	-0.236***	-0.237***	-0.237***
	(0.035)	(0.035)	(0.035)	(0.033)	(0.034)	(0.034)
Urban region	0.028	0.024	0.024	0.027	0.023	0.023
	(0.024)	(0.024)	(0.024)	(0.023)	(0.023)	(0.023)
Rural region	0.100***	0.095***	0.095***	0.046*	0.041	0.041
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Art		0.041*	0.025		0.015	-0.011
		(0.019)	(0.022)		(0.020)	(0.023)
Music		0.149***	0.121***		0.139***	0.105***
		(0.018)	(0.018)		(0.018)	(0.020)
Both		0.088***	0.058**		0.069***	0.052*
		(0.020)	(0.022)		(0.020)	(0.024)
Art*Wave			0.019			0.029
			(0.015)			(0.016)

Table 4 Cont.

Music*Wave			0.031*			0.038**
			(0.012)			(0.012)
Both*Wave			0.034*			0.020
			(0.014)			(0.015)
Overall constant	0.014	-0.054	-0.037	-0.029	-0.081*	-0.065
	(0.031)	(0.034)	(0.034)	(0.031)	(0.035)	(0.036)

Notes: Racial category dummy variables were included in these models, with white omitted as the reference category. They were removed from the tables to conserve space. No. of observations = 45,670. No. of adolescents = 20,810. No. of schools = 1,000. Standard errors are in parentheses.

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 8: Weighted

In-School Arts Education in Kindergarten, 1st-Grade, 3rd-Grade, and 5th-Grade Predicting Achievement in Mathematics and Reading From Kindergarten to 5th-Grade (ECLS-K)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wave	0.763***	0.767***	0.696***	0.885***	0.888***	0.817***
	(0.009)	(0.009)	(0.023)	(0.011)	(0.010)	(0.021)
Wave squared	0.003	0.003	0.008**	-0.037***	-0.037***	-0.032***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Female	-0.061***	-0.062***	-0.062***	0.069***	0.068***	0.068***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Socioeconomic status	0.165***	0.165***	0.165***	0.164***	0.163***	0.163***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
% minority in school	-0.002***	-0.001***	-0.001***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
% free lunch in school	-0.014**	-0.013*	-0.012*	-0.020***	-0.019***	-0.018***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Starting teacher salary	0.020*	0.019*	0.019*	0.009	0.009	0.008
	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Public school	-0.001	-0.001	-0.003	-0.036*	-0.036*	-0.037*
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Urban region	-0.002	-0.003	-0.003	-0.005	-0.005	-0.005
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Rural region	-0.063***	-0.063***	-0.062***	-0.046**	-0.045**	-0.045**
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Art		0.013	-0.083		0.000	-0.102*
		(0.025)	(0.044)		(0.026)	(0.051)
Music		0.063**	-0.027		0.039	-0.091
		(0.022)	(0.046)		(0.022)	(0.049)
Both		0.057**	-0.076*		0.042*	-0.095*
		(0.019)	(0.036)		(0.017)	(0.037)
Art*Wave			0.036			0.039
			(0.021)			(0.022)

Table 8 Cont.

Music*Wave			0.038			0.057**
			(0.022)			(0.019)
Both*Wave			0.063***			0.064***
			(0.018)			(0.015)
Overall constant	-0.884***	-0.941***	-0.812***	-0.948***	-0.990***	-0.856***
	(0.019)	(0.026)	(0.042)	(0.019)	(0.026)	(0.042)

Notes: Racial category dummy variables were included in these models, with white omitted as the reference category. They were removed from the tables to conserve space. No. of observations = 31,615. No. of children = 13,873. No. of schools = 1,895. Standard errors are in parentheses

* p<0.05, ** p<0.01, *** p<0.001

Appendix C: Race/Ethnicity Coefficients of Main (Unweighted) HLM Models

Table 3: Race/Ethnicity Coefficients

Racial Components of the Models Predicting Achievement in Mathematics and Reading From 8th-Grade to 12th-Grade (NELS:88)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
African American	-0.314***	-0.316***	-0.316***	-0.295***	-0.297***	-0.297***
	(0.021)	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
Hispanic	-0.173***	-0.169***	-0.168***	-0.174***	-0.169***	-0.169***
	(0.019)	(0.019)	(0.019)	(0.021)	(0.021)	(0.021)
Asian	0.265***	0.264***	0.264***	0.022	0.022	0.022
	(0.023)	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)
American Indian	-0.339***	-0.337***	-0.337***	-0.385***	-0.382***	-0.382***
	(0.049)	(0.049)	(0.049)	(0.052)	(0.052)	(0.052)

Notes: All the variables in the models in the main text were included in these models (gender, socioeconomic status, school characteristics, and arts education). Coefficients are unweighted point estimates. Standard errors are in parentheses.

*** $p<0.001$

Table 4: Race/Ethnicity Coefficients

Racial Components of the Models Predicting Achievement in Science and History From 8th-Grade to 12th-Grade (NELS:88)

	Science			History		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
African American	-0.390***	-0.392***	-0.392***	-0.246***	-0.247***	-0.247***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Hispanic	-0.204***	-0.200***	-0.199***	-0.155***	-0.151***	-0.151***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Asian	0.080***	0.080***	0.080***	0.096***	0.096***	0.096***
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
American Indian	-0.380***	-0.379***	-0.378***	-0.359***	-0.357***	-0.356***
	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)

Note: All the variables in the models in the main text were included in these models (gender, socioeconomic status, school characteristics, and arts education). Coefficients are unweighted point estimates. Standard errors are in parentheses.

*** $p<0.001$

Table 8: Race/Ethnicity Coefficients

Racial Components of the Models Predicting Achievement in Mathematics and Reading From Kindergarten to 5th-Grade (ECLS-K)

	Mathematics			Reading		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
African American	-0.219***	-0.218***	-0.220***	-0.121***	-0.120***	-0.121***
	(0.014)	(0.014)	(0.014)	(0.013)	(0.013)	(0.013)
Hispanic	-0.141***	-0.140***	-0.140***	-0.103***	-0.102***	-0.102***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Asian	-0.031	-0.031	-0.031	-0.012	-0.012	-0.012
	(0.016)	(0.016)	(0.016)	(0.015)	(0.015)	(0.015)
American Indian	-0.165***	-0.166***	-0.166***	-0.165***	-0.166***	-0.166***
	(0.030)	(0.030)	(0.030)	(0.029)	(0.029)	(0.029)
Other	-0.086***	-0.086***	-0.087***	-0.012	-0.012	-0.013
	(0.022)	(0.022)	(0.022)	(0.021)	(0.021)	(0.021)

Notes: All the variables in the models in the main text were included in these models (gender, socioeconomic status, school characteristics, and arts education). Coefficients are unweighted point estimates. Standard errors are in parentheses.

** $p<0.01$, *** $p<0.001$

Appendix D: Hausman Test

```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |   fe_model     re_model       Difference          S.E.
-------------+----------------------------------------------------------------
        wave |    .9012106     .9289072       -.0276966               .
       wave2 |   -.0371131    -.0439059        .0067928               .
        zses |     .008405     .1465187       -.1381137        .0051094
      zlearn |    .0349756     .1084057       -.0734301        .0015215
       1.art |    .0143415     .0127999        .0015416         .003187
     1.music |    .0513448     .0738567       -.0225118        .0033118
      1.both |    .0654572     .0832938       -.0178367        .0022936
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =     1773.63
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

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CURRICULUM VITAE

EDUCATION:

2012-2017 Rutgers University Camden, New Jersey.
PhD
Department of Childhood Studies
Defended Dissertation with Distinction
Dissertation Title: *In-School Arts Education and Academic Achievement: Analysis of National Data Using Three-Level Hierarchical Linear Modeling and Child Fixed Effects Techniques*

2003-2007 Ohio University Athens, Ohio.
BFA
Major: Ceramics; Minor: Anthropology

PROFESSIONAL EXPERIENCE:

2015-2016 Rutgers University Camden, New Jersey.
Sole Instructor for an undergraduate research design and statistics course
- Designed syllabus, curriculum, exams, and other course materials
- Engaged undergraduate students is original empirical research
- Maintained records of student progress and assigned grades

2014-2015 Rutgers University Camden, New Jersey.
Spanish Translator for the City Life Research Study
- Coordinated with local schools and social service agencies to facilitate participant recruitment
- Surveyed low-income Spanish speaking teen-parent dyads in their homes

2013-2015 Rutgers University Camden, New Jersey.
Lead Researcher of comparison family recruitment for the Family Counts Research Study
- Conducted focus groups with social service workers
- Conducted interviews with low-income families in their homes
- Transcribed interview and focus group audio recordings
- Designed and created survey data codebooks
- Cleaned datasets

2012-2015 Rutgers University Camden, New Jersey.
Lead Researcher of participant recruitment for the Epic Camden Research Study
- Personally surveyed 200 adolescents
- Designed and created survey data codebooks
- Identified and developed survey questions for follow-up data collection
- Participated in statistical analysis and the writing of manuscripts

PROFESSIONAL EXPERIENCE CONT.:

2011-2012 Peninsula Union School District Samoa, California.
Program Director for a small rural K-8 after-school program

- Planned and implemented fine art and life-skill based enrichment programs, including ceramics, movie making, music, and cooking
- Maintained records of student attendance and academic achievement
- Annually assessed whether the after-school program contributed to student attendance and academic achievement
- Prepared and presented program evaluation reports

2010-2011 Art, Research, and Curriculum San Francisco, California.
Site Coordinator for an after-school kindergarten Spanish literacy program

- Collaborated with parents and classroom teachers in curriculum development
- Trained and managed a team of four instructors
- Oversaw literacy instruction and worked on-on-one with children when individual attention was needed
- Maintained records of student literacy progress
- Prepared and presented program evaluation reports

2010-2011 Bay Teachers San Francisco, California.
Substitute Teacher for top-tier K-8 private schools in the bay area

- Implemented preplanned lessons in a wide range of subjects including science, mathematics, and reproductive health

2008-2010 Speak English! Torrelles de Llobregat, Spain.
English Teacher for private English language center

- Taught English as a second language to children and adults
- Designed course materials and curriculum for the summer program

PUBLICATIONS:

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