Working Paper

2018-2

Examining Predictors of Academic Growth in Secondary School Among Academically-Advanced Youth Across 21 years

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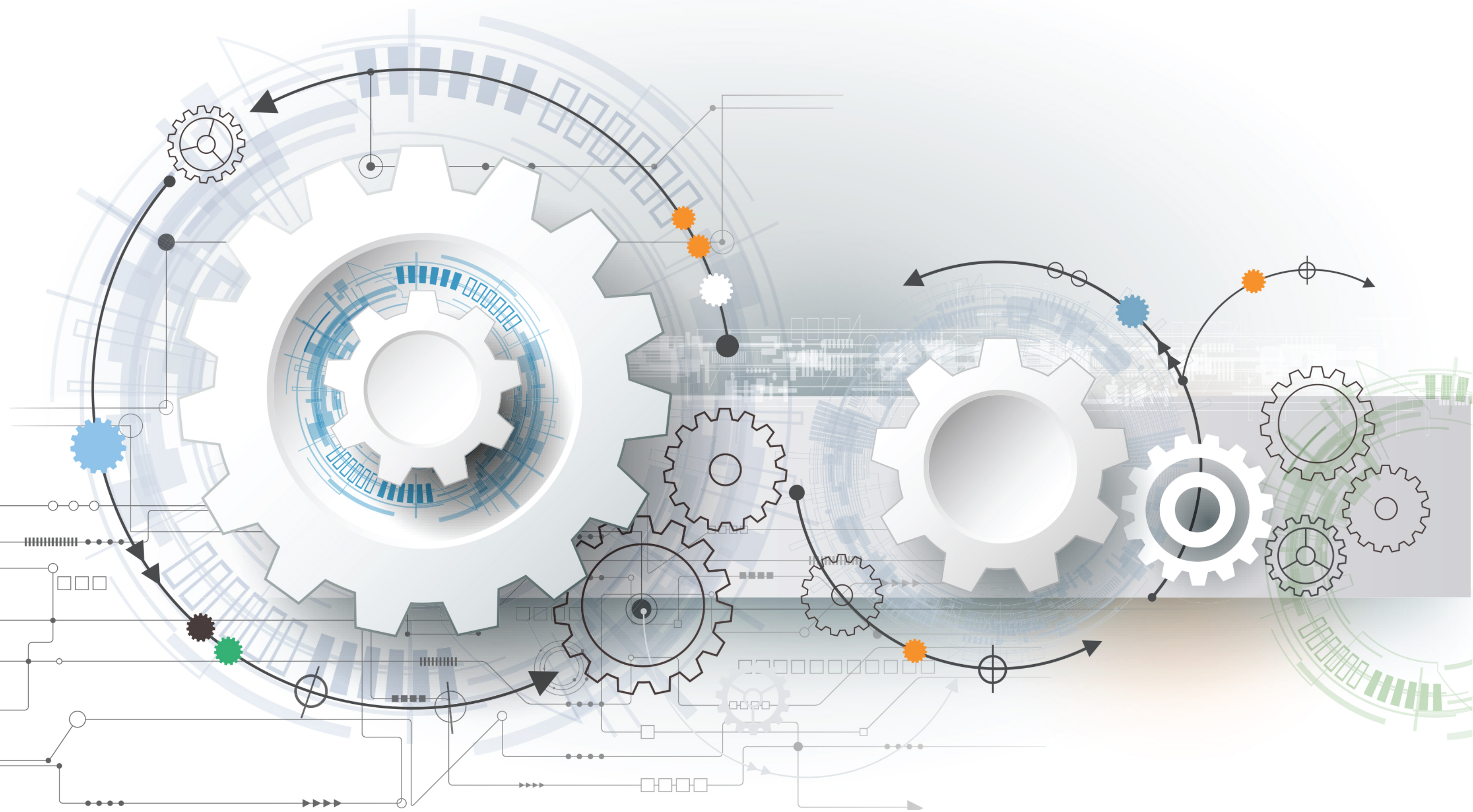

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R1702

Abstract

Many academically-advanced youth take the ACT® test in 7th grade for academic talent searches and again in 11th or 12th grade for college admissions. We leveraged this sample of 460,033 students, taking an exploratory analytic approach to examine trends in academic growth from 1996 to 2016. We examined potential predictors of academic growth, including sociodemographics, interests, high school characteristics, high school coursework and GPA, and extracurriculars. We find these variables account for 29% of the explainable variance in academic growth. Overall, growth improved from 2005 to 2016, but growth for low-income and Hispanic students was stagnant. Students attending Catholic and private schools had the highest growth, whereas homeschooled students and students attending high-poverty public schools showed lowest growth. Elective high school courses in STEM subjects were associated with higher growth, and advanced AP, accelerated, or honors courses were associated with significantly higher growth. In addition, students with Investigative and Conventional interests had higher growth. Some extracurriculars had significant relationships with academic growth, though the effects were small. Factors that had a positive impact on the academic growth trend across time included fewer students being schooled in rural areas, students earning higher grades, more students taking STEM and advanced courses, and an increase in Investigative interests. We discuss leverage points for educational intervention to improve academic growth among academically-advanced students. Better understanding how to improve academic growth in this population can lead to significant improvements in their personal fulfillment and academic achievement as well as societal innovation and GDP.

Keywords: academic growth, academically advanced, gifted and talented, the ACT test, advanced coursework, high school characteristics.

1.1 INTRODUCTION

Better understanding the factors that influence academic achievement growth is of great importance to students, parents, educators, scholars, and policymakers interested in human capital development (Heckman, 2000) and national competitiveness (Augustine, 2005; Hanushek & Woessmann, 2015; National Science and Technology Council, 2016). The talent development of academically-advanced students in particular has important implications not only for their individual educational development, personal fulfillment, and later educational and occupational achievement, but also for societal innovation (e.g., Lubinski & Benbow, 2006; Subotnik, Olszewski-Kubilius, & Worrell, 2011), including the development of a sufficient innovation pipeline, such as deep analytical talent needed for data science (e.g., The Networking and Information Technology Research and Development Program and Big Data Senior Steering Group, 2016), artificial intelligence advancement (e.g., Executive Office of the President, 2016), and increased GDP (e.g., Rindermann & Thompson, 2011). The long-term rate of return of early investment in academically advanced vs. academically behind students has been shown to be significantly greater (Heckman, 2000), suggesting that even small improvements enhancing the performance of academically-advanced students would result in a large payoff in intellectual and technological innovations and economic growth (Wai & Worrell, 2016). Scholars have for many decades expressed concern (e.g., Benbow & Stanley, 1996; Wai & Worrell, 2016) that academically-advanced US students could be performing much better in international comparison assessments (e.g., PISA) if more attention was paid to their talent development, so a better understanding of trends in academic growth over time is needed.

Each year, over 100,000 academically-advanced students take a college entrance exam designed for high school juniors and seniors such as the ACT (ACT, 2014) or SAT (College

Board, 2016) in the 7th grade as part of an academic talent search. They typically qualify for participation in the talent search by being identified as academically advanced (i.e., scoring in the top 5%) on a within-grade test. These academically-advanced students are then further tested on the ACT or SAT in the 7th grade to better determine their academic readiness for advanced educational programming matched to their level and pattern of domain strengths. The ceiling problem on a typical on-grade test is mostly removed on a much harder test designed for 11th or 12th graders, but also means many students will score quite low, capturing the full range of academic achievement variability. Although there are many ways to operationalize and measure academic readiness, the ACT test as a whole can broadly be considered one such measure (ACT, 2014).

Due to the 7th-grade talent search coupled with the need for students to take a college admissions exam in high school, many students who take the ACT in the 7th grade do so again in 11th or 12th grade (Allen, 2016), providing a unique leverage point to investigate academic development through the secondary school years. The talent search has operated for at least two decades, providing an historical window into changes in academic growth among academically-advanced youth.

Given that high school ACT and SAT scores help predict first-year college outcomes as well as later educational and occupational success (e.g., Kobrin, Patterson, Shaw, Mattern, & Barbuti, 2008; Kuncel, Hezlett, & Ones, 2004; Schmitt, Keeney, Oswald, Pleskac, Billington, Sinha, & Zorzie, 2009), a better understanding of which factors improve score growth can lead to educational interventions that can improve the achievement of academically-advanced students and potentially all students. Prior research using the ACT as a measure of academic growth uncovered that additional high school coursework and improved course performance enhanced academic growth for the general population of students (Sawyer, 2008) and that participation in a summer academic program enhanced academic growth for academically-advanced students (Schiel, 1998). Though important, such research focuses primarily on the impact of a handful of educational aspects, whereas the role of variables that fall outside that scope, such as sociodemographics, interests, high school characteristics and extracurricular activities, especially in conjunction with a wider variety educational variables, remains relatively unexplored territory. In particular for academically-advanced students, an understanding of whether growth has improved over the last 21 years, and for which subgroups of interest, as well as an understanding of which factors (educational or otherwise) predict growth, overall and across time, are also important.

The period between 7th grade and 11th/12th grade includes many opportunities for academic development, both inside and outside of school. Therefore it is important to examine as many variables as possible that might contribute to academic growth, with some factors being more or less amenable to intervention. In this study, we leveraged this unique sample and took an exploratory analytic approach to examine trends in academic growth across 21 years. We specifically examine potential predictors that might contribute to academic growth and for which data were systematically collected: sociodemographics, interests, high school characteristics, high school coursework and GPA, and extracurriculars. The study attempts to explain two types of changes: students' ACT score change from grade 7 to grade 11 or 12 (academic growth) and group improvement in academic growth from 1996 to 2016 (growth trend).

1.2 Research Questions

We address the following research questions in this study:

1. Has growth in academic achievement from 7th to 11th/12th grade improved among academically-advanced youth in the last two decades?
2. Has growth in academic achievement from 7th to 11th/12th grade improved among academically-advanced youth within special subgroups of interest?
3. Is variation in academic growth among academically-advanced youth explained by sociodemographics, high school characteristics, coursework taken, high school GPA, Holland-type vocational interests, or extracurriculars?
4. To what extent have predictors of academic growth among academically-advanced youth changed over the last two decades?
5. If growth in academic achievement from 7th to 11th/12th grade has changed among academically-advanced youth in the last two decades, can the change be explained by predictor trends?

2. METHODS

2.1 Sample

The sample consists of 460,033 students who took the ACT test in 7th grade and again in 11th or 12th grade and were projected to complete high school between 1996 and 2016. Because high school characteristics are of interest, students must have provided a high school code (or indicated that they were homeschooled), and high school data must have been available from a secondary database described later. The sample size gradually increased by cohort, with N=14,282 for the 1996 cohort and N=26,622 for the 2016 cohort. The increase in the sample size over cohorts is likely due, in part, to increasingly large cohorts of US high school graduates[1] and increased participation in the ACT college admissions test.[2]

The vast majority of students in the sample (96%) sent their ACT score results to a major talent search program in the 7th grade. Talent searches identify students through a two-step process (Assouline & Lupkowski-Shoplik, 2012). The first step begins with performance on a grade-level standardized test, typically administered by the school. Students who score in the top 3-5% on a grade-level standardized test are invited to take the ACT (ACT, 2014) or SAT (College Board, 2016). Over 100,000 middle school students currently take one of these exams as part of the talent searches each year, and their score distributions are similar to (but as we report later in the methods section, have slightly lower mean and SD than) college-bound high school students. The purpose of the talent search is to help identify and match these academically-advanced students with educational opportunities for which they are ready. For example, the average talent search participant scoring in the top 0.5% for their age group can assimilate a typical high school course in three weeks, and those scoring in the top 0.01% for their age group can assimilate two times this amount or more (Benbow & Stanley, 1996; Stanley, 2000).

The sample of academically-advanced students can be compared to the general population of 11th-grade students in the United States on gender, race/ethnicity, geographic region, school type, and school locale (Table 1). The sample and population are both evenly split on gender. The sample contains a much higher percentage of White students (82.1%) than the

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[1] Estimates of the number of high school graduates in the US were 2.5 million for 1996 and 3.4 million for 2016 (WICHE, 1998; Bransberger & Michelau, 2016).

[2] The percentage of high school graduates taking the ACT test was 36% in 1996 and 61% in 2016 (ACT, 1996; 2016).

population (52.9%) and lower percentages of African American (3.9% vs. 15.0%), Asian (2.8% vs. 5.6%), and Hispanic (3.6% vs. 23.1%) students. The sample is predominantly from the Midwest (36.1%) and South (61.2%), with very little representation from the Northeast and West. The geographic disparity is caused by the ACT test being the predominant college admissions test used in the Midwest and South, and the SAT test being more common in the Northeast and West. The sample contains relatively more students from Catholic schools (9.3% vs. 3.2%) and private schools (8.8% vs. 4.2%) and fewer students from public schools (80.5% vs. 89.5%). Students from public schools with a higher poverty concentration (larger percent of students eligible for free or reduced lunch) are not well represented. The sample contains relatively more students attending schools in town (17.1% vs. 10.8%) and rural locales (21.7% vs. 13.1%). A small percentage of students in the sample (0.3%) were homeschooled when they took the test in 11th or 12th grade.

Table 1. Comparing the Sample to the Population of US Students in 11th Grade

Variable	Sample %	Population %
Gender		
Female	49.8	49.4
Male	50.2	50.6
Race/ethnicity		
African American	4.0	15.0
Asian	2.7	5.6
Hispanic/Latino	3.5	23.1
Other	2.4	3.4
White	81.2	52.9
Unknown	6.2	
Region[3]		
Midwest	36.1	22.3
Northeast	0.6	16.8
South	61.2	37.6
West	2.1	23.3
School type		
Catholic	9.3	3.2
Home	0.3	NA
Private	8.8	4.2
Other	1.1	3.1
Public, <20% FRL	28.7	15.8
Public, 20-40% FRL	28.5	23.8
Public, 40-60% FRL	17.0	23.0
Public, 60-80% FRL	5.2	15.8
Public, >80% FRL	1.1	10.3
Public, FRL unknown	NA	0.8
School locale		
Rural	21.7	13.1
Town	17.1	10.8
Suburban	31.9	39.9
City	29.3	32.4
Unknown		3.8

Note: Population percentages for gender and race/ethnicity reflect public school students only.

FRL = free or reduced lunch.

2.2 Measure of academic growth

[3] Definition of geographic region used by the US Census Bureau

Academic growth is measured by students’ performance on the ACT tests they took in 7th grade and again in high school (11th or 12th grade). The tests are designed to measure the academic skills necessary for education and work after high school, and the content of the tests is related to major curriculum areas (ACT, 2014). The ACT test focuses on the knowledge and skills attained as the cumulative effect of school experience. It is not designed to measure specific course content but is instead a test of educational achievement oriented towards the general content areas of college and high school instructional programs. The multiple choice portion of the test (215 questions) determines subject area scores in English, mathematics, reading, and science; the writing score is determined from the optional essay portion of the test. The ACT Composite score is the average of the four ACT subject area scores from the multiple choice portion of the test (English, mathematics, reading, and science) and is the focus of this study. Academically-advanced 7th graders, who presumably have not taken specific college-prep courses, score about 0.5 standard deviations below ACT-tested high school graduates, on average (ACT, 2016; Allen, 2016). Research has shown that 7th-grade scores on a college admissions test (the SAT) predict later long-term achievement (e.g., Park, Lubinski, & Benbow, 2007; Wai, Lubinski, & Benbow, 2005).

ACT scale scores range from 1-36 and have reliabilities ranging from 0.83 (for the science test) to 0.96 (for the Composite) (ACT, 2014). Many students take the ACT more than once during high school. For this study, we used students’ 7th-grade scores and last scores from high school. The mean (SD) number of months between the 7th-grade test and high school test was 55.1 (3.5), or about 4.6 years.

Because ACT scale scores are equated across test administrations, scores from 7th grade and later are on the same scale. One measure of growth is the simple gain score (later ACT score

– 7th-grade ACT score). This measure is attractive for its simplicity and intuitive appeal but suffers from ceiling effects (very high 7th-grade scores have less room to improve), regression to the mean (e.g., the lowest scoring students in 7th grade are expected to show larger gains), and high standard error of measurement. Moreover, there is an implicit assumption of an interval scale, such that a *k*-point gain has the same meaning across the score scale. The ceiling and regression to the mean effects are depicted in Figure 1.

The residual gain score (Castellano & Ho, 2013) is an alternative to the simple gain score and is calculated as the residual from a regression of the later test score on the earlier test score. The residual gain model belongs to the same family of conditional status models as other popular growth models, including the student growth percentile model (Betebenner, 2009) and value-added models (Castellano & Ho, 2015). The regression model can be a simple linear model, a higher-order polynomial model, or even a categorical model. Because of our large sample (and sufficient N at each 7th-grade score point), we used a categorical model. Demonstrating this model, Figure 1 shows the mean 11th/12th grade ACT Composite score for each possible 7th-grade ACT Composite score. The residual gain model addresses the ceiling and regression to the mean effects because average gain is allowed to vary across the entire score scale. In Figure 1, for example, a student who scores 32 in 7th grade and 35 in 11th grade (gray star, gain score=3) has a residual gain score of -0.1, while a student who scores 13 in 7th grade and 16 in 11th grade (black star, gain score=3) has a residual gain score of -5.7. Relative to gain scores, residual gain scores often have lower standard error of measurement.

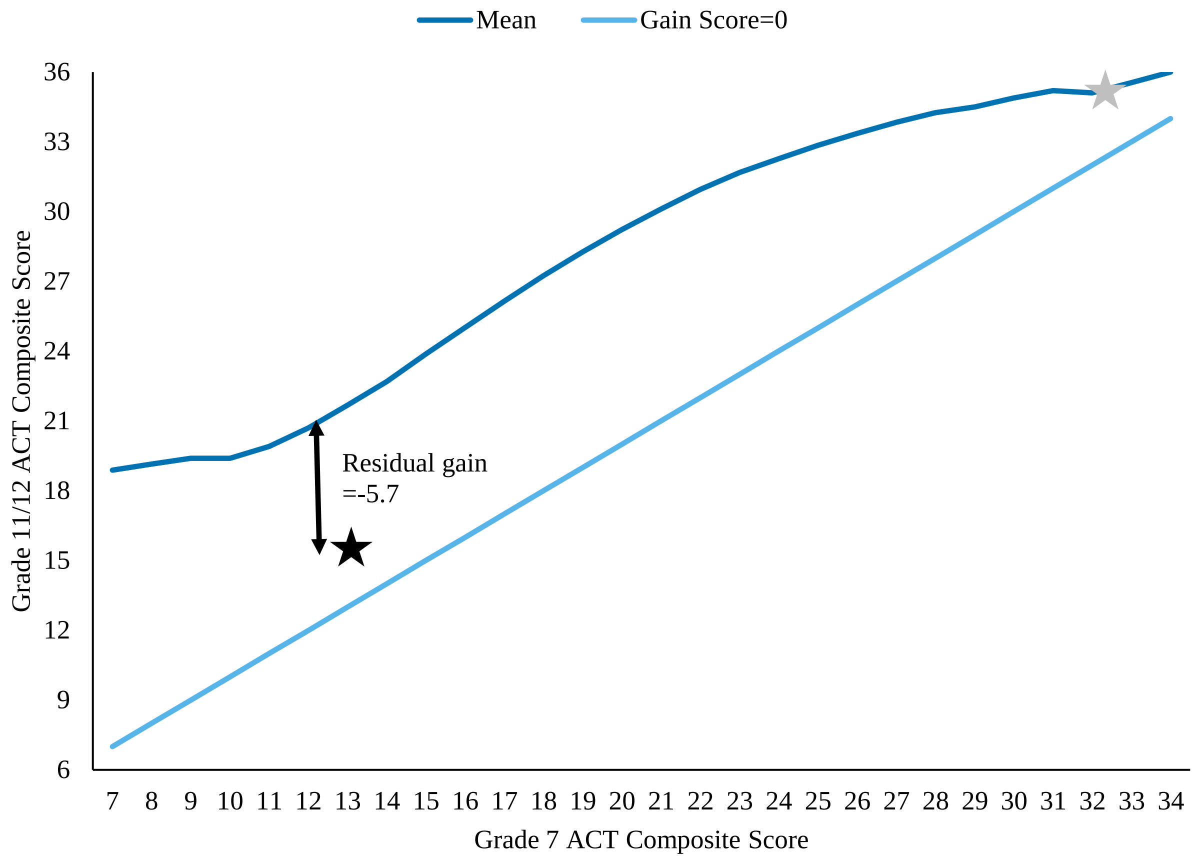

Figure 1. Mean 11th/12th-grade ACT Composite score by 7th-grade ACT Composite score

In addition to 7th-grade test score, the residual gain model can also accommodate other covariates in the regression equation. We used the number of months between the two tests as a covariate because students are expected to show more growth with longer intervening periods. Many students with disabilities take the ACT test with special accommodations. Because students generally perform better with special testing accommodations, we also used indicators of special accommodations as covariates. Across all students and cohorts, the mean and standard deviations were 17.7 (3.1) for the 7th-grade ACT Composite score, 26.7 (4.0) for the 11th/12th-grade ACT Composite score, 9.0 (2.7) for the gain score, and 0.0 (2.7) for the residual gain score. The correlation of 7th-grade and later ACT Composite scores was $r = 0.737$.

2.3 Predictors

2.3.1 Socio-demographic variables

Gender, family income level, parent education level, and race/ethnicity were collected when students registered for the ACT in high school and were used as predictors of academic growth and to identify students in special subgroups of interest. Family income level was collected as an ordinal variable and was categorized relative to the median household income in the US during the student's cohort year: low income (<75% of median), middle income (75-125% of median income), and high income (>125% of median). For students in the 2011-2016 cohorts, paternal and maternal education level was collected, and the maximum level was used, with categories of high school or less, some college but less than a bachelor's degree, and bachelor's degree or higher. Race/ethnicity was categorized as African American, Asian, Hispanic, White, and other (including Native American and two or more races). The ACT registration form also collects data on disability status[4] and whether English is the primary language spoken in the home. This data was used to identify additional special subgroups of interest.

2.3.2 High school characteristics

Data on high school characteristics was obtained from the National Center for Education Statistics (NCES) Common Core of Data (Glander, 2016) and the Market Data Retrieval school database (http://schooldata.com/). Variables included school category (Catholic, private, public, or other), percent of students eligible for free or reduced lunch (FRL, available only for public schools), class size, and locale (rural, town, suburban, or city). Combining school category,

[4] Students are asked whether they have a disability that requires special provisions from the educational institution.

homeschooling indicators obtained when students registered for the ACT test in high school, and school FRL%, a school type variable was created with nine categories: Catholic, private, home, other (e.g., state or county-operated schools), public < 20% FRL, public 20-40% FRL, public 40-60% FRL, public 60-80% FRL, and public > 80% FRL.

2.3.3 High school coursework and GPA

High school coursework and grades are collected when students register for the ACT test in high school. For 30 different courses, students are asked if they 1) have taken the course (or are currently taking the course), 2) have not taken the course but plan to later, or 3) have not taken the course and will not take it later. For this study, students were classified as having taken a course if they marked option 1. Some high school courses (e.g., English 9, algebra I, biology, and US History) are taken by virtually all students because of prerequisites or high school graduation requirements and so are of less interest as predictors of academic growth among academically-advanced students. We examined 18 elective courses, coded as binary indicators, which may serve as an intermediate form of advanced coursework, as predictors of academic growth (see Table 5 for list of courses).

When students register for the ACT test, they are also asked whether they have taken advanced placement, accelerated, or honors courses in English, mathematics, social studies, natural sciences, or foreign languages. Binary indicators for each type of advanced coursework were used as predictors of academic growth.

High school GPA was determined by averaging grades reported by students across 23 core high school courses. While the high school GPA measure is based on student self-reports, it is highly correlated with high school GPA obtained from high school transcripts (r = 0.84, Sanchez & Buddin, 2016) and is used as a predictor of academic growth.

2.3.4 Vocational interests

Holland's theory of vocational choices (1997) proposed there are six work environments that correspond to six personality types: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional. The ACT Interest Inventory (ACT, 2009) is a 72-item instrument that measures the six dimensions corresponding to Holland's typology of interests and occupations. Students can complete the Interest Inventory when they register for the ACT test. Each item describes an activity (e.g., "Explore a science museum"), and students are asked to indicate if they like, dislike, or are indifferent to doing the activity. Table 2 provides the names and descriptions of the six scales, and the items are available online (ACT, 2009, p.53). The six ACT Interest Inventory scores obtained in high school were used as predictors of academic growth. While interest scores obtained in 7th grade were not used due to high rates of missing data, interests have been shown to be reasonably stable from 7th grade to age 28 for a similar population of academically-advanced students (Lubinski, Benbow, & Ryan, 1995).

Table 2. ACT Interest Inventory Scales

ACT Interest Inventory scale (corresponding Holland type)	Description (ACT, 2009, p. 3)
Science & Technology (Investigative)	Investigating and attempting to understand phenomena in the natural sciences through reading, research, and discussion.
Arts (Artistic)	Expressing oneself through activities such as painting, designing, singing, dancing, and writing; artistic appreciation of such activities (e.g., listening to music, reading literature).
Social Service (Social)	Helping, enlightening, or serving others through activities such as teaching, counseling, working in service-oriented organizations, and engaging in social/political studies.
Administration and Sales (Enterprising)	Persuading, influencing, directing, or motivating others through activities such as sales, supervision, and aspects of business management.
Business Operations (Conventional)	Developing and/or maintaining accurate and orderly files, records, accounts, etc.; following systematic procedures for performing business activities.
Technical (Realistic)	Working with tools, instruments, and mechanical or electrical equipment. Activities include building, repairing machinery, and raising crops/animals.

2.3.5 Extracurricular activities

Students are also asked which types of extracurricular activities they have participated in during high school. We examined 13 types of extracurricular activities, coded as binary indicators, as predictors of academic growth (see Table 5 for list of activities).

2.3.6 Imputation of missing predictor variables

Student-level predictor data (sociodemographic, high school coursework and GPA, vocational interests, and extracurricular data) is provided voluntarily by students and can be missing. Missing data rates were 22% for family income level, 7% for race/ethnicity, ~0% for gender, 10% for high school GPA, 5-16% for specific high school courses, 14% for the advanced high school coursework indicators, 15% for vocational interest scores, and 12% for extracurricular activities.[5] Parent education level was only collected for students in cohorts of 2011 and later and was missing for 18% of those cases.

To avoid potential bias from using listwise deletion (excluding from analyses all students with any missing data), we used multiple imputation (Berglund, 2010) for the predictor variables. In addition to all predictor variables, the ACT test scores were used to inform the imputation. The analysis results are based on single imputed data set, and additional analyses were conducted to ensure that results were consistent across multiple imputed data sets.

Other data used to identify special student subgroups (disability status and whether English is the primary language spoken in the home) had much higher rates of missingness. We

[5] Students who provided a Yes/No response to any extracurricular items are counted as not missing. Students may treat the extracurricular item list as “mark all that apply” instead of answering Yes/No for each item. Therefore, non-response can be interpreted as “No” when students provide at least some responses. The same rule was applied to the advanced high school coursework indicators.

chose not to impute these indicators and did not include them as predictors in multiple regression models.

2.4 Statistical analysis

Linear regression models were fit to address the research questions. For research questions (RQs) 1-4, we describe the corresponding linear regression models in Table 3. For each model, residual gain ACT Composite score is the dependent variable. For each research question, we list the subgroups and cohorts for which the model is fit and the predictor variables used.

Table 3. Regression Model Specifications for Addressing Research Questions 1-4

Research question (RQ)	Groups and Cohorts	Predictor variable(s)
1. Is growth in academic achievement from 7th to 11th/12th grade improving among academically advanced youth in the last two decades?	Total group Cohorts 1996-2016, 1996-2004, 2005-2016	Cohort year used as a categorical variable and the per-year change is estimated through a linear contrast of the cohort year means.
2. Is growth in academic achievement from 7th to 11th/12th grade improving among academically advanced youth within special subgroups of interest?	By subgroup (male, African American, Hispanic, Low-income, with disability, and non-English speaking home) Cohorts 1996-2016, 1996-2004, 2005-2016	
3. Is variation in academic growth among academically advanced youth explained by sociodemographics, high school characteristics, coursework taken, GPA, Holland-type vocational interests, or extracurriculars?	Total group Cohorts 1996-2016	Sociodemographics, high school characteristics, coursework, GPA, Holland-type vocational interests, extracurriculars
4. To what extent have predictors of academic growth among academically advanced youth changed over the last two decades?	Total group Cohorts 1996-2000, 2012-2016	

Preliminary analyses of trends in growth from 1996-2016 (RQ1 and RQ2) showed an increasing trend for the period from 2005 to 2016. Therefore, we fit the trend models for three periods of interest: 1996-2016, 1996-2004, and 2005-2016. For RQ3 and RQ4, multiple regression is used to relate the full set of predictor variables to academic growth. The model is fit across all cohorts (1996-2016) to address RQ3. For RQ4, the model is fit for the five earliest cohorts (1996-2000) and the five most recent cohorts (2012-2016), and the results are contrasted.

Predictors associated with cohort year can potentially help explain trends in academic growth among academically-advanced youth. For example, if more students are taking advanced mathematics courses over time, and taking advanced mathematics courses is associated with higher academic growth, then we might expect academic growth to improve over time. Research question 5 (*If growth in academic achievement from 7th to 11th/12th grade has changed among academically-advanced youth in the last two decades, can the change be explained by predictor trend*s?) was addressed by including cohort year in the full regression model. If the cohort year coefficient is near 0, then there is evidence that the other predictors explain the growth trend.

We also examined how each predictor trended over time and whether those trends impacted the growth trend. To do this, we first regressed each predictor variable on cohort year to estimate the mean change in the predictor over the 21 year period. Cohort year was treated as a categorical variable, and the mean change in the predictor is estimated through a linear contrast of the cohort year means. The impact of the predictor trend on the academic growth trend was then estimated by multiplying the mean change in the predictor by the predictor's regression coefficient from the total group model for RQ3. For example, if the mean of a predictor X changes by 0.25 units over the 21 year period and the regression coefficient for X (relating X to academic growth) is 0.06, then we would expect academic growth to increase by 0.015 units (0.25*0.06) over the 21 year period, all other factors equal.

Research questions 3, 4, and 5 involve interpretation of several regression coefficients. To facilitate these interpretations, the continuous variables (residual gain ACT Composite score, school class size, high school GPA, and Holland-type vocational interests) were standardized to have mean 0 and standard deviation 1. All categorical variables (school type, school locale, race/ethnicity, income level, parent education level, elective and advanced coursework, and extracurricular activities) were dummy-coded.

3. RESULTS

We now present results informing each research question.

3.1 *Is growth in academic achievement from 7th to 11th/12th grade improving among academically-advanced youth in the last two decades?*

To address this question, we first plotted the mean growth scores (residual gain ACT Composite scores) by cohort year (Figure 2). By definition, the mean growth score is 0 in the total group. There was a general downward trend in growth from 1996 to 2005, and the mean growth score was at its lowest point (-0.59) for the 2003 cohort. From 2005 to 2016, there was a consistent upward trend in growth, and the mean score was at its highest point (0.55) for the 2016 cohort. Because the trend was different for 1996-2004 and 2005-2016, we conducted three separate trend tests: 1996-2016 (entire study period), 1996-2004 (early period of the downward trend), and 2005-2016 (later period of the upward trend).

Over the entire study period, mean growth from 7th to 11th/12th grade improved by 0.035 units per year for academically-advanced youth (Table 4, $p < 0.001$). This translates to 0.70 (0.035*20) ACT Composite score points over the 21-year period. The standard deviation of ACT Composite scores among all ACT-tested high school graduates is 5.6 (ACT, 2016), so this improvement has an effect size of about 0.13 (0.70/5.6). For the later period (2005-2016), mean growth improved by 0.072 units per year and for the earlier period (1996-2004), mean growth decreased by 0.052 units per year. The results suggest that academic growth from 7th to 11th/12th grade among academically-advanced youth has improved over the past two decades, with the improvement occurring over the last 12 years. The average gain in ACT Composite score from grade 7 to grade 11/12 was 9 points, about 2 points per academic year. Therefore, the improvement of 0.70 ACT Composite score points over the 21 year period is comparable to students in 2016 having received an extra 0.35 year of instruction, relative to students in 1996.[6]

Table 4. Testing for Trends in Academic Growth Among Academically-Advanced Students, by Subgroup

Subgroup	N	Trend tests					
		1996-2016		1996-2004		2005-2016	
		β	SE	β	SE	β	SE
Total group	460,033	*0.035	0.001	*-0.052	0.003	*0.072	0.001
Male	229,056	*0.037	0.001	*-0.063	0.004	*0.075	0.002
African American	19,521	*0.017	0.004	-0.030	0.015	*0.064	0.007
Hispanic	17,715	0.007	0.005	*-0.119	0.018	*0.045	0.008
Low income	67,653	0.002	0.002	*-0.028	0.007	*0.022	0.004
Student with disability	12,280	*0.033	0.005	*-0.077	0.017	*0.087	0.010
Non-English speaking home	7,284	0.007	0.008	-0.009	0.031	*0.045	0.013

[6] Calculated as 0.70 / 2.00.

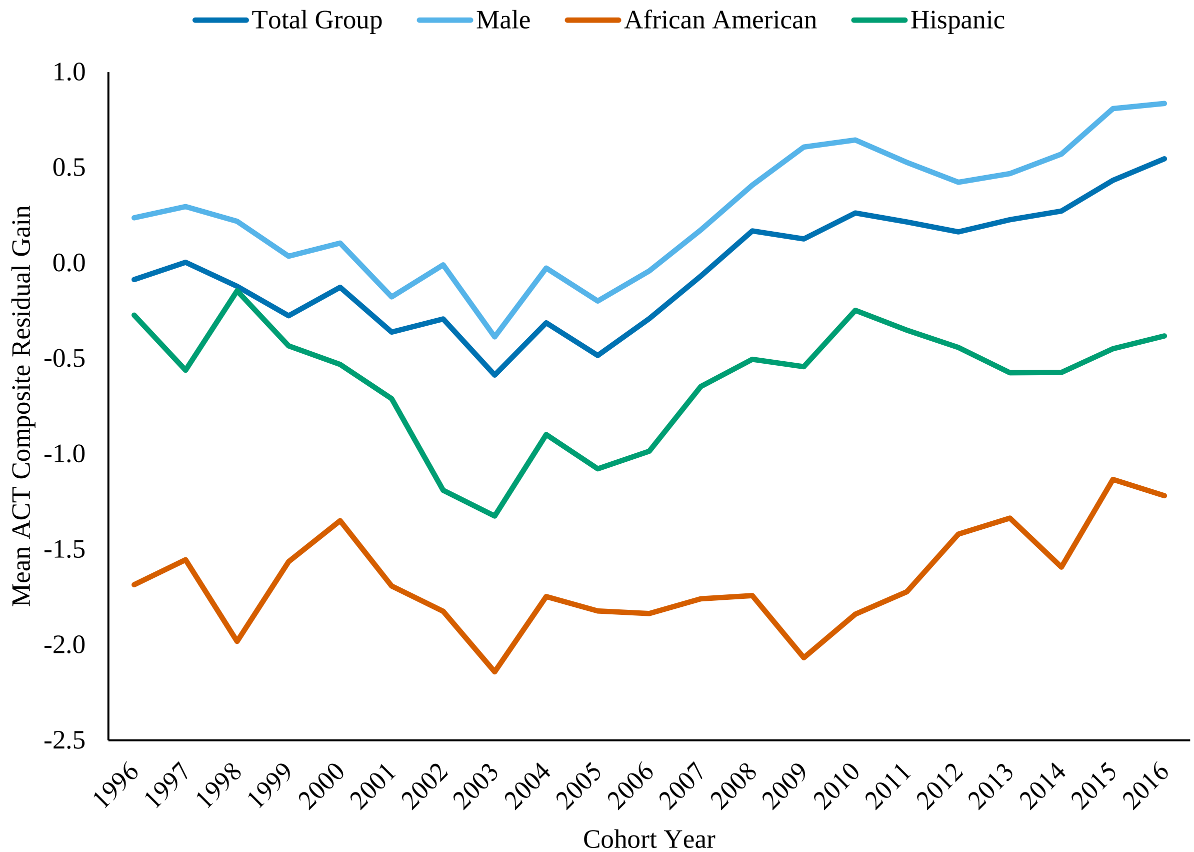

Figure 2. Mean ACT Composite residual gain scores for total group, gender, and racial/ethnic subgroups, by cohort

3.2 *Is growth in academic achievement from 7th to 11th/12th grade improving among academically-advanced youth within special subgroups of interest?*

To address this question, the growth trends were examined separately for the following student subgroups: male, African American, and Hispanic (Figure 2); and low-income students, students with disabilities (SWD), and students from non-English speaking homes (Figure 3). From 1996-2016, significant improvement in growth was observed for males, African Americans, and students with disabilities, but not for Hispanic, low-income, and students from non-English speaking homes (Table 4). Relative to the total group, the improvement in growth was less pronounced for African American students. The improvement for males and students with disabilities was very similar to the total group improvement. Each subgroup showed more improvement during the later time period (2005-2006) relative to the earlier time period (1996-2004). The largest differential was observed for Hispanic students and students with disabilities.

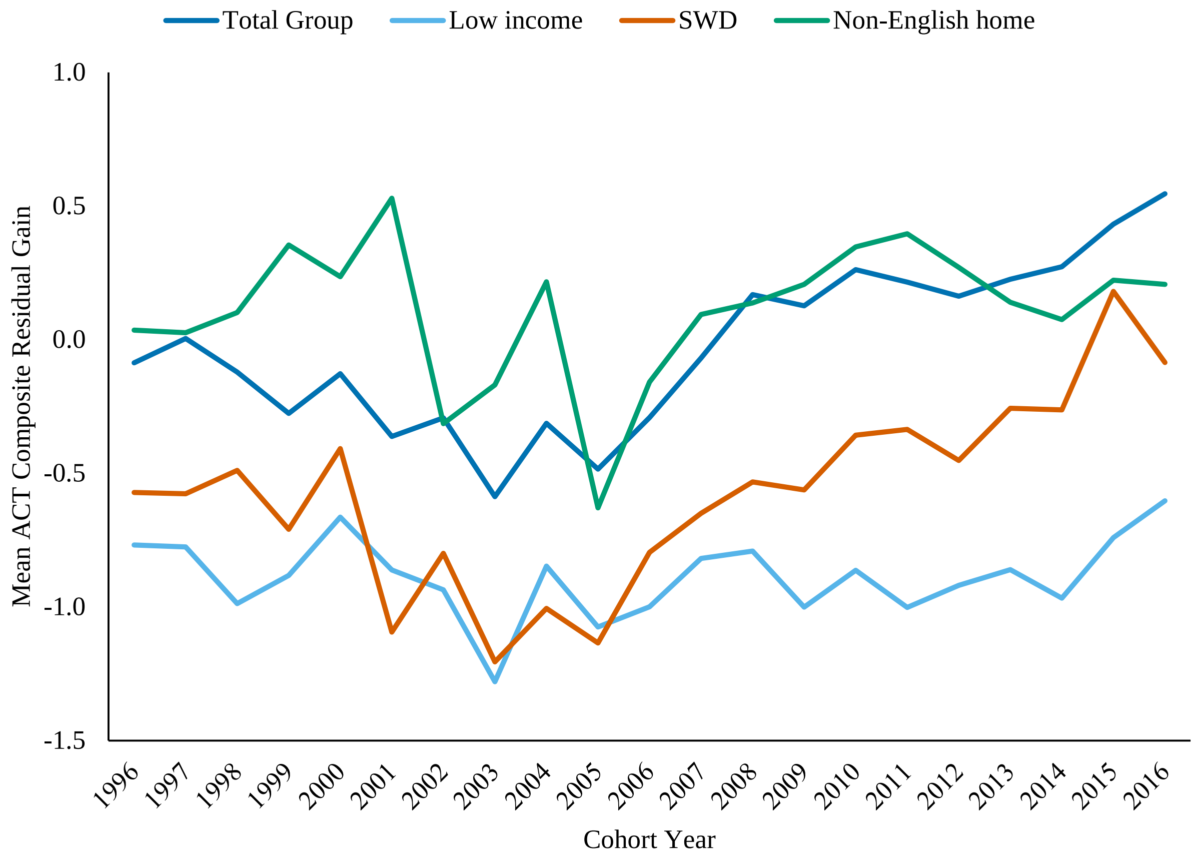

Figure 3. Mean ACT Composite residual gain scores for total group and other student subgroups, by cohort

Note: SWD = students with disabilities. Low-income = students who reported a household income of <75% of median. Non-English home = students who reported that English is not the primary language spoken in the home.

3.3 *Is variation in academic growth among academically-advanced youth explained by sociodemographics, high school characteristics, coursework taken, GPA, Holland-type vocational interests, or extracurriculars?*

Linear regression was used to relate the full set of predictors to the measure of academic growth using the total sample and all cohorts of students (see Table 5, results for all cohorts). Due to the large sample size, most predictors were statistically significant, even if the regression coefficient was very small. We consider effects of 0.05 and larger as most worthy of discussion. Overall, the model explained 22% of the variance in academic growth (*Multiple R* = 0.464). The dependent variable (residual gain ACT Composite score) is a function of ACT Composite scores with known standard error of measurement, and we estimate that an upper bound for the model R^2 is 77%. Therefore, the model explained 29% of the explainable variance in academic growth.

Relative to White students, African American (β=-0.377), Hispanic (β=-0.198), and students of other minority groups (β = -0.069) had lower academic growth. Low-income (β=-0.172) and middle-income (β=-0.092) students had lower growth than high-income students, and males (β=0.249) had higher growth than females. Because the growth score was standardized, males had higher average growth by 0.249 SD units, and this corresponds to a difference of about 0.67 points on the ACT Composite score scale.

Relative to students attending low-poverty public high schools, students attending Catholic (β=0.122) and private (β=0.066) schools had more growth. Lower growth was observed in public schools with higher poverty concentrations. Relative to low-poverty public high schools, growth was 0.397 SD lower at high-poverty public schools. Lower growth was also observed for homeschooled students (β=-0.256). Relative to students attending school in cities, students attending school in rural (β=-0.083) and town (β=-0.058) locales had lower growth. Higher high school GPA was related to higher growth (β=0.226).

The elective high school course with the strongest positive relationships with academic growth was beginning calculus (β=0.134), followed by trigonometry, chemistry, physics, other advanced math, and other foreign language. Social studies courses (geography, psychology, economics, and other history) and courses in the arts had negative relationships. Students taking advanced coursework (AP, accelerated, or honors courses) had significantly higher growth. The effect was strongest for advanced mathematics (β=0.109), followed by social studies (β=0.090), and natural sciences (β=0.062).

Higher Science and Technology vocational interest scores (corresponding to the *Investigative* personality type) were related to higher growth (β=0.078), as were higher Business Operations scores (*Conventional* personality type) (β=0.043). Higher Technical scores (*Realistic* personality type) (β=-0.040) were related to lower growth.

Relative to the other predictors, extracurricular activities were not as predictive of academic growth. Activities positively related to academic growth included school or community service organizations (β=0.051), instrumental music, and debate. Activities negatively related to academic growth included fraternity, sorority, or other social clubs (β=-0.066), radio/TV (β=-0.059), and varsity athletics (β=-0.049).

Table 5. Predictors of Academic Growth

Variable	All cohorts (1996-2016)		Early cohorts (1996-2000)		Recent cohorts (2012-2016)	
	β	SE	β	SE	β	SE
Intercept	*-0.344	0.009	*-0.397	0.019	*-0.199	0.019
School type						
Catholic	*0.122	0.006	*0.085	0.013	*0.057	0.011
Home	*-0.256	0.025	-0.205	0.107	*-0.359	0.036
Private	*0.066	0.006	0.008	0.014	0.017	0.012
Other	0.031	0.013	0.006	0.031	*-0.086	0.022
#Public, <20% FRL						
Public, 20-40% FRL	*-0.064	0.004	*-0.060	0.008	*-0.132	0.008
Public, 40-60% FRL	*-0.158	0.004	*-0.157	0.010	*-0.251	0.009
Public, 60-80% FRL	*-0.256	0.007	*-0.225	0.016	*-0.350	0.012
Public, >80% FRL	*-0.397	0.013	*-0.324	0.030	*-0.519	0.023
School locale						
Rural	*-0.083	0.004	*-0.041	0.009	*-0.156	0.009
Town	*-0.058	0.004	*-0.029	0.010	*-0.085	0.009
Suburban	*-0.017	0.004	-0.003	0.009	*-0.036	0.006
#City						
School class size	*0.040	0.002	*0.029	0.004	*0.033	0.003
Race/ethnicity						
African American	*-0.377	0.007	*-0.364	0.018	*-0.387	0.012
Asian	*0.041	0.008	0.021	0.023	0.022	0.013
Hispanic	*-0.198	0.007	*-0.106	0.022	*-0.207	0.011
Other	*-0.069	0.009	-0.060	0.025	*-0.089	0.013
#White						
Family income						
Low	*-0.172	0.004	*-0.153	0.009	*-0.145	0.008
Middle	*-0.092	0.003	*-0.079	0.007	*-0.080	0.007
#High						
Parent education						
High school or less					*-0.182	0.011
Some college					*-0.115	0.007
#Bachelor’s or higher						
Male gender	*0.249	0.003	*0.247	0.007	*0.245	0.006
High school GPA	*0.226	0.002	*0.214	0.003	*0.237	0.003
High school courses						
Speech	*-0.047	0.003	-0.002	0.006	*-0.033	0.007
Trigonometry	*0.121	0.003	*0.144	0.007	*0.113	0.005
Other advanced math	*0.056	0.003	*0.056	0.006	*0.033	0.005
Beginning calculus	*0.134	0.003	*0.150	0.007	*0.105	0.006
Computer science	0.000	0.003	0.010	0.007	-0.003	0.007
Psychology	*-0.017	0.003	*-0.042	0.007	-0.004	0.006

Variable	All cohorts (1996-2016)		Early cohorts (1996-2000)		Recent cohorts (2012-2016)	
	β	SE	β	SE	β	SE
Geography	*-0.067	0.003	*-0.048	0.006	*-0.056	0.005
Economics	*-0.054	0.003	*-0.038	0.006	*-0.042	0.005
Other History	*-0.015	0.003	*-0.026	0.006	-0.010	0.005
Chemistry	*0.118	0.005	*0.131	0.011	*0.100	0.011
Physics	*0.095	0.003	*0.120	0.006	*0.067	0.005
Spanish	*-0.051	0.004	*-0.036	0.009	*-0.037	0.009
French	*-0.025	0.005	-0.008	0.009	0.001	0.010
German	-0.002	0.006	0.026	0.012	0.022	0.013
Other foreign language	*0.039	0.005	*0.059	0.011	*0.034	0.009
Art	*-0.035	0.003	*-0.040	0.006	*-0.023	0.005
Drama	*-0.031	0.004	*-0.033	0.009	*-0.019	0.007
Music	*-0.010	0.004	-0.012	0.009	0.003	0.007
AP/accelerated/honors courses						
English	*0.013	0.004	0.000	0.008	*0.033	0.008
Mathematics	*0.109	0.004	*0.095	0.008	*0.134	0.008
Social studies	*0.090	0.003	*0.069	0.007	*0.077	0.007
Natural sciences	*0.062	0.003	*0.027	0.007	*0.081	0.007
Foreign language	*0.038	0.003	0.018	0.007	*0.038	0.006
ACT Interest Inventory scores						
Science & Technology	*0.078	0.001	*0.065	0.003	*0.074	0.003
Arts	*0.022	0.002	*0.034	0.004	*0.015	0.003
Social Service	*-0.025	0.002	*-0.027	0.004	*-0.029	0.004
Administration and Sales	*-0.029	0.002	*-0.025	0.004	*-0.016	0.004
Business Operations	*0.043	0.002	*0.035	0.004	*0.040	0.003
Technical	*-0.040	0.002	*-0.026	0.004	*-0.043	0.003
Extracurricular activities						
Instrumental music	*0.038	0.004	*0.035	0.008	*0.031	0.007
Vocal music	*-0.019	0.004	-0.006	0.008	*-0.033	0.008
Student government	-0.001	0.003	-0.006	0.007	0.013	0.006
Publications	*-0.014	0.003	0.001	0.007	*-0.020	0.007
Debate	*0.034	0.005	0.022	0.010	0.017	0.008
Dramatics, theater	*0.023	0.004	*0.040	0.008	0.002	0.007
Religious organizations	*0.021	0.003	*0.030	0.006	0.005	0.006
Racial or ethnic organizations	*0.029	0.007	0.017	0.017	*0.046	0.013
Varsity athletics	*-0.049	0.003	*-0.047	0.006	*-0.063	0.006
Political organizations	0.012	0.005	-0.023	0.011	*0.036	0.010
Radio-TV	*-0.059	0.006	*-0.046	0.013	*-0.054	0.013
Fraternity, sorority, other social clubs	*-0.066	0.004	*-0.096	0.009	*-0.048	0.007
School or community service org.	*0.051	0.003	*0.048	0.007	*0.058	0.006
Model Multiple R	0.464		0.456		0.471	

[#] Indicates reference group, *p<0.01. FRL = free or reduced lunch.

3.4 *To what extent have predictors of academic growth among academically-advanced youth changed over the last two decades?*

By addressing RQ3, we found that several variables were predictive of academic growth among academically-advanced youth over the entire study period (1996-2016). However, it is possible that the prediction model has shifted over the 21 year period and some predictors have become more (or less) important over time. We fit the regression model for the five earliest cohorts (1996-2000) and the five most recent cohorts (2012-2016) and contrasted the results. We consider predictors whose regression coefficients changed by 0.05 or more as most worthy of discussion.

The regression results are presented in Table 5 for the early and recent cohorts. The early-cohorts model accounted for 27% of the explainable variance in academic growth while the recent-cohorts model explained 29%. The negative relationship of homeschooling and academic growth became more pronounced over time (β=-0.205 for early cohorts vs. -0.359 for recent cohorts). Similarly, the negative effect of higher school poverty concentration became more pronounced over time. For example, the difference between the highest and lowest public school poverty levels was 0.519 SD for the recent cohorts but only 0.324 SD for the early cohorts. Negative effects of rural and town school locales also became more pronounced over time.

The negative relationship of Hispanic ethnicity and academic growth became more pronounced over time (β=-0.106 for early cohorts vs. -0.207 for recent cohorts). Positive effects of beginning calculus and physics courses decreased over time. Positive effects of advanced courses increased over time, particularly for mathematics, natural sciences, and English.

For the recent cohorts (2011-2016), we examined the relationship of parent education level and academic growth, as such data was collected only for these cohorts. Relative to students whose parent had a bachelor's degree or higher, those whose parents did not attend college (β=-0.182) or who had some college less than a bachelor's degree (β=-0.115) had lower growth.

3.5 *If growth in academic achievement from 7th to 11th/12th grade has changed among academically-advanced youth in the last two decades, can the change be explained by predictor trends?*

The final set of analyses examined the extent that predictor trends explain the improving growth trend. Earlier (RQ1), we found that the growth score (residual gain ACT Composite score) increased by 0.035 units per year over the 21-year period. After accounting for the model predictors (e.g., fitting a model with cohort year and the full set of predictors), we found that the growth score increased by 0.018 units per year. Therefore, the model's predictors (Table 5) explain part, but not all, of the improvement in growth.

Several predictors had significant trends over time (Table 6). For example, the proportion of students attending rural schools decreased by 0.176, while the proportion of students attending suburban schools increased by 0.145. School class size increased over time, but this is likely due to the increasing number of secondary school students in the US (WICHE, 2016).

The *impact* of predictor trends on academic growth trend was estimated by multiplying the change in the predictor (δ from Table 6) by the predictor's effect on estimated growth (β from Table 5). Predictors with impacts of magnitude 0.01 and larger are discussed (see "Impact" column of Table 6). More students attending public schools with higher poverty concentrations had a negative impact on the growth trend, while the decrease in students attending rural schools had a positive impact (because attending rural schools was associated with lower growth).

Greater representation of African American and Hispanic students had a negative impact on the growth trend.

Higher high school GPAs over time had a rather large impact on the academic growth trend, and more males over time had a positive impact. Fewer students taking speech courses had a positive impact on the growth trend, and fewer students taking trigonometry had a positive impact. There were large shifts in the proportion of students taking advanced courses (Figure 4), and this had a large impact on the growth trend, particularly for mathematics, natural sciences, and social studies. Finally, students had higher Science and Technology (*Investigative*) scores over time (by 0.405 SD), contributing to the improving growth trend. Trends in extracurricular activities were significant but did not impact the academic growth trend because of the weak relationship of extracurriculars and academic growth.

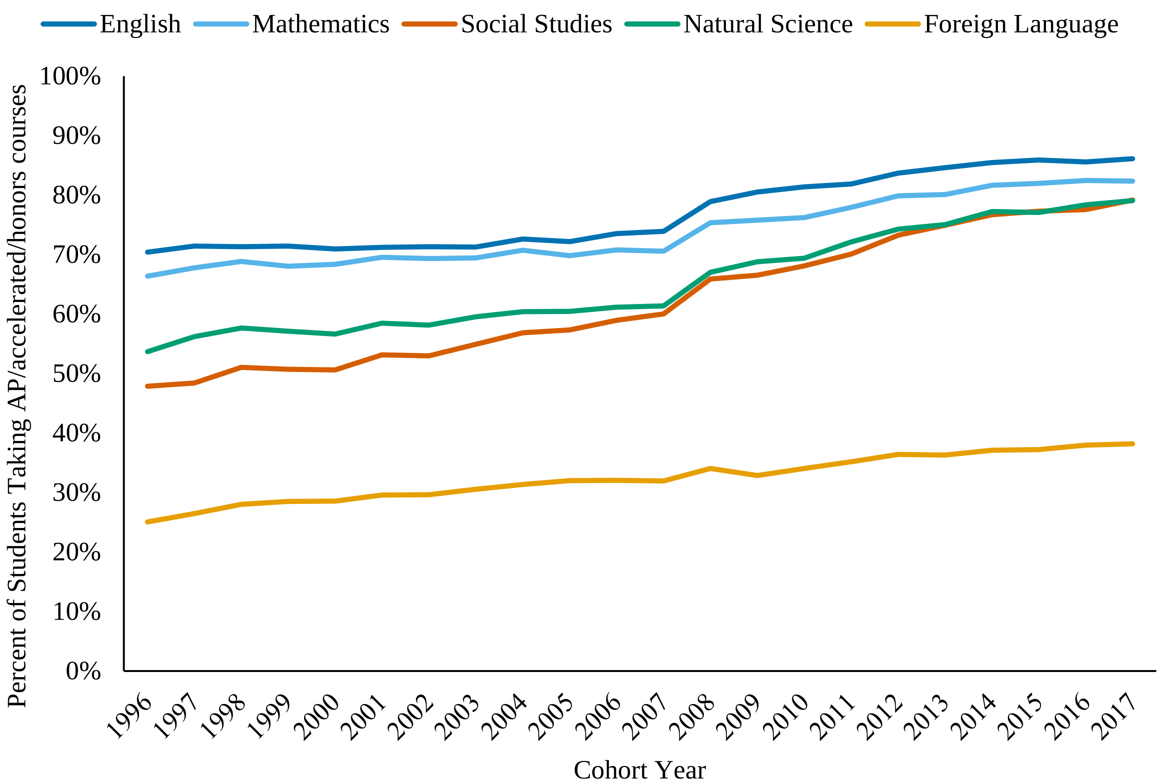

Figure 4. Percentage of students taking AP/accelerated/honors courses, by cohort

Table 6. Predictor Trends and Impact on Academic Growth

Variable	δ	SE	Impact
School type			
Catholic	*0.030	0.001	0.004
Home	*0.005	0.000	-0.001
Private	*0.050	0.001	0.003
Other	*0.006	0.001	0.000
#Public, <20% FRL			
Public, 20-40% FRL	-0.003	0.002	0.000
Public, 40-60% FRL	*0.137	0.002	**-0.022**
Public, 60-80% FRL	*0.050	0.001	**-0.013**
Public, >80% FRL	*0.004	0.001	-0.002
School locale			
Rural	*-0.176	0.002	**0.015**
Town	*-0.070	0.002	0.004
Suburban	*0.145	0.002	-0.002
#City			
School class size	*0.360	0.005	**0.014**
Race/ethnicity			
African American	*0.034	0.001	**-0.013**
Asian	*0.033	0.001	0.001
Hispanic	*0.060	0.001	**-0.012**
Other	*0.029	0.001	-0.002
#White			
Family income			
Low	-0.002	0.002	0.000
Middle	*-0.091	0.002	0.008
#High			
Male gender	*0.039	0.003	**0.010**
High school GPA	*0.201	0.005	**0.045**
High school courses			
Speech	*-0.312	0.002	**0.015**
Trigonometry	*-0.097	0.003	**-0.012**
Other advanced math	*0.104	0.003	0.006
Beginning calculus	*0.072	0.002	**0.010**
Computer science	*-0.067	0.002	0.000
Psychology	*0.035	0.002	-0.001
Geography	*-0.029	0.003	0.002
Economics	*0.041	0.002	-0.002
Other History	*-0.030	0.002	0.000
Chemistry	*0.030	0.001	0.004
Physics	*0.069	0.003	0.007
Spanish	*0.095	0.002	-0.005
French	*-0.130	0.002	0.003

Variable	δ	SE	Impact
German	*-0.050	0.001	0.000
Other foreign language	*0.025	0.002	0.001
Art	*0.108	0.003	-0.004
Drama	0.004	0.002	0.000
Music	*-0.078	0.003	0.001
AP/accelerated/honors courses			
English	*0.178	0.002	0.002
Mathematics	*0.164	0.002	**0.018**
Social studies	*0.326	0.002	**0.029**
Natural sciences	*0.252	0.002	**0.016**
Foreign language	*0.117	0.002	0.004
ACT Interest Inventory scores			
Science & Technology	*0.405	0.005	**0.032**
Arts	*-0.147	0.005	-0.003
Social Service	*-0.019	0.005	0.000
Administration and Sales	*-0.137	0.005	0.004
Business Operations	*0.043	0.005	0.002
Technical	*0.065	0.005	-0.003
Extracurricular activities			
Instrumental music	*-0.045	0.002	-0.002
Vocal music	*-0.075	0.002	0.001
Student government	*-0.080	0.002	0.000
Publications	*-0.150	0.002	0.002
Debate	*0.016	0.002	0.001
Dramatics, theater	*-0.094	0.002	-0.002
Religious organizations	*-0.034	0.003	-0.001
Racial or ethnic organizations	*0.013	0.001	0.000
Varsity athletics	*0.028	0.003	-0.001
Political organizations	*-0.012	0.001	0.000
Radio-TV	*-0.017	0.001	0.001
Fraternity, sorority, other social clubs	*0.054	0.002	-0.004
School or community service org.	*0.087	0.002	0.004

[#] Indicates reference group, *p<0.01. FRL = free or reduced lunch.

4. DISCUSSION

4.1 Academic growth has increased among academically-advanced youth in the last 12 years

Academically-advanced students showed a decline in growth from 1996 to 2004 but since 2005 have been on an upward trajectory, with the highest growth occurring in 2016. The level of improvement in academic growth is comparable to students in 2016 having received an extra 0.35 years of school over what students in 1996 had. First, this shows that the pattern of academic growth in this population is not static. It is possible that societal factors, such as changes in education policy or funding, may have had an impact on the growth of academically-advanced students. Some scholars (e.g. Gallagher, 2004; Gentry, 2006) have suggested that No Child Left Behind (NCLB), first implemented in 2002, may have had a negative impact on academically-advanced students in particular given the focus on less academically-advanced students generally. However, given that NCLB was implemented just before the rise in growth starting in 2005, it is possible it had a positive impact or potentially no impact, but not a negative impact on academically-advanced students as a whole. Additionally, Benbow and Stanley (1996) noted that government K-12 gifted education funding was 0.0002% of the education budget, and Wai and Worrell (2016) showed that this had remained unchanged two decades later. This suggests that although funding did not improve, academic growth did, starting in 2005, suggesting that funding is not the only cause of improved growth. Additionally, our discussion of RQ5 illustrates some predictor trends (e.g., higher grades, more AP and honors courses, and lower rural enrollment) that help explain the improvement in growth that may be unrelated to policies such as NCLB. There may have been other education policies enacted that negatively or positively impacted gifted students.

Overall, the variables included in the model—sociodemographic variables, high school characteristics, high school coursework and GPA, advanced high school coursework, vocational interests, and extracurricular activities—accounted for 29% of the explainable variance in academic growth. There are individual differences in academic growth that are not explained by the model. Aspects of cognitive development, mental health, motivation, home environment, and parental influence are examples of constructs that were not directly measured by our study but may impact academic growth. Quality and intensity of instruction, relationships with school personnel, school safety climate, and peer interactions are examples of school contextual effects also not directly measured but plausibly related to the academic growth of academically-advanced students.

4.2 Academic growth has not uniformly increased across all subgroups of interest

Whereas academically-advanced students overall increased in academic growth, not all subgroups of interest showed similar levels of improvement. Here we discuss the trends within each class of variables used to investigate what is related to academic growth and improvement over the last 21 years.

4.2.1 Sociodemographic variables and high school characteristics: Disadvantaged students have shown lower growth and less improvement over time

Type of school. Catholic and private high schools tended to have the highest growth, followed by low poverty public high schools, homeschooling, and finally high poverty public schools (> 60% receiving free or reduced lunch). This suggests that broadly, at least for academically-advanced students, Catholic and private schools are schooling environments that outperform public schools that outperform homeschooling. Some research on general population students has documented positive Catholic school effects (e.g. Wenglinsky, 2007; West &

Woessmann, 2010). Much research for students in the general population suggests that students in private schools have higher achievement than students in public schools, even after controlling for multiple student and school characteristics (e.g., Braun, Jenkins, & Grigg, 2006; Coleman, Hoffer, & Kilgore, 1982; Petersen & Llaudet, 2006), though some scholars have noted the differential effects of public and private schools are unclear (e.g., Wenglinsky, 2007), with other scholars documenting advantages of public schools (e.g., Lubienski & Lubienski, 2013). Our analysis shows that, for whatever reason, academically-advanced students in Catholic and private schools tend to have higher growth than their public school counterparts. Perhaps due to lower-gifted education funding for public education (Benbow & Stanley, 1996; Wai & Worrell, 2016), such public educational programming is not as impactful in increasing academic growth or talent development due to a primary focus on the needs of average or below-average students. Similar to private and public school debates, there is disagreement on how homeschooling overall impacts general population students (e.g., Jones & Gloeckner, 2004; Rudner, 1999; Kunzman & Gaither, 2013; Snyder, 2013; Welner & Welner, 1999). The finding that academically-advanced students who attend high school at home showed lower growth may be due to such environments not being as consistent or standardized as other environments, or perhaps students with medical problems that impact academic growth are more likely to be homeschooled. Of course, it is important to note that there is great variability across each of these schooling environments and these conclusions are based on averages across these types of schools.

Students with disabilities showed improvement. While students with disabilities demonstrated less growth than the total group, they showed the most improvement in growth from 2005-2016. It is possible that the improvement is partly explained by changes in procedures allowing special testing accommodations over the 12 year period. While the growth measure controlled for whether students received special testing accommodations, the specific nature of the accommodations may have changed over time. The lower growth from grade 7 to grade 11/12 among students with disabilities is consistent with suggestions that gifted students who also have disabilities, often known as "twice exceptional," are not receiving adequate attention in terms of academic growth (Assouline & Whiteman, 2011; Brody & Mills, 1997; Reis, Baum, & Burke, 2014). However, over time they have closed the gap significantly with the total group.

Groups with relatively high growth. Relative to the general population, Asians were underrepresented and Whites overrepresented in the study sample. Asians showed higher academic growth than Whites. Males had higher growth than females, suggesting that for whatever reason, talent development opportunities or potential barriers may still be impacting academically-advanced females.

Groups with less improvement in growth. Additionally, there was less pronounced growth for Hispanics and African Americans. African American students showed improved growth over the study period, but not to the same degree as other groups. This suggests that talent development opportunities or potential barriers may still be impacting academically-advanced underrepresented minorities. The group of students from non-English speaking homes demonstrated academic growth similar to the total group but saw no improvement in growth over the 21 year period. Some scholars have suggested that gifted students with limited English proficiency tend to be underserved educationally (e.g. Bernal, 2001), so similar growth to the broader cohort does not directly align with this literature and perception. In our sample of students from non-English speaking homes, 39% were Hispanic, 36% were Asian, and 21% were White; other studies may have had larger shares of underserved Hispanic students.

Low-income students demonstrated lower growth relative to the total group, and no improvement in growth over the 21 year study period. This aligns with the literature indicating that gifted low-income students are disadvantaged and losing ground compared to their advantaged counterparts (e.g., Loveless, 2016; Plucker & Peters, 2016; Wyner, Bridgeland, & DiIulio, 2007). Students who do not have a parent with a bachelor's degree or higher tended to have lower growth. This collectively suggests that there are widening gaps between the more-advantaged and less-advantaged academically-advanced students when it comes to academic growth (Plucker & Peters, 2016; Wai & Worrell, 2016), which likely has long-term implications not only for college admissions and readiness (Bastedo & Jaquette, 2011), but also long-term educational and occupational achievement among high level careers.

4.2.2 Elective high school coursework and grade point average (GPA): STEM courses are associated with higher academic growth

The types of courses students elect to take are in part a reflection of their personal interests as well as availability and may serve as an intermediate form of advanced coursework or educational enrichment. The finding that higher growth was associated largely with STEM courses (physics, trigonometry, chemistry, beginning calculus) suggests that STEM coursework improves academic growth. Overall, students with a higher high school GPA also had higher growth. This could be due to students being more serious about the grades they earn, indicating a stronger work ethic. It could also be that both higher GPA and higher growth are caused by other similar sets of factors. This links with research suggesting that high school GPA is a positive predictor of college performance broadly (Kobrin et al., 2008; Sackett, Kuncel, Beatty, Rigdon, Shen, & Kiger, 2012) and other research showing positive effects of grades on ACT score growth in typical high school students (Sawyer, 2008).

4.2.3 Advanced high school coursework

Overall, students who indicated they took advanced coursework (AP, accelerated, or honors courses) had significantly higher academic growth. This was strongest for advanced mathematics, social studies, and natural sciences, again suggesting that STEM coursework is associated with enhanced academic growth, and links with research findings showing that a high dosage of K-12 STEM coursework is predictive of long-term STEM outcomes (Wai, Lubinski, Benbow, & Steiger, 2010). These findings also align with a large body of research literature supporting academic acceleration and enrichment as effective interventions for academically-advanced students (Assouline, Colangelo, VanTassel-Baska, & Lupkowski-Shoplik, 2015; Hertzog & Chung, 2015; Schiel, 1998; Steenbergen-Hu, Makel, & Olszewski-Kubilius, 2016).

4.2.4 Vocational interests

Academically-advanced students who had higher Investigative and Conventional scores, which indicate an interest in understanding natural phenomena in the natural sciences and being organized and following procedures, respectively, had higher academic growth. In contrast, students who had higher Realistic scores, those with more hands-on mechanical and spatial interests, had lower academic growth, which may be explained in part by the fact that the ACT includes primarily math and verbal but not spatial measures, meaning such growth, if present, would not be captured. It appears that having more STEM-related interests coupled with organization and procedural interests is related to academic growth broadly.

4.2.5 Extracurricular activities

Overall, extracurricular activities were not as predictive of academic growth as the other groups of variables included in the model, suggesting that what students do outside of school does not have much of a collective impact on academic development. Research generally has found positive associations between extracurricular activity participation and academic achievement (Broh, 2002; Cooper, Valentine, Nye, & Lindsay, 1999; Marsh & Kleitman, 2002). In this study, participating in school or community service organizations, instrumental music, debate, and racial or ethnic organizations was related to higher academic growth. Perhaps participating in community service or racial/ethnic organizations shows values of service and diversity which may be linked to growth generally. The practice of debate may be linked to academic growth, in part, due to learning to construct logical arguments. The finding that participating in social clubs, radio/TV, and varsity athletics was negatively related to academic growth suggests that too much involvement in non-academic activities (perhaps at the expense of academic activities) may lower academic growth. Though there was no category in our analysis to detect the impact of screen time on academic growth, the association between radio/TV and academic growth suggests too much screen time could be of concern. More broadly, it suggests that how academically-talented students allocate their time is of potential importance (e.g., Makel, Wai, Putallaz, & Malone, 2015), and though extracurriculars overall were not impactful on academic growth, it is possible they might have an impact on non-cognitive skills or other forms of development (e.g., Heckman, Stixrud & Urzua, 2006) for talented students.

4.3 Which predictors of academic growth have become more important over time?

The prior section discussed which variables have predicted academic growth overall. But have there been changes over the last 21 years in which variables predict growth and what was the degree to which they predict growth? Overall, there was not much change in the predictive model across time. High school poverty concentration, rural and town school locales, Hispanic ethnicity, and homeschooling were all associated with lower growth, and this became more pronounced over time. Broadly, this suggests that poor students in rural areas of Hispanic ethnicity, even in comparison to disadvantaged students generally, are losing ground in recent years. As for high school coursework, some high school elective STEM coursework, which tended to have a positive relationship to growth, showed decreased effects over time, whereas the positive effects of advanced courses, particularly in mathematics, increased over the 21 year period.

4.4 Which variables had an impact on the academic growth trend across time?

Trends among disadvantaged students. More students attending higher-poverty high schools, and a greater representation of African American and Hispanic students, had a negative impact on the growth trend. However, fewer students attending rural schools over time had a positive impact on the growth trend. On the one hand, the finding that more African American and Hispanic students being identified as academically advanced or gifted is positive; however, their growth is still not being maximized. More academically-talented students attending high-poverty high schools indicates that such schools need funding to help support the academic development of these students. Finally, it appears that academically-advanced students are increasingly not being found in rural environments in recent years, which may reflect general trends of lower rural populations or may suggest that rural students need better access to academic talent identification and development.

Trends in high school electives, advanced coursework, and GPAs. More students taking advanced courses—especially math, natural sciences, and social studies—had a positive impact on the growth trend. Higher high school GPAs over time also had a positive impact on the growth trend. Overall, it appears that STEM coursework, both elective and advanced, has had an important impact on the growth trend. Higher participation in advanced coursework for academically-advanced students appears to be linked to the improved growth in ACT scores from the 7th through 11th/12th grades, further supporting the literature on academic acceleration and enrichment (e.g., Assouline et al., 2015; Steenbergen-Hu et al., 2016), or a higher educational dosage (Wai et al., 2010) for these students.

Trends in interests, a "Holland shift." Higher Investigative vocational interests over time positively impacted the growth trend. This means academically-advanced youth, as a whole, have increased their interests in investigating and attempting to understand phenomena in the natural sciences. Culturally, there has been a large push to enhance interests in STEM (Ceci & Williams, 2010; Halpern, Benbow, Geary, Gur, Hyde, & Gernsbacher, 2007), and perhaps this has increased such interests. Alternatively, perhaps such interests have risen due to academically-advanced students having parents with STEM interests who married each other (e.g., assortative mating: Robinson et al., 2016). Research indicates that interests among general population students (e.g., Su & Rounds, 2015) and academically-advanced students (e.g., Lubinski & Benbow, 2006) have an impact on later STEM achievement. Thus, regardless of why the Holland shift is occurring, it suggests that STEM achievement likely will be higher in the future as more of these students are likely to pursue STEM occupations. In turn, this might contribute to the innovation workforce pipeline, including deep analytical talent needed for data science (e.g., The Networking and Information Technology Research and Development Program and Big Data Senior Steering Group, 2016) and artificial intelligence advancement (e.g., Executive Office of the President, 2016).

4.5 Potential areas for educational intervention based on these findings

We used an exploratory modeling approach including as many variables as possible to potentially uncover factors that predict academic growth that might be leveraged in some capacity through educational interventions. Some of these variables likely have more or less malleability, but we provide in this section some potential directions of educational intervention research and application.

Geographic location and poverty. Broadly, it would seem that providing greater access to programs for advanced youth in rural areas and high poverty high schools would benefit their academic growth. These environments, and perhaps other factors surrounding them, would be worth investigating further.

School type. Future research might seek to uncover what elements of a Catholic and/or private school are causing higher academic growth: is it the quality of education, peer effects, teacher effects, or a combination of these or other factors? If uncovered, replicating elements of such school environments in public schools could be helpful. While homeschools may not be the best environment for academic growth of academically-advanced students, there may be other benefits or ways such educational environments could be improved.

STEM coursework. A thread that ran through this study is the consistent prediction of STEM courses on academic growth broadly. Therefore, STEM education may actually enhance academic growth not just in STEM areas such as math and science, but also overall.

Advanced coursework. A large literature already supports the idea that advanced coursework in the form of academic acceleration and enrichment is impactful for enhancing the talent of academically-advanced students. This study confirms the importance of such interventions and illustrates that advanced coursework may be a ready intervention for students from disadvantaged backgrounds and thus needs to be more widely available and easily accessible.

Investigative and Conventional interests. Investigative and Conventional interests were linked to higher growth; therefore, educational interventions could be designed to enhance such interests in the academically advanced population, and this could potentially improve growth. However, consideration should be given to whether enhancing STEM and organizational-related interests in this population would be at the expense of developing interests in areas such as the arts and social services. Given that interests in this population have changed over time, and such interest shifts are likely to have a long-term impact on later educational and career choice and achievement, it is important to consider what educational aspects schools in particular emphasize.

Extracurriculars. It appears that involvement in social clubs, radio/TV, and varsity athletics was related to lower academic growth, but that involvement in school and community service, instrumental music, debate, and racial or ethnic organizations was related to higher academic growth. Extracurricular choice typically is not made based on consideration of academic benefits but on other considerations (e.g., time, enjoyment, social opportunities, fitness); however, parents and students should be aware that investment of time in one area of development correspondingly means less investment in another, likely impacting areas of differential growth.

Test preparation. Many students and parents are interested in ways to enhance ACT or SAT test scores due to their importance in college admissions. Beyond the importance of basic test familiarity, however, the literature does not support the idea that extensive test preparation programs give significant and/or meaningful gains (Briggs, 2001; Powers & Rock, 1999; Schiel & Valiga, 2014). For example, ACT Composite scores increased by 9 points, on average, from 7th to 11th/12th grade in this study, whereas in prior research, upon retesting with the ACT, Composite scores were 0.6 points higher on average for students who prepared for the second test (outside of normal classroom participation), versus those who did not (Schiel & Valiga, 2014). As this study shows, score growth is likely linked to the cumulative effect of a variety of academic-related interventions over many years, and some of those interventions have now been identified for academically-advanced students.

4.6 Limitations and future research directions

One important limitation is the issue of access to the talent search. Our sample included students who had such access, but it is likely that students who are identified for the talent search this early in their educational trajectories are already select. For example, Table 1 shows that when comparing poverty level of schools, the talent search sample is more financially secure than the general population. This means there are more academically-advanced students at these schools, and/or they are more likely to participate in the talent search. Despite this limitation, our sample sizes were quite large, even across subgroups of interest, suggesting that these findings are likely robust and, because this study includes data from multiple talent search centers, provide important information about gifted students in the US broadly.

The ACT test is only one measure of academic growth, and it could be useful to use other measures of academic growth to examine whether these trends and predictive factors replicate. We examined ACT Composite score, which is the average across mathematics, science, reading, and English. This is an important first step in investigating growth generally, and the study is strengthened by using a highly reliable growth measure at two time points. Future research could look at mathematics and English/Language Arts areas separately, or individual subtests to better understand whether the prediction models vary across subject areas.

We included as many academic, extracurricular, sociodemographic and other potential intervening variables that had the potential to impact academic growth in our model for which we had sufficient samples and made sense to include. However, we did not have information on every impactful variable possible, and much of the variance in academic growth remained unexplained. Despite this limitation, our sample size was quite large—especially for a sample of academically-advanced youth—and of the variables studied, these findings are likely robust.

Although we uncovered important trends across time showing less-pronounced improvement among disadvantaged students broadly, this analysis focused on the factors that predicted growth in the sample as a whole. Future research should be conducted to examine which of these factors explains growth among disadvantaged students to better understand intervention points that could be leveraged to help the talent development of these students.

4.7 Conclusions

We leveraged a unique sample of over 460,000 academically-advanced students over two decades who took the ACT in 7th grade for academic talent searches and again in 11th or 12th grade for college admissions. We took an exploratory analytic approach to examine potential intervening factors that might contribute to such change in development. All variables combined—sociodemographics, interests, high school characteristics, high school coursework and GPA, and extracurriculars—explained 29% of the variance in academic growth. Overall, growth has increased from 2005 to 2016, with the highest growth occurring in 2016. The level of improvement is comparable to students in 2016 having received an extra 0.35 years of school over what students in 1996 had. However, growth for low-income students did not improve over the 21 year period. Students attending Catholic and private schools had the highest growth, whereas homeschooled students and students attending high-poverty public schools showed the lowest. Elective high school courses in STEM areas were associated with higher growth, as were advanced AP, accelerated, or honors courses. Students with Investigative and Conventional interests had higher growth. Variables that had a positive impact on the academic growth trend across time included fewer students in rural areas, more students taking STEM and advanced courses, and an increase in Investigative interests. These findings are likely leverage points for potential educational interventions to improve academic growth among academically-advanced students. Better understanding how to improve academic growth in this population can lead to significant improvements in their personal fulfillment and academic achievement as well as societal innovation and economic growth.

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