Measuring Middle School Achievement Trajectories for College Readiness

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Abstract:
This study identifies students' academic trajectories in the middle grades relative to a set of college readiness benchmarks. We apply math and reading college readiness benchmarks to rich longitudinal data for more than 360,000 students across the nation. Student-level and school-level demographic characteristics significantly predict academic trajectories. Compared to White and Asian students, higher proportions of Black and Hispanic student are always off-track throughout middle school. Among students who started 6th grade on track, being male, Black, Hispanic, and attending schools with a higher percentage of low-income students are positively associated with falling off track.

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Increasing higher education access has long been a mantra of policy advocates. The Every Student Succeeds Act (ESSA, 2015) encourages states to include College and Career Readiness as a measure of school accountability. Currently, 33 states and the District of Columbia have some type of college readiness benchmark (Rowland Woods, 2018). While college readiness broadly encompasses knowledge and skills necessary to complete a degree (Allensworth et al., 2018; Kless et al., 2013); academic readiness for college-level coursework is front and center. Recently, high schools have sought to increase the availability of college preparatory courses, however, students who are academically off-track at the end of 8th grade still have little chance to participate (Cassidy et al., 2010; Klopfenstein & Thomas, 2009; Kolluri, 2018; Museus et al., 2007; Royster et al., 2015; Xu et al., 2019; Song & Zeiser, 2019). Thus, policy that aims to increase academic readiness for college must focus earlier in the education pipeline—by addressing student achievement in the middle grades. To help students access and sustain an academic trajectory that leads to college readiness, early monitoring and detection of needs for support is essential.

Middle school standardized test scores are one measure commonly used to predict academic readiness for college coursework in the design of early warning indicators in recent research (Allensworth et al., 2014; Allensworth et al., 2018; Balfanz et al., 2007). One weakness in the current approach to predicting academic readiness for college is the use of achievement scores at a single timepoint (e.g., ACT, 2012; Balfanz et el., 2007). Measures of student growth provide a better indication of students' progress towards college and career readiness. Growth data is particularly useful to identify students who have not met college readiness benchmarks but have still improved, as well as to identify students who previously met benchmarks but have

fallen off track and may need additional supports. Furthermore, students' academic trajectories are less strongly tied to underlying socioeconomic inequalities and more reflective of schools impacts on learning than students' achievement at a point in time (Hegedus, 2018; Reardon, 2018). However, little research exists that uses longitudinal achievement patterns in middle school that helps individual students become academically ready for college.

This paper is the first to leverage longitudinal academic *trajectories* in the middle grades to inform an early academic indicator system. We use rich assessment data for more than 360,000 students in about 5,900 schools across 49 states and the District of Columbia and demonstrate an early academic indicator approach that continuously monitors students' on-track status from the beginning of 6th grade to the end of 8th grade. In both math and reading, each student was assessed up to six times. The test scores are vertically scaled, allowing us to compare achievement within and across grades, identifying when achievement growth acceleration and deceleration happen. We apply a set of longitudinal college readiness benchmarks to these unique data and based on the series of on-track statuses, we identify six trajectory patterns commonly exhibited by middle school students. Then, we provide the demographic characteristics of students that follow each of the six common trajectories. Lastly, we test whether certain demographic subgroups were more at risk of falling off-track or were more likely to move on-track for academic college readiness.

Student Development in the Middle Grades

The middle school years represent a unique transitional period in children's life, which according to the stage-environment fit theory (Eccles & Midgley, 1989) results from a combination of the changing development needs of adolescents and changes in their school and family contexts. There are multiple facets that determine the fit between students' developmental

needs and environment, each of which are likely to be related to whether students are likely to stay on track for college readiness. For example, a large body of research has documented declines in academic motivation and engagement in school during the middle school grades (Dweck, 2002; Eccles & Roeser, 2004), declines that often coincide with the transition to middle school (Wigfield et al., 2006). Students who feel that school is not sufficiently engaging or challenging may be more likely to fall off track during this period. Additionally, middle school is a period in which class tracking becomes more widespread and associated with specific post-secondary trajectories. Placement on "lower" tracks has been found to be negatively associated with later achievement outcomes (Kao & Thompson, 2003).

School and student characteristics are also likely to moderate some of these development transitions during the middle school grades. Student academic motivation and achievement depend largely on school resources and climate (Eccles & Roeser, 2004). Black and Hispanic students are afforded few educational opportunities because they are concentrated in high-poverty schools with low levels of resources and high rates of teacher turnover (Reardon et al., 2019). Within school, academic tracking practices can also trap students in low-track or remedial courses and prevent them from accessing high-quality curriculum and instruction (Oakes, 2005). Due to these structural inequalities in the education system, students of color are likely to enter the middle grades with lower achievement than their White peers, and those achievement gaps stay the same or widen over time (Reardon et al., 2015). Students of color have reported increased rates of racial/ethnic discrimination as they move through secondary school (Greene, Way, & Pahl, 2006), which has been tied to declines in academic self-concept and grades across middle school and high school (Wong et al., 2003). Lower expectations and negative stereotypes held by their teachers are associated with increased anxiety and school disengagement in African

American students (Aronson & Steele, 2005). Additionally, there are gender differences during this period, with girls tending to be more motivated, feel more connected to school, and get better grades than boys (Akos & Galassi, 2004), while also reporting higher levels of anxiety and worry (Pomerantz et al., 2002). Given these differences, it is likely that boys and girls react differently to academic challenges during the middle school years.

Middle School Academic College Readiness

A line of recent research on early warning indicators demonstrated the importance of monitoring middle school achievement as they predict high school test scores that are used later in high-stakes decisions (e.g., Allensworth, 2013; Allensworth & Easton, 2005; Allensworth et al., 2014; Balfanz et al., 2007). These studies developed indicators for being "on-track" to high school graduation or college readiness by leveraging a variety of academic and behavioral measures, as well as other predictors including eligibility for English Learner or Special Education services. On-track is defined as having met thresholds on the relevant measures, such as test score, grade point average, credits accumulated, and number of days of school attendance. Though not the sole indicator of college readiness, academic achievement, often represented by standardized test scores, is a crucial element found in most early indicator systems. A recent study included the Illinois standardized test scores as an indicator and found that middle school test scores were strong predictors of high school test scores but weaker as predictors of high school graduation (Allensworth et al., 2014). This study highlighted that ACT scores affect the likelihood of being admitted to selective colleges and scholarship decisions.

A separate line of research used the link among three assessments provided by ACT Inc.—ACT, PLAN, EXPLORE—to predict college readiness. In these studies, college readiness was conceptualized as students' probability of receiving a passing grade in a college-level

course. A score of 22 on the ACT math, 18 on the English, and 22 on the Reading assessment respectively predict 75% probability of receiving a C in a college-level course in math, English, or social science (Allen & Radunzel, 2017). Being on-track for college readiness was defined as meeting the cut scores on the EXPLORE (taken in 8th grade) or on the PLAN (taken 10th grade) that predict meeting the three ACT cut scores in 12th grade. The studies examined the prevalence of academic mobility (ACT, 2012; Dougherty, 2014; Dougherty & Fleming, 2012). Their samples consisted of (a) four cohorts of students who took EXPLORE in 8th grade and the ACT in 12th grade and (b) two cohorts of students in Arkansas who took the Arkansas Benchmark Exams in 4th grade and EXPLORE in 8th grade. Students were categorized by scores on the respective exams into three groups: "on track" or met the benchmark; "off track" or missing the benchmark by one standard deviation (SD) or less, and "far off track" or missing the benchmark by more than one SD. The studies found that in 8th grade, higher percentages of African American and Hispanic students were off track or far off track for college readiness than other students. Also, upward mobility was rare. Only 37% and 46% of students who were off track in 4th grade in reading and math, respectively, were on track in 8th grade. Between 8th and 12th grade, the rates of moving on-track were only 3% (math) and 10% (reading) for far-off-track students, and 19% and 29% for off-track students.

The ACT studies began to explore the dynamic nature of academic readiness but faced four major limitations. First, the studies only reported percentages of students who were on- or off-track. The relations between student- and school-level predictors and mobility were largely left unexplored. Second, the data used to calculate the probability of catching up between 4th and 8th grade came from a single state, so the generalizability of the findings is low. Third, student test scores were only observed in 4th, 8th, and 12th grade, and trajectories in the four years in-

between testing is unknown, limiting the actionability of the findings for schools. Finally, the test content of the ACT examines likely varied from the statewide assessments that students took in middle school, which are intended to measure proficiency in grade-level standards.

The Need to Examine Learning Trajectories

As Lee (2010) asserted, "The problem with college readiness should be viewed as an issue of sustainable academic growth and transition across all levels of schooling rather than an isolated high school problem per se" (p. 827). Balfanz (2009) found, for example, that 6th grade is a critical year in which many students fall off-track for high school graduation by failing a course or having too many absences. Importantly, he also found that students who triggered off-track indicators in middle schools were resilient and continued to participate in subsequent years of schooling. These findings suggest that students who struggle in the middle grades stand to benefit from intervention, and early detection is key in shaping their academic trajectories.

Recent research that examined academic achievement and achievement gaps in the middle grades did not examine growth towards college readiness. For example, Reardon et al. (2015) used 4th/5th grade and 8th grade assessment data from the National Assessment of Educational Progress Long-Term Trend (NAEP-LTT) and ECLS-K:1998 and showed that racial/ethnic and socioeconomic achievement gaps are fairly stable across those two grade levels. Using more recent data from NWEA's MAP Growth assessments, growth trajectories in math and reading were found to be fairly similar across racial/ethnic groups throughout the middle school years (Kuhfeld et al., 2019), while gender gaps in reading favoring girls appeared to widen during middle school (Downey, Kuhfeld, & van Hek, 2020). These studies add to the understanding of inequalities in learning trajectories in middle school but do not address downstream consequences for college readiness. Current research lacks good measures for when

students in the middle grades are meeting college readiness benchmarks, and equally important, when students are falling off track.

Based on findings from the ACT studies, we might expect higher percentages of Black and Hispanic students to be *consistently* off-track as they move through the middle grades. But existing research is silent on the issue of consistency. It is also possible that students' race/ethnicity is associated with academic mobility (e.g., the degree to which students change their relative rank-ordering over time, such as moving upwards in the distribution of test scores). Using the Early Childhood Longitudinal Study Kindergarten Cohort of 1998 (ECLS-K:1998), Quintana and Correnti (2019) found that Black and Hispanic students showed higher academic mobility between kindergarten to 8th grade than White and Asian students. Alarmingly, they found that Black students were far more likely than any other racial/ethnic to move from the top test score quartile to the lowest quartile. Given these findings, we might expect that Black and Hispanic students who start on-track are more likely to fall off track by the end of 8th grade, though extant research has not been able to directly answer such questions, likely due to limited longitudinal data on achievement within the middle school grades.

Few studies have combined the examination of academic trajectories in middle school with prediction of being ready to enter college by the end of high school. The primary exception is Lee (2012), who combined data from the Early Childhood Longitudinal Study–Birth Cohort (ECLS-B), ECLS-K:1998, and National Education Longitudinal Study of 1988 (NELS:88) to examine achievement trajectories in math for different college pathways. College readiness benchmark scores were set based on NELS 8th, 10th, and 12th-grade math test scores that best differentiated between students who attended two-year versus four-year colleges. Lee found that for successful completion of a bachelor's degree, students needed to perform at or above the

national test "proficient" level (NAEP) in math in 8th grade, which was well above the national average. Additionally, he found that from late elementary to high school, Hispanic and Black students gradually fell behind their White and Hispanic peers in terms of being on track for four-year college entrance. However, since college readiness standards used in this study are based on students from the NELS:88 data who entered college in the early 1990s, it is unclear how generalizable these findings are to the current college admissions system.

Current Study

In summary, we have little evidence on the dynamic development of academic college readiness during the middle school grades. Some basic and important questions remain unanswered, such as (a) What fraction of students start 6th grade academically on-track? (b) What fraction of students who start 6th grade on-track are off-track at the end of 8th grade? and (c) What factors predict falling off-track? In this study, we fill these gaps by using recently-collected (2015-16 to 2017-18) math and reading test score data from over 360,000 middle school students along with a set of college readiness benchmarks (Thum & Matta, 2015) to classify students as on-track or off-track to be college ready across six time points between 6th and 8th grade. The college readiness benchmarks used in this study link MAP Growth test scores in middle school to ACT performance in high school, where an ACT score of 22 or above is considered on track for college readiness. The benchmarks are applied by schools that use MAP Growth to measure whether middle and high school students are on track to be college ready.

This trajectory-based approach to an early academic indicator system can be easily implemented by schools and districts. The series of on-track indicators and the trajectory groups they form allow schools to identify and provide timely interventions to individual students. Interpreting students' achievement trajectories relative to a clear set of benchmarks facilitates

conversations with students and their families about setting goals to make progress toward academic college readiness. Middle schools will be able to monitor as students move on-track, fall off track, or sustain their status, and respond by targeting programs and services. High schools will be able to look at students' 6th to 8th grade trajectories and plan to address their needs in the next four years. In demonstrating this trajectory-based approach to gauging academic readiness for college, our goal is to provide practitioners and policymakers with an actionable way of organizing data and identifying viable points of intervention to support individual and subgroups of students.

Researchers can also combine this trajectory-based approach and sophisticated statistical analyses to examine trajectory patterns for subgroups of students, generating findings that will help policymakers and practitioners to identify needs for improvement at the setting-level (Allensworth et al., 2018). Recent research shows that Black and Hispanic students may be more prone to downward academic mobility (Quintana & Correnti, 2019). We test this using multilevel models and identify student- and school-level predictors for two of the possible academic trajectories: falling off track and moving on-track.

Data

Data Sources

The student achievement data for this study come from NWEA's Growth Research Database (GRD), which contains longitudinal test scores data for students in schools across the nation. The schools and students in the GRD were not randomly sampled. Schools and districts choose to partner with NWEA and administer the MAP Growth assessments to their students for a variety of reasons (e.g., monitor students' academic growth, teacher evaluation, placement for special programming). Thus, the students and schools that select into the GRD are not nationally

representative. However, two facts provide some reassurance that the generalizability of our findings will be high. First, the GRD includes achievement data for approximately 30% of public schools serving 6th through 8th grade across the nation. Second, most schools that partner with NWEA test the majority of students within each grade (an average of 80% of enrolled students). A comparison of the school in our analytic sample with the population of public schools serving 6th to 8th grade students is provided in Appendix Table A1. Schools in the sample are similar to the population in terms of the percentages of students who are White, Asian, and eligible for free or reduced-price lunch (FRPL). However, schools in the sample on average serve a lower percentage of Hispanic students and a higher percentage of Black students and are more urban and less rural than the population of public schools.

The student and school covariates used in our analyses come from the GRD and the National Center for Education Statistics (NCES), Common Core of Data. Students' gender and race/ethnicity variables were reported by the schools prior to the MAP Growth test administrations. We use school characteristics reported in the CCD, including the percentage of Asian, Black, White, and Hispanic students, the percentage of enrolled students who are eligible for FRPL, and enrollment in 6th, 7th, and 8th grades.

Sample

We follow one cohort of students who attended 6th grade in academic year 2015-16 through the end of their 8th grade year (2017-18). We start with a data set that contains over 3.6 million test events for 867,948 students across 8,817 schools. For each student, we observe up to six terms of test scores. In order to examine a full trajectory through the middle grades, we restrict the analytic sample to students who had test scores in all of the following terms: (a) the fall of 6th grade; (b) either the fall or spring of 7th grade; and (c) the spring of 8th grade. This

analytic sample contains 363,686 students for math and 363,959 students for reading across 49 states and Washington DC. The analytic sample is 49% female, 54% White, 14% Black, 17% Hispanic, and 4% Asian. Our main analyses use this analytic sample, and we focus on reporting these analysis and results in this paper. The analytic sample is more White and less Black and has a slightly higher initial achievement score than the full sample. Therefore, we also check the sensitivity of our findings to using two alternative samples: the full sample (N=867,728 for math) with multiply-imputed test scores ("imputed full sample")[1], and a subsample (N=308,282 for math) with complete test scores from all six terms ("complete-data subsample"). Appendix Tables A2 and A3 show the summary statistics for the imputed full sample and complete-data subsample.

About 72% of the students in our analytic sample attended only one school from the fall of 6th grade to the spring of 8th grade; 26% attended two schools. Students may have changed schools due to family reasons or to transition from a school that only serves up to grade 6 or grade 7 to another school that serves upper grades. We generate indicators for students' having changed schools during transition from 6th to 7th grade ("SchoolChange6" = 1 for 22% of students) and during transition from 7th to 8th grade ("SchoolChange7" = 1 for 5% of students) and use these indicators to control for school mobility in our analyses. For the purpose of analyses that leverage school-level characteristics, students are assigned to the school at which they tested the most; where there is a tie between two "modal" schools, the first school is chosen chronologically. About 29% of the modal schools for students in the sample only served grades 6 to 8; another 5% of the schools served only grades 7 and 8; the rest served other combinations, such as K-8 or 5-8. In this paper, we use the term "middle school" to refer generally to schooling between 6th and 8th grade, regardless of the actual grades served by the school.

Measures

Test scores. We use students' scores on the MAP Growth mathematics and reading assessments. MAP Growth is a computer adaptive test—which means measurement is precise even for students above or below grade level—and is vertically scaled to allow for the estimation of gains across time. Each test takes approximately 40 to 60 to administer and typically takes place three times per academic year—in the fall, winter, and spring. The assessments are aligned to content standards within each state. Scores are reported on the RIT (Rasch Unit) scale, where RIT is a linear transformation of the logit scale units of the Rasch item response theory model.

Benchmarks. The benchmarks we use to classify math and reading test scores in each grade and test term (i.e., fall or spring) as on- or off-track for college readiness come from Thum and Matta (2015). These benchmarks anchor on the ACT score of 22 for math and reading[2], the minimum ACT scores required to "have at least a 50% chance of earning a B or higher grade and approximately a 75-80% chance of earning a C or higher grade in the corresponding college course or courses" (Allen & Radunzel, 2017). ACT scores are a widely accepted barometer for college readiness. Schools use ACT scores or projections of ACT scores to place students into Advanced Placement and dual enrollment. Further, 15 states currently use ACT scores as a measure of college and career readiness for accountability metrics under ESSA (Achieve, 2016).

The MAP benchmarks were created using a sample of over 620,000 test events for 83,318 students in 4th to 12th grade in 410 schools across the country. Scoring above the MAP benchmark in a test term represents being on a projected growth trajectory for scoring a 22 or above on the ACT in high school. Referenced against NWEA's national MAP Growth norms (Thum & Hauser, 2015), the benchmarks imply that students who scored at or above the 61st to 76th percentiles in math or between the 59th to 69th percentiles in reading were likely to be on-

track for college readiness. The benchmarks were estimated through a multivariate growth model that simultaneously modeled MAP Growth trajectories and ACT scores while accounting the self-selection in taking the ACT in high school. Accounting for potential self-selection biases allow the benchmarks to be generally applicable to all middle school students, not just ones who are very likely to take the ACT in high school. Thum and Matta (2015) found that about 67 to 75 students out of 100 who met or exceeded the benchmarks were correctly classified as college ready and only 13 to 20 students of 100 of students who were not on-track were misclassified.

We focus on MAP Growth ACT benchmarks because they are being applied by schools and districts across the country to track students' progress towards college readiness. State and districts have also utilized these benchmarks for accountability and goalsetting purposes. For instance, one medium district in Illinois sets the goal for middle school and elementary schools that feed into their high schools to attain the college ready MAP benchmark prior to entering high school (School District 86, 2018). The state of Colorado uses MAP Growth ACT benchmarks to set standards for college readiness which schools are held accountable for fulfilling college readiness requirements (Colorado Department of Education, 2019). However, as we discuss in the limitation section, this set of benchmarks seek to capture one aspect of college readiness and are not deterministic of students' eventual college enrollment and success.

On-track indicators. Using the MAP benchmarks described above, we assign a binary indicator to students that specify whether they are on- or off-track for college readiness in a specific grade and term. For example, students who scored 225.30 RIT or higher in math in the fall of 6th grade are classified as on-track (1), while students scoring 225.29 RIT or lower are classified as off-track (0). Thus, in each subject, each student is assigned a value of 1 or 0 on up to six indicators for the fall and spring of 6th through 8th grade. Online Appendix Table A4 shows

the benchmarks and percentage of students who met the benchmarks by test term. If a student did not take an assessment during a test term, her on-track indicator for that term would be missing. The analytic sample includes students who had non-missing on-track indicators for the three terms described above. Students in the imputed full sample and the complete-data subsamples have no missing on-track indicators for any term.

Analysis

Trajectory Groups

Since students are either on-track or off-track in each of the six terms, there is a total of $2^6 = 64$ unique trajectories. For example, students could be on-track at all six timepoints, on-track for the first five timepoints but not the sixth, on-track all but the second timepoint, and so on. We examined all 64 patterns to see the frequency of each pattern and look for common trends among the groups. There does not appear to be a large amount of switching between on-track/off track status during the middle school grades, and so we collapse most of the groups into smaller subsets. In the end, we organize student trajectories in each subject into six groups: three who start on-track and three who start off-track.

(a) "always on-track": students who were consistently on-track for college readiness throughout all the terms in which test scores are observed;

(b) "inconsistently on-track": students who were on-track in the fall of 6th grade and the spring of 8th grade, but off-track during at least one term in between;

(c) "fell off track": students who were on-track in the fall of 6th grade but off-track in the spring of 8th grade;

(d) "always off-track": students who were consistently off-track for college readiness throughout all the terms in which test scores are observed;

(e) "inconsistently off-track": students who were off-track in the fall of 6th grade and the spring of 8th grade, but on-track during at least one term in between;

(f) "moved on-track": students who were off-track in the fall of 6th grade but on-track in the spring of 8th grade.

For the remainder of this paper, we refer to these six classifications as "trajectory groups." Organizing trajectories into these six groups allows us to focus on three phenomena of interest (i.e., starting status, change in status, and end status) with no substantive loss of data. Although this approach of assigning trajectory group status is not as statistically sophisticated as latent class analysis, it has the important advantage of being easily interpretable and actionable for practitioners. We chose this method for its transparency and straight-forward implementation.

Appendix Table A5 reports the agreement between math and reading trajectory group membership. About 52% of the students who were tested in both subjects in the analytic sample were in the same trajectory group for math and reading. We analyze the two subjects separately. For students in each trajectory group, we present student-level summary statistics, including gender, race/ethnicity, indicators for having changed schools between 6th and 7th grade and between 7th and 8th grade, and RIT score in the fall of 6th grade. To illustrate the academic growth patterns of these trajectory groups, we plot the mean RIT scores for each group across the six test terms.

Predicting Status Change

To test if demographic characteristics are associated with academic mobility, we employ two restricted samples. First, we focus on the subset of students who were on-track in the fall of 6th grade and predict falling off track in the spring of 8th grade. For a student *i* in school *j*, we generate an indicator for having changed status (y_{ij}: 1=finished 8th grade off-track, 0=finished 8th

grade on-track) and use this binary variable as the outcome. Then, we focus on students who were off-track in the fall of 6th grade and generate the same indicator for having changed status (y_{ij}: 1=finished 8th grade on-track, 0=finished 8th grade off-track).

To identify student and school characteristics that predict either falling off or moving on-track, we estimate a series of hierarchical generalized linear models (HGLM), where students' on/off track status indicators are nested within schools. In the notation below, we focus on the "falling off track" case. Let the level-1 outcome y_{ij} take a value of 1 with conditional probability p_{ij}. The null HGLM without predictors (Model I) estimates the log odds of falling off track as

$$\ln\left[\frac{p_{ij}}{1-p_{ij}}\right] = \gamma_{00} + u_{0j} \qquad (1)$$

In this model, γ_{00} is the grand-mean log odds of falling off track and u_{0j} is the school-level random effect that captures between-school variation in the odds of falling off track by the end of 8th grade. Model II builds on Model I and includes student-level covariates: Male, Black, Hispanic, Asian, having changed schools between 6th and 7th grade, having changed schools between 7th and 8th grade, and grand-mean-centered initial RIT score in the fall of 6th grade.

$$\ln\left[\frac{p_{ij}}{1-p_{ij}}\right] = \gamma_{00} + \gamma_{10}\text{Male}_{ij} + \gamma_{20}\text{Black}_{ij} + \gamma_{30}\text{Hispanic}_{ij} + \gamma_{40}\text{Asian}_{ij} +$$

$$\gamma_{50}\text{SchoolChange6}_{ij} + \gamma_{60}\text{SchoolChange7}_{ij} + \gamma_{70}\text{InitialRIT}_{ij} + u_{0j} \qquad (2)$$

Model III additionally includes a set of school-level covariates: (a) percentage of students eligible for free or reduced-price lunch, (b) percentage of students who are Black, (c) percentage of students who are Hispanic, and (d) percentage of students who are Asian.

$$\ln\left[\frac{p_{ij}}{1-p_{ij}}\right] = \gamma_{00} + \gamma_{01}\%\text{FRPL}_j + \gamma_{02}\%\text{Black}_\text{j} + \gamma_{03}\%\text{Hispanic}_\text{j} + \gamma_{04}\%Asian_\text{j} + \gamma_{10}\text{Male}_{ij} + \gamma_{20}\text{Black}_{ij} + \gamma_{30}\text{Hispanic}_{ij} + \gamma_{40}\text{Asian}_{ij} + \gamma_{50}\text{SchoolChange6}_{ij} + \gamma_{60}\text{SchoolChange7}_{ij} + \gamma_{70}\text{InitialRIT}_{ij} + u_{0j}$$

Main Findings

Trajectory Groups

Table 1 presents the percentage of students in the analytic sample within each trajectory group. In math, the majority (73%) of students did not change status at all during the six time periods. Specifically, 54% of students were always off-track to be college ready in math throughout middle school while 19% of students were on-track during the entire period. Only 15% of students switched status between the start and end of middle school, with 4% of students falling off track and 11% of students moving on-track. The remaining 12% of students were inconsistently on-track or off-track throughout middle school. In reading, there was somewhat more mobility in students' trajectories. Thirty-five percent of students were always off-track for college readiness with regards to their reading skills, while 25% were always on-track. Twenty percent of students were unstably on or off-track in reading, while the remaining 20% changed status (11% falling off and 9% moving on track).

Figure 1 shows the average RIT score trajectories for students within each group between the fall of 6th grade and the spring of 8th grade. The black horizontal bars display the college readiness benchmark within each grade/term. In math, the groups that change status (either move on-track or fall off track) appear to be changing status during 7th grade on average. In addition, the always on-track and always off-track groups in math are spreading further apart during each grade, so that the already large gap between the two groups at the start of middle school (1.88

SDs) is even larger by the end of 8th grade (2.02 SDs). In reading, the groups who are moving on-track or falling off track look very similar between the spring of 6th grade through the fall of 8th grade, whereas the always on-track and always off-track groups are fairly spread out (a gap of approximately 2 SDs). Appendix Figures 1 and 2 show trajectories by gender and race/ethnicity.

Figure 2 shows the percentage of students within each trajectory group by gender and race/ethnicity. There does not appear to be significant gender differences in the distribution of students in each trajectory group within math, though male students are more likely to be always off-track in reading than female students. However, there are clear patterns by racial/ethnic group. Black and Hispanic students are far more likely to be always off-track in both math and reading than White and Asian students. Specifically, 77% of Black students are always off-track in math, relative to 69% of Hispanic students, 44% of White students, and 28% of Asian students. Similarly, only five percent of Black students are always on-track in math, compared with 43% of Asian students and 24% of White students. The patterns in reading are quite similar, with over half of Black (54%) and Hispanic (51%) of students always off-track, relative to 26% of White students and 18% of Asian students.

The two groups of students who were always on-track and students who were always off-track also differed in terms of the demographic composition of the schools they attended (see Table 1). The average always on-track student attended schools that were more affluent and had lower percentages of Black, Hispanic, or Asian students than the always off-track students. For example, students who are always on-track in math are in schools with an average of 33% of its student body eligible for FRPL and 33% Black, Hispanic, or Asian students, compared with the always off-track students who are in schools with 56% of its student body eligible for FRPL and 49% Black, Hispanic, or Asian students.

Predicting Status Change

Table 2 presents the associations between demographic characteristics and status change (i.e., falling off track or moving on-track). The dependent variable is an indicator for status change, and the coefficients are presented as odds ratios. Coefficients larger than 1 represent higher odds; coefficients smaller than 1 represent lower odds. We begin by looking at the model predicting falling off track in math among the subset of the sample (28%) that was initially on track in the fall of 6th grade. Panel A shows the odds that students who were on-track at the beginning of 6th grade fell off track (i.e., off-track in the spring of 8th grade). Column (1) shows the results from the null model with no predictors. The odds-ratio for falling off track is 0.202, which translates into a predicted probability of 16.8%. Column (2) shows the associations between student-level covariates and falling off track, where White female students who did not change schools during the study period are the omitted category. Being male, Black, Hispanic, or a member of another race/ethnicity group is associated with significantly higher odds of falling off track in math (odds ratios of 1.38, 1.40, 1.17, and 1.14, respectively). Changing schools between grades is also associated with higher odds of falling off track (odds ratios of 1.35 and 1.66). Being Asian and having higher initial achievement are associated with lower odds of falling off track. Column (3) shows the findings from a model that additionally includes school-level predictors: the percentage of students eligible for FRPL and the percentages of students who are Black, Hispanic, and Asian. The percentage of FRPL-eligible students in the school is significantly associated with higher odds of falling off track. The percentage of Hispanic students and the percentage of Asian students in the school are associated with significantly lower odds of falling off track. The estimate for the percentage of Black students in the school also suggests lower odds of falling off track, but it is not significant.

Panel B shows the odds ratios for students who were off-track in the fall of 6th grade to move on-track. Estimates are the opposite direction as those presented in Panel A. Being male, Black, Hispanic, and changing schools between grades were associated with significantly lower odds of moving on-track. Being Asian and having higher initial achievement were associated with higher odds of moving on-track. The percentage of FRPL-eligible students in the school is associated with lower odds of moving on-track. In contrast, the percentages of Black, Hispanic, and Asian students in the school are associated with higher odds of moving on-track.

Panels C and D show the findings for changing status in reading. The estimates are slightly different in magnitude compared to the math results, but the findings are qualitatively similar. Being Male, Black, or Hispanic, changing schools, and higher school percentage of FRPL-eligible students are associated with higher odds of falling off track and lower odds of moving on-track. The opposite is true for being Asian, having higher initial achievement, and attending a school with higher percentages of Black, Hispanic, and Asian students.

Sensitivity Checks

Appendix Tables A2, A3, and A6 report findings from our sensitivity checks. When we apply the analysis to the imputed full sample and to the complete-data subsample, results are qualitatively similar to the findings for the analytic sample.[3]

Discussion

Leveraging a unique large data set, this study presents novel evidence on academic trajectories and demonstrates an approach for monitoring college readiness in middle school. We report three main findings. First, on-track for college readiness status remains stable for most students throughout middle school. Second, students who are always on-track differ from students who are always off-track in terms of individual characteristics and in terms of their

schools' demographics. Third, individual and school characteristics significantly predict changing status (i.e., moving on-track or falling off track).

Students' trajectories are relatively stable from the fall of 6th grade to the spring of 8th grade. About 73% of our sample maintained the same status (19% were always on-track; 54% were always off-track). Another 12% of the sample fluctuated in the middle terms but finished middle school with the same status as they started. This is not surprising, as previous research demonstrated student trajectories are stable over time (Reardon et al., 2015). However, this finding also highlights the need for intervention, both in elementary and middle school, to help students move on-track and stay on track. To increase postsecondary access and attainment, policy needs to focus upstream and increase the proportion of students entering middle school with the prerequisite foundation to be college ready at the end of 8th grade.

Participation in college preparatory and early college programs hinges on academic preparedness at high school entry. As extant research has demonstrated, the recent overall expansion of programs such as dual enrollment has not reduced the racial and SES gaps in participation (Xu et al., 2019). Simply increasing the general coverage of college preparatory or college-level courses does not resolve the underlying racial/ethnic and socioeconomic gaps in 8th grade achievement that results in gaps in access to those advanced courses. The enduring gap in access to advanced coursework can partly be explained by the strong relationship we find between student and school demographics and academic trajectories in middle school.

A large fraction of "always on-track" students are White or Asian and attend a school with relatively low percentages of FRPL-eligible students. In contrast, a large fraction of "always off-track" students are Black or Hispanic and attend a school with relatively high percentages of FRPL-eligible students. The predictive power of race/ethnicity and SES also applies to positive

and negative change in on-track status. Among students who start with the same status (e.g., on-track in the fall of 6th grade), individual and school demographics are strongly associated with changing status. Specifically, being male, Black, Hispanic, or Other Race and attending a school with higher percentage of students who are eligible for FRPL are associated with lower odds of moving on-track and higher odds of falling off-track. In other words, the odds are working against students from disadvantaged backgrounds throughout the middle grades: students who are already behind tend to stay behind; students who are on-track tend to fall behind.

To the extent that college preparation opportunities are allocated by on-track status in 8th grade, middle school presents the last chance for students to become ready and eligible. Since students from disadvantaged backgrounds are more likely to start the middle grades off-track or fall off track during the middle grades, schools need to vigilantly monitor their achievement within and across grades and engage in equitable practices that support their success. Teacher professional development can focus on building trust and a sense of community in and outside the classroom. Programmatic interventions should shift from general expansion of college preparatory curriculum to targeted implementation. For example, course placement policies might be interrogated to increase access to high-quality teachers and curriculum for historically-underserved student populations. Additional support services should be offered to boys and Black and Hispanic students, especially those who are on the margin of college readiness (i.e., within a few points of moving on-track or falling off-track).

For the purpose of identifying students in need of support, data from annual state standardized tests are both untimely and inadequate. To ensure timely provision of instructional intervention, individual student performance should be measured regularly and consistently. As this study demonstrates, schools and districts can follow the straight-forward steps below to

monitor students' on-track status. First, compare the student's test scores in a given academic term (i.e., fall, winter, or spring) to college readiness benchmark cut scores and determine if the student is on-track or off-track. Then, examine the student's available previous test scores and on-track statuses to assign the student into a trajectory group. Schools might adopt the six trajectory groups defined in this study or customize groups according to their data availability and the timing of their intervention programs. Each student needs to be tested at two time points in order to be assigned to a trajectory group. For instance, if a school aims to target a math tutoring program that starts in 7th grade, they might consider examining students' math on-track trajectory from the fall to the spring of 6th grade to identify students who need support (e.g., those who were always off-track or fell off track during 6th grade). This trajectory-based process only requires very simple computation and can easily be implemented by schools and districts.

Limitations

This study has a few limitations that merit cautious interpretation of its findings. First, our analyses are descriptive, and the estimates should not be taken as causal links. Second, our unique large sample includes students from across the nation but may not be representative of the nation. Third, in constructing a sample using only students who had at least one test score in each grade between 6th and 8th, we likely excluded students with the highest mobility from the analyses. Therefore, we may be underestimating the percentage of students who are always off-track. Also, we do not observe other student-level characteristics that may predict academic trajectories, such as eligibility for FRPL, English Learner, or Special Education services.

Finally, we acknowledge that the definition of college readiness used by the ACT (i.e., having a 50% chance of earning a B in an introductory course) is limited in scope and nuance. We considered using MAP Growth SAT benchmarks but ultimately chose ACT benchmarks

because (a) SAT benchmarks were only available for total scores pooling math and English and (b) ACT cut scores for college readiness are widely used by researchers and practitioners. The models used to create the ACT benchmarks rest on probabilistic and not deterministic interpretations. Our intention is not to establish a single cut score as the ultimate standard for college readiness. Schools should not rely on standardized test scores as the sole indicator, and we certainly do not advocate using benchmarks to group and label students for the purpose of academic tracking. Extant research recommends using multiple indicators to evaluate college readiness, including course grades and attendance (Allensworth et al., 2014). Students' socioemotional wellbeing and behavior are important factors that contribute to their ability to learn and thrive as young adults but are outside the scope of this paper (Gaertner, 2015; Kieffer 2014; Mattern et al., 2016). College success depends on a variety of factors; academic achievement in the middle grade is (only) one important predictor. Our goal was to describe a framework using which researchers and policymakers can identify students in need of additional support, as well as viable points for effective intervention.

Conclusion

This study makes three key contributions to the literature on academic achievement and college readiness. First, we illustrate academic growth trajectories from the fall of 6th grade to the spring of 8th grade for the pooled sample and for student subgroups by gender and ethnicity. We report details about academic growth and growth gaps unfound in previous research. Second, we demonstrate an actionable approach for tracking student progress in the middle grades. The nascent literature highlights the importance of being college-ready by the end of 8th grade but does not offer any tangible methods to monitor readiness throughout middle schools. We generate an actionable indicator by applying benchmarks that districts currently use to monitor

college readiness. Finally, using multilevel models that significantly improve upon prior studies, we report the associations between being on-track for college readiness and student- and school-level characteristics. In addition, we identify predictors for changing college readiness during the middle grades (i.e., falling off track or moving on-track). Whereas previous studies only examine indicators of college readiness as a static measure at a couple of points in time, we add to the literature new knowledge on the dynamic development of college readiness.

In this study, we use a set of college readiness benchmarks to classify students as either on track (at or above the benchmark) or off track (below the benchmark) in each timepoint. However, this is not the only way that one could establish college readiness trajectories. In an ideal world, we would be able to follow each student longitudinally until after high school to establish the score trajectories that were associated with two- or four-year college enrollment. Given our students recently completed middle school, we lack those long-term outcomes for this cohort, but future research could aim to follow up with these students to study their postsecondary outcomes. Additionally, instead of using observed cut scores such as NWEA's college readiness benchmarks (Thum & Matta, 2015), remaining on track or falling off track for college could be treated as an unobserved characteristic of students that could be estimated from students' academic trajectories. For instance, growth mixture modeling assumes that there are unobserved sub-population of individuals (such as students who are on and off track for college readiness) that show different growth trajectories over time (Ram & Grimm, 2009). We are unaware of any studies using such an approach to detect latent classes of likely to be college-ready students based on their math and reading score trajectories, but additional research could compare these latent modeling approaches with our benchmarking approach.

Notes

[1] Data are imputed using the -mi impute- command in STATA 16. Ten imputed data sets were generated, and the average of the ten achievement scores was used in the analyses.

[2] Thum and Matta (2015) presented two sets of MAP Growth benchmarks, for ACT scores of 22 and 24, respectively. We use the benchmarks for ACT scores of 22, following Allen and Radunzel (2017).

[3] We do not test for statistical significance for the differences among the three samples because all three samples have more than 300,000 students, which likely results in statistical significance.

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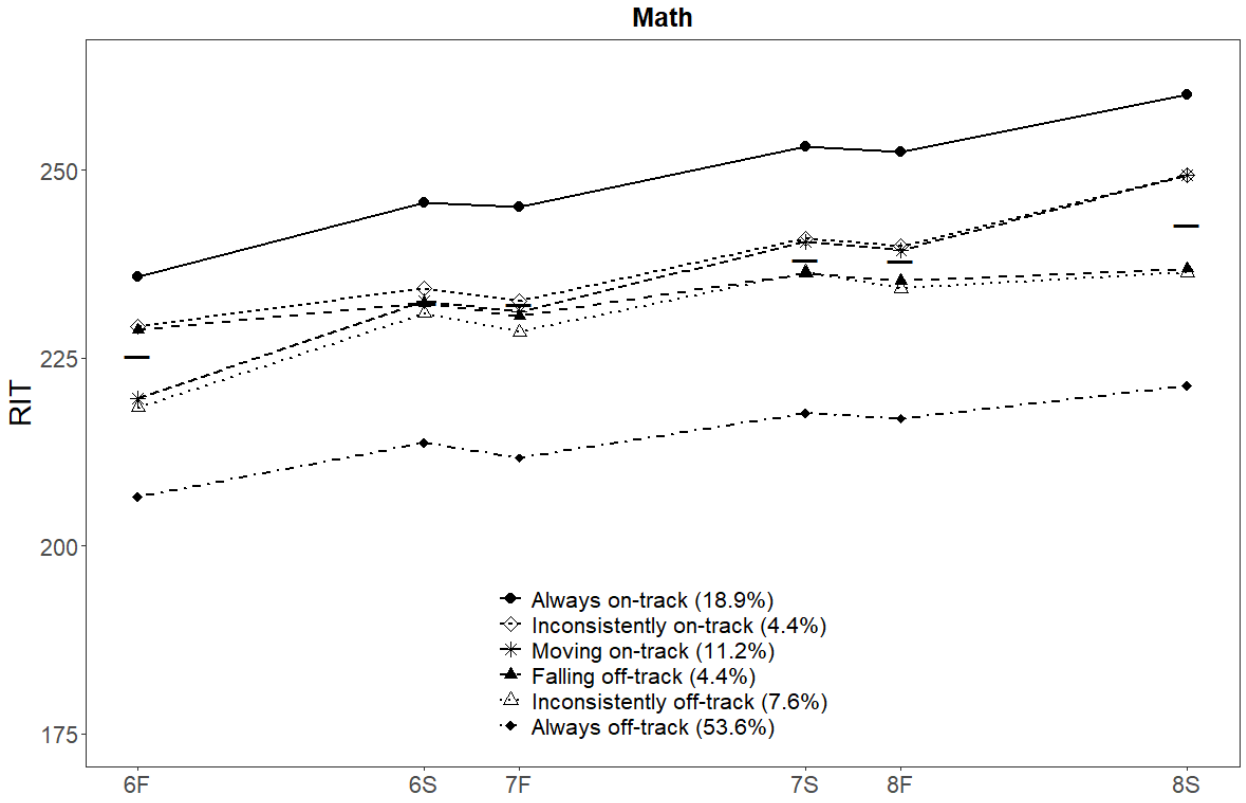
Figure 1. Achievement Growth by Trajectory Group



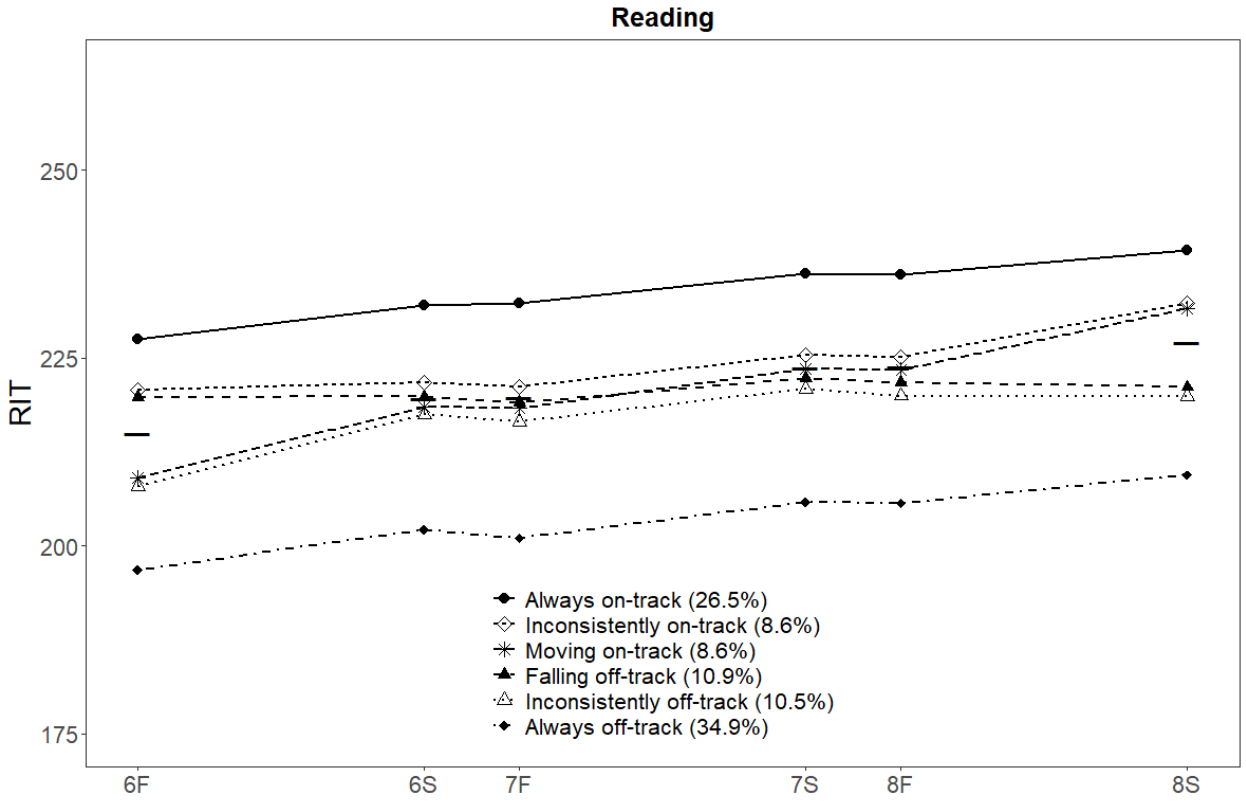


Figure 2. Trajectory Group Distribution by Gender and Race/Ethnicity

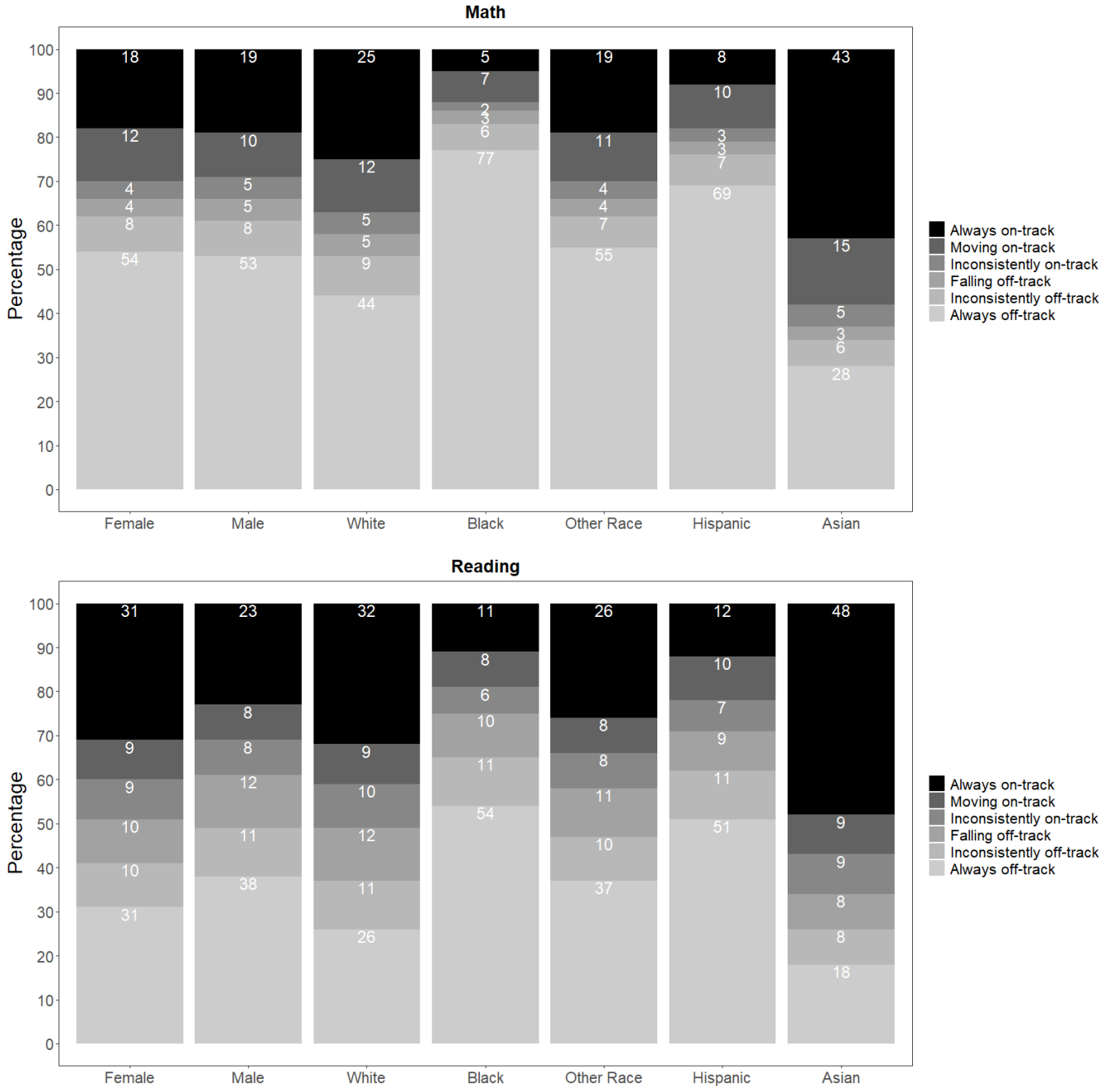


Table 1. Analytic Sample Summary Statistics by Trajectory Group, Math

	Analytic Sample	(1) always on-track	(2) always off-track	(3) inconsistently on-track	(4) inconsistently off-track	(5) fell off track	(6) moved on-track
				Math			
N	363,686	68,569	194,867	16,074	27,751	15,865	40,560
% of Sample	100%	19%	54%	4%	8%	4%	11%
Gender	51%	54%	50%	53%	50%	57%	46%
White	53%	69%	44%	66%	60%	65%	60%
Black	14%	4%	20%	7%	11%	9%	9%
Hispanic	17%	7%	22%	11%	15%	12%	15%
Asian	4%	9%	2%	4%	3%	2%	5%
Other Race	11%	11%	12%	11%	11%	12%	11%
Initial RIT	216.43	235.85	206.58	229.25	218.42	228.72	219.66
School Change 6-7th Grade	22%	22%	22%	21%	25%	25%	20%
School Change 7-8th Grade	5%	3%	6%	4%	5%	5%	4%
School % FRPL	48%	33%	56%	39%	45%	42%	44%
School % White	57%	67%	51%	65%	61%	65%	61%
School % Black	15%	9%	19%	11%	13%	11%	12%
School % Hispanic	19%	14%	22%	15%	18%	15%	19%
School % Asian	4%	6%	3%	4%	4%	4%	4%
District SES (SD)	0.08	0.54	-0.16	0.35	0.17	0.32	0.18
District %ELL	8%	6%	9%	6%	7%	6%	7%
District %Poverty	13%	10%	14%	11%	12%	11%	12%
District Gini Index	0.37	0.36	0.38	0.36	0.37	0.36	0.37

Table 1. Analytic Sample Summary Statistics by Trajectory Group, Reading

	Analytic Sample	(1) always on-track	(2) always off-track	(3) inconsistently on-track	(4) inconsistently off-track	(5) fell off track	(6) moved on-track
				Reading			
N	363,959	96,336	127,066	31,312	38,231	39,752	31,262
% of Sample	100%	25%	35%	9%	11%	11%	9%
Gender	51%	45%	56%	48%	52%	54%	46%
White	54%	67%	40%	61%	54%	60%	53%
Black	14%	6%	22%	11%	15%	12%	13%
Hispanic	17%	9%	25%	13%	17%	13%	19%
Asian	4%	7%	2%	4%	3%	3%	4%
Other Race	11%	11%	12%	11%	11%	12%	11%
Initial RIT	211.71	227.46	196.82	220.70	207.94	219.80	209.01
School Change 6-7th Grade	22%	21%	23%	22%	22%	23%	20%
School Change 7-8th Grade	5%	4%	7%	4%	5%	5%	5%
School % FRPL	48%	36%	58%	43%	48%	44%	49%
School % White	57%	65%	49%	62%	58%	62%	57%
School % Black	15%	11%	20%	13%	15%	13%	15%
School % Hispanic	19%	14%	24%	17%	19%	17%	21%
School % Asian	4%	5%	3%	4%	4%	4%	4%
District SES (SD)	0.10	0.46	-0.24	0.24	0.08	0.22	0.05
District %ELL	8%	7%	9%	7%	8%	7%	8%
District %Poverty	13%	10%	15%	12%	13%	12%	13%
District Gini Index	0.37	0.36	0.38	0.37	0.37	0.37	0.37

Table 2. Analytic Sample HLM Estimates for Predicting Changing Status (Fell off Track or Moved On-Track)

	Math						Reading					
	Panel A: Changed Status: Fell Off Track			Panel B: Changed Status: Moved On-Track			Panel C: Changed Status: Fell Off Track			Panel D: Changed Status: Moved On-Track		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Intercept	0.202***	0.061***	0.062***	0.148***	0.056***	0.057***	0.342***	0.147***	0.148***	0.180***	0.128***	0.130***
	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
Male		1.381***	1.380***		0.856***	0.856***		1.502***	1.504***		0.804***	0.804***
		(0.028)	(0.028)		(0.011)	(0.011)		(0.020)	(0.020)		(0.011)	(0.011)
Black		1.398***	1.365***		0.646***	0.610***		1.527***	1.534***		0.669***	0.620***
		(0.061)	(0.064)		(0.017)	(0.017)		(0.039)	(0.043)		(0.017)	(0.017)
Hispanic		1.171***	1.202***		0.828***	0.787***		1.144***	1.184***		0.865***	0.802***
		(0.044)	(0.048)		(0.020)	(0.019)		(0.028)	(0.030)		(0.019)	(0.019)
Asian		0.465***	0.484***		1.896***	1.825***		0.590***	0.612***		1.479***	1.395***
		(0.030)	(0.032)		(0.072)	(0.070)		(0.022)	(0.024)		(0.058)	(0.056)
Other Race		1.137***	1.136***		0.848***	0.839***		1.119***	1.122***		0.838***	0.823***
		(0.047)	(0.047)		(0.024)	(0.024)		(0.030)	(0.030)		(0.024)	(0.023)
School Change 6-7th grade		1.350***	1.332***		0.769***	0.788***		1.238***	1.223***		0.851***	0.867***
		(0.055)	(0.053)		(0.025)	(0.025)		(0.031)	(0.030)		(0.021)	(0.021)
School Change 7-8th grade		1.664***	1.633***		0.723***	0.724***		1.349***	1.335***		0.866***	0.871***
		(0.099)	(0.098)		(0.031)	(0.031)		(0.050)	(0.050)		(0.030)	(0.030)
Initial RIT		0.768***	0.769***		1.248***	1.248***		0.816***	0.817***		1.143***	1.143***
		(0.002)	(0.002)		(0.002)	(0.002)		(0.001)	(0.001)		(0.002)	(0.002)
School % FRPL			1.836***			0.635***			1.445***			0.624***
			(0.177)			(0.055)			(0.082)			(0.037)
School % Black			0.852			1.888***			0.819***			1.721***
			(0.092)			(0.177)			(0.055)			(0.113)
School % Hispanic			0.586***			1.976***			0.674***			1.798***
			(0.063)			(0.180)			(0.043)			(0.113)
School % Asian			0.437***			2.200***			0.616***			1.682***
			(0.121)			(0.507)			(0.114)			(0.282)
Students	100425	100425	100425	262771	262771	262771	167240	167240	167240	196238	196238	196238
Schools	4038	4038	4038	5689	5689	5689	4672	4672	4672	5415	5415	5415
Intercept-Variance	0.665	0.643	0.618	0.711	0.798	0.777	0.287	0.224	0.214	0.308	0.258	0.248

Odds ratio robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Samples for Panels A and C include students who were on-track in fall of 6th grade. Samples for Panels B and D include students off-track in fall of 6th grade. Dependent variables are binary (changed=1). Columns (1)-(3) correspond to models (1)-(3) described in the Analysis.

Supplemental Materials

Appendix Table A1. Schools in Analytic Sample vs. Public Schools in NCES

	NWEA Reading Schools				NWEA Math Schools				Public Schools Serving 6th-8th Grade		
	N	M	SD	Stdized. Diff.	N	M	SD	Stdized. Diff.	N	M	SD
6th grade	5,194	118.62	107.40	0.14	5,271	118.61	107.58	0.14	36,086	103.29	108.29
7th grade	4,887	130.58	118.60	0.08	4,948	130.14	118.25	0.08	31,085	119.88	129.18
8th grade	4,767	130.62	118.77	0.09	4,826	130.30	118.58	0.08	31,021	119.67	129.86
Minimum Grade Offered	5,779	3.41	2.97	0.06	5,863	3.39	2.97	0.06	41,433	3.22	3.08
Maximum Grade Offered	5,779	8.23	1.65	-0.02	5,863	8.23	1.65	-0.02	41,433	8.27	2.04
Percent FRPL	5,712	0.54	0.28	-0.02	5,806	0.55	0.28	-0.02	39,971	0.55	0.28
Percent Hispanic	5,779	0.19	0.24	-0.13	5,863	0.19	0.24	-0.12	41,434	0.22	0.27
Percent Black	5,779	0.18	0.28	0.14	5,863	0.18	0.28	0.13	41,434	0.15	0.24
Percent White	5,779	0.54	0.34	0.00	5,863	0.54	0.34	0.00	41,434	0.54	0.34
Percent Asian	5,779	0.03	0.07	-0.05	5,863	0.03	0.07	-0.05	41,434	0.03	0.08
City	5,779	0.31	0.46	0.10	5,863	0.31	0.46	0.09	41,414	0.27	0.44
Suburb	5,779	0.28	0.45	0.00	5,863	0.28	0.45	0.00	41,414	0.28	0.45
Town	5,779	0.12	0.32	0.01	5,863	0.12	0.32	0.01	41,414	0.12	0.32
Rural	5,779	0.29	0.45	-0.10	5,863	0.29	0.45	-0.09	41,414	0.33	0.47

Note. Stdized. Diff. = standardized difference between the NWEA school characteristic and the US public school characteristic.

Appendix Table A2. Imputed Full Sample Characteristics

	Imputed Full Sample	(1) always on-track	(2) always off-track	(3) inconsistently on-track	(4) inconsistently off-track	(5) fell off track	(6) moved on-track
				Math			
N	867,728	164,968	514,182	31,383	52,309	26,570	78,316
% of Sample	100%	19%	59%	4%	6%	3%	9%
Male	51%	54%	51%	52%	50%	56%	47%
White	49%	65%	41%	64%	57%	63%	58%
Black	16%	5%	22%	8%	12%	9%	10%
Hispanic	17%	8%	22%	11%	16%	12%	15%
Asian	4%	11%	2%	5%	3%	3%	5%
Other Race	13%	12%	14%	12%	12%	12%	12%
Initial RIT	215.1	235.5	205.8	228.9	218.9	228.4	220.5
Moving 6th-7th Grade	41%	39%	43%	33%	36%	34%	34%
Moving 7th-8th Grade	26%	23%	28%	20%	20%	18%	21%
% FRPL	49%	33%	57%	40%	46%	42%	44%
% White	54%	64%	48%	63%	59%	63%	59%
% Black	16%	9%	20%	11%	14%	12%	13%
% Hispanic	21%	14%	24%	16%	19%	16%	19%
% Asian	4%	8%	3%	5%	4%	4%	5%
District SES (SD)	0.06	0.59	-0.17	0.36	0.17	0.32	0.22
District %ELL	8%	7%	9%	7%	7%	7%	8%
District %Poverty	13%	10%	14%	11%	12%	11%	12%
District Gini Index	0.38	0.36	0.38	0.36	0.37	0.36	0.37
				Reading			
N	847,576	224,600	358,235	59,676	76,215	74,090	54,760
% of Sample	100%	26%	42%	7%	9%	9%	6%
Male	51%	46%	56%	48%	52%	53%	47%
White	50%	64%	37%	58%	52%	57%	52%
Black	16%	7%	23%	11%	15%	13%	14%
Hispanic	17%	9%	24%	14%	18%	14%	18%
Asian	4%	7%	2%	4%	3%	3%	4%
Other Race	13%	12%	13%	12%	12%	13%	12%
Initial RIT	210.1	226.8	196.5	220.2	208.6	219.2	210.0
Moving 6th-7th Grade	39%	38%	44%	34%	35%	36%	32%
Moving 7th-8th Grade	24%	23%	29%	19%	21%	20%	18%

% FRPL	49%	37%	59%	44%	49%	45%	49%
% White	54%	63%	46%	60%	56%	60%	55%
% Black	16%	11%	21%	13%	16%	14%	15%
% Hispanic	21%	16%	25%	18%	20%	18%	21%
% Asian	4%	6%	3%	4%	4%	4%	4%
District SES (SD)	0.06	0.45	-0.25	0.23	0.08	0.20	0.07
District %ELL	8%	7%	10%	7%	8%	7%	8%
District %Poverty	13%	11%	15%	12%	13%	12%	13%
District Gini Index	0.38	0.36	0.39	0.37	0.37	0.37	0.38

The imputed full sample was constructed using all students who had any test score between 6th and 8th grade. Missing scores were imputed using Stata's -mi impute- command. The mean RIT and standard error of measurement from 10 imputed data sets were averaged, then, using the average scores, students were assigned to trajectory groups. No student or school covariates were missing or imputed. Students were assigned to the school in which they took the most number of tests; when there was a tie in the modal school assignment, the first chronological school was chosen.

Appendix Table A3. Complete-Data Subsample Characteristics

	Students with all 6 terms	(1) always on-track	(2) always off-track	(3) inconsistently on-track	(4) inconsistently off-track	(5) fell off track	(6) moved on-track
				Math			
N	308,282	59,357	161,738	14,338	24,234	13,477	35,138
% of Sample	100%	19%	52%	5%	8%	4%	11%
Male	51%	54%	50%	53%	50%	57%	46%
White	55%	70%	45%	66%	61%	66%	62%
Black	14%	4%	20%	7%	10%	9%	8%
Hispanic	16%	7%	21%	11%	15%	11%	14%
Asian	4%	8%	2%	4%	3%	3%	5%
Other Race	11%	11%	12%	11%	11%	11%	11%
Initial RIT	216.8	235.8	206.8	229.3	218.5	228.7	219.7
Moving 6th-7th Grade	21%	22%	21%	20%	24%	24%	20%
Moving 7th-8th Grade	4%	3%	5%	4%	4%	5%	3%
% FRPL in School	47%	33%	55%	39%	45%	41%	43%
% White in School	59%	68%	53%	66%	62%	65%	62%
% Black in School	15%	9%	18%	11%	13%	11%	12%
% Hispanic in School	18%	13%	21%	15%	17%	15%	18%
% Asian in School	4%	6%	3%	4%	4%	4%	4%
District SES (SD)	0.11	0.57	-0.13	0.36	0.19	0.32	0.21
District %ELL	8%	6%	9%	6%	7%	6%	7%
District %Poverty	13%	10%	14%	11%	12%	11%	12%
District Gini Index	0.37	0.36	0.38	0.36	0.37	0.36	0.37
				Reading			
N	308,684	83,432	103,424	27,800	33,389	34,109	26,530
% of Sample	100%	27%	34%	9%	11%	11%	9%
Male	51%	45%	56%	48%	52%	54%	47%
White	55%	68%	41%	62%	55%	61%	55%
Black	13%	6%	21%	10%	14%	12%	12%
Hispanic	16%	8%	24%	13%	17%	13%	18%
Asian	4%	8%	2%	4%	3%	3%	4%
Other Race	11%	11%	12%	11%	11%	12%	11%
Initial RIT	212.1	227.5	197.0	220.7	208.0	219.8	209.1
Moving 6th-7th Grade	21%	20%	21%	21%	21%	22%	19%
Moving 7th-8th Grade	4%	3%	5%	4%	4%	5%	4%

% FRPL in School	46%	35%	57%	42%	47%	43%	47%
% White in School	59%	66%	50%	63%	59%	63%	58%
% Black in School	14%	10%	19%	12%	14%	13%	14%
% Hispanic in School	18%	14%	23%	16%	18%	16%	19%
% Asian in School	4%	6%	3%	4%	4%	4%	4%
District SES (SD)	0.14	0.50	-0.20	0.27	0.11	0.26	0.10
District %ELL	8%	6%	9%	7%	7%	7%	8%
District %Poverty	12%	10%	14%	11%	12%	11%	13%
District Gini Index	0.37	0.36	0.38	0.37	0.37	0.37	0.37

The complete-data subgroup refers to students who had test scores for all 6 terms (fall of 6th grade through spring of 8th grade). Students were assigned to the school in which they took the most number of tests; when there was a tie in the modal school assignment, the first chronological school was chosen.

Appendix Table A4. MAP Growth Benchmarks

	Fall 6th Grade	Spring 6th Grade	Fall 7th Grade	Spring 7th Grade	Fall 8th Grade	Spring 8th Grade
Math						
Benchmark	225.30	232.34	232.20	238.06	238.00	242.73
Benchmark Percentile	68	66	71	70	74	74
Mean RIT (Analytic Sample)	216.43	225.01	223.22	230.30	229.26	234.81
Mean Percentile (Analytic Sample)	47	49	51	54	57	58
Percent Met Benchmark	28%	34%	30%	35%	32%	34%
Reading						
Benchmark	214.97	219.59	219.83	223.73	223.88	227.10
Benchmark Percentile	61	61	64	65	67	67
Mean RIT (Analytic Sample)	211.71	216.83	216.19	220.61	220.22	223.60
Mean Percentile (Analytic Sample)	52	53	55	56	58	59
Percent Met Benchmark	46%	47%	45%	46%	44%	44%

Appendix Table A5. Analytic Sample Math and Reading Trajectory Group Membership

Math Trajectory Group	Reading Trajectory Group: always on-track	always off-track	inconsistently on-track	inconsistently off-track	fell off track	moved on-track	Total
always on-track	49,233	529	5,490	1,607	4,510	2,699	64,068
%	76.84	0.83	8.57	2.51	7.04	4.21	100
always off-track	7,988	106,844	9,724	22,671	17,276	14,372	178,875
%	4.47	59.73	5.44	13	10	8	100
inconsistently on-track	6,700	713	2,697	1,175	2,313	1,394	14,992
%	44.69	4.76	17.99	7.84	15.43	9.3	100
inconsistently off-track	5,508	4,356	3,408	4,329	4,756	3,324	25,681
%	21.45	16.96	13.27	16.86	18.52	12.94	100
fell off track	4,357	1,594	2,238	1,720	3,773	1,049	14,731
%	29.58	10.82	15.19	11.68	25.61	7.12	100
moved on-track	13,863	3,603	5,670	4,244	4,120	6,375	37,875
%	36.6	9.51	14.97	11.21	10.88	16.83	100
Total	87,649	117,639	29,227	35,746	36,748	29,213	336,222
%	26.07	34.99	8.69	10.63	10.93	8.69	100

Notes: The analytic sample in this table (N=336,222) includes students who had test scores in fall of 6th grade, at least one term in 7th grade, and spring of 8th grade in both math and reading. About 52% of students in the sample had the same trajectory in both subjects. Percentages are of math groups (e.g., 76.8% of the 64,068 students who were always on-track for math were also always on-track for reading; 0.83% of the students who were always on-track for math were always off-track for reading); each row of percentages sums up to 100% of the corresponding math trajectory group.

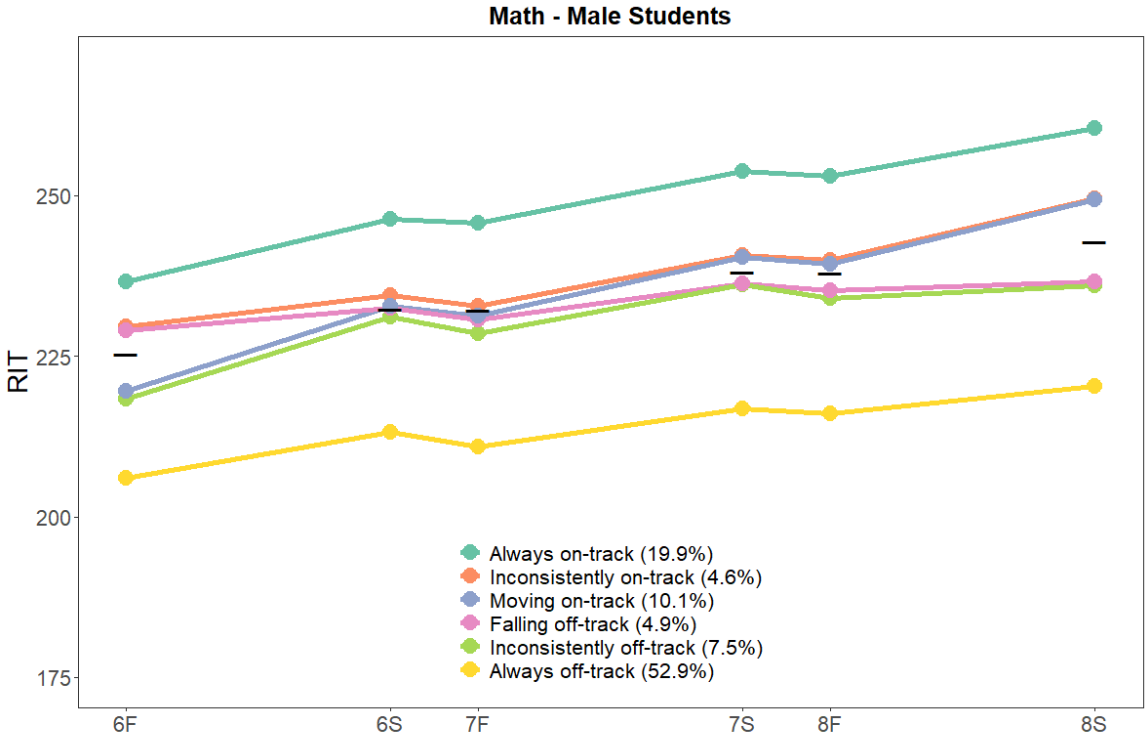
Appendix Table A6. HLM Estimates for Predicting Changing Status (Fell off Track or Moved On-Track), Comparing All 3 Samples

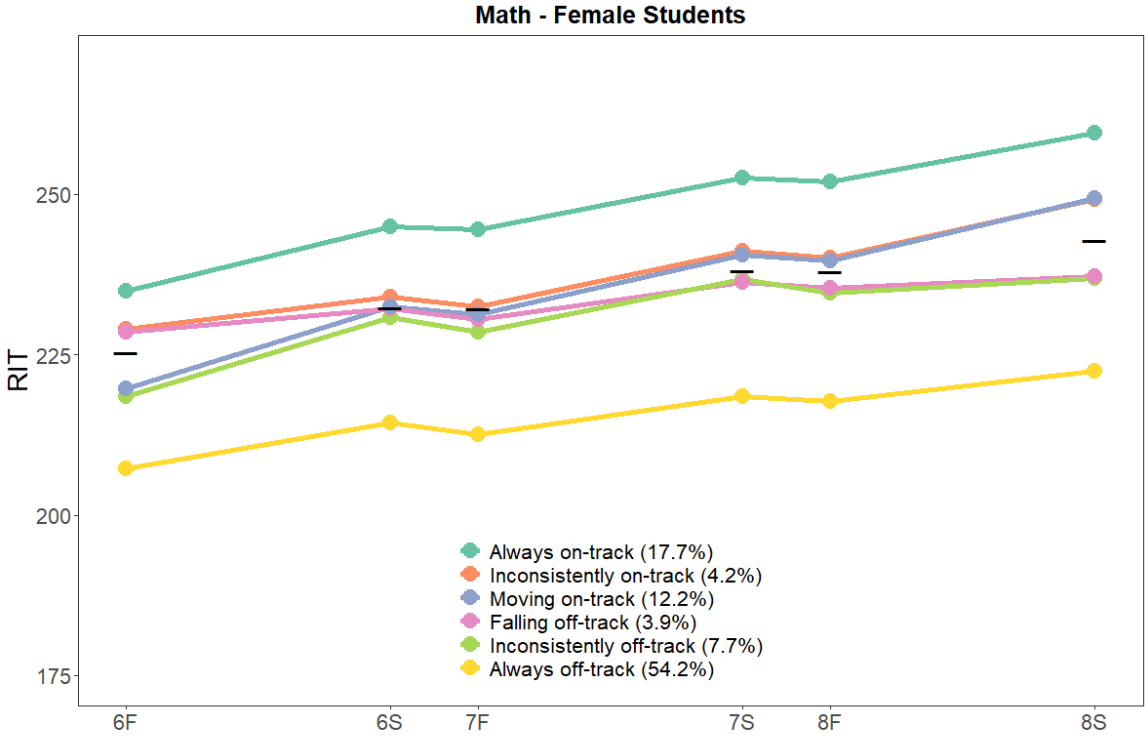
	Math						Reading					
	Panel A: Changed Status: Fell Off Track			Panel B: Changed Status: Moved On-Track			Panel C: Changed Status: Fell Off Track			Panel D: Changed Status: Moved On-Track		
	(1) Imputed Full Sample	(2) Analytic Sample	(3) Complete-Data Subsample	(1) Imputed Full Sample	(2) Analytic Sample	(3) Complete-Data Subsample	(1) Imputed Full Sample	(2) Analytic Sample	(3) Complete-Data Subsample	(1) Imputed Full Sample	(2) Analytic Sample	(3) Complete-Data Subsample
Intercept	0.048***	0.062***	0.061***	0.022***	0.057***	0.059***	0.127***	0.148***	0.149***	0.062***	0.130***	0.133***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.001)	(0.003)	(0.003)
Male	1.326***	1.380***	1.382***	0.890***	0.856***	0.851***	1.363***	1.504***	1.505***	0.849***	0.804***	0.804***
	(0.020)	(0.028)	(0.030)	(0.009)	(0.011)	(0.012)	(0.013)	(0.020)	(0.022)	(0.009)	(0.011)	(0.012)
Black	1.312***	1.365***	1.399***	0.669***	0.610***	0.603***	1.426***	1.534***	1.561***	0.663***	0.620***	0.619***
	(0.045)	(0.064)	(0.072)	(0.013)	(0.017)	(0.018)	(0.029)	(0.043)	(0.047)	(0.013)	(0.017)	(0.019)
Hispanic	1.171***	1.202***	1.202***	0.801***	0.787***	0.785***	1.207***	1.184***	1.192***	0.827***	0.802***	0.800***
	(0.034)	(0.048)	(0.052)	(0.014)	(0.019)	(0.021)	(0.022)	(0.030)	(0.033)	(0.014)	(0.019)	(0.020)
Asian	0.521***	0.484***	0.484***	1.664***	1.825***	1.821***	0.678***	0.612***	0.603***	1.338***	1.395***	1.418***
	(0.024)	(0.032)	(0.035)	(0.045)	(0.070)	(0.075)	(0.018)	(0.024)	(0.025)	(0.037)	(0.056)	(0.063)
Other Race	1.057*	1.136***	1.140***	0.848***	0.839***	0.850***	1.115***	1.122***	1.126***	0.810***	0.823***	0.822***
	(0.031)	(0.047)	(0.051)	(0.017)	(0.024)	(0.026)	(0.021)	(0.030)	(0.032)	(0.016)	(0.023)	(0.025)
Changed Schools 6th-7th grade	0.757***	1.332***	1.348***	0.667***	0.788***	0.788***	0.859***	1.223***	1.210***	0.618***	0.867***	0.848***
	(0.018)	(0.053)	(0.060)	(0.011)	(0.025)	(0.028)	(0.012)	(0.030)	(0.033)	(0.009)	(0.021)	(0.023)
Changed Schools 7th-8th grade	0.741***	1.633***	1.457***	0.764***	0.724***	0.774***	0.809***	1.335***	1.289***	0.620***	0.871***	0.874***
	(0.021)	(0.098)	(0.103)	(0.014)	(0.031)	(0.038)	(0.012)	(0.050)	(0.057)	(0.010)	(0.030)	(0.037)
Initial RIT	0.744***	0.769***	0.768***	1.317***	1.248***	1.251***	0.785***	0.817***	0.817***	1.196***	1.143***	1.145***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
% FRPL in school	1.873***	1.836***	1.875***	0.643***	0.635***	0.651***	1.535***	1.445***	1.496***	0.675***	0.624***	0.605***
	(0.131)	(0.177)	(0.196)	(0.036)	(0.055)	(0.060)	(0.065)	(0.082)	(0.089)	(0.028)	(0.037)	(0.037)

% Black in school	0.762***	0.852	0.863	1.472***	1.888***	1.617***	0.702***	0.819***	0.826***	1.392***	1.721***	1.666***
	(0.060)	(0.092)	(0.102)	(0.088)	(0.177)	(0.162)	(0.034)	(0.055)	(0.060)	(0.065)	(0.113)	(0.117)
% Hispanic in school	0.561***	0.586***	0.654***	1.575***	1.976***	1.677***	0.623***	0.674***	0.725***	1.330***	1.798***	1.617***
	(0.043)	(0.063)	(0.078)	(0.093)	(0.180)	(0.168)	(0.029)	(0.043)	(0.050)	(0.060)	(0.113)	(0.109)
% Asian in school	0.323***	0.437***	0.481**	1.542***	2.200***	1.987***	0.486***	0.616***	0.644**	1.463***	1.682***	1.509**
	(0.060)	(0.121)	(0.153)	(0.208)	(0.507)	(0.471)	(0.067)	(0.114)	(0.128)	(0.179)	(0.282)	(0.272)
Students	222,791	100,425	87,105	643,991	262,771	220,794	358,105	167,240	145,211	488,595	196,238	163,091
Schools	7,322	4,038	3,350	8,649	5,689	4,576	7,945	4,672	3,783	8,418	5,415	4,341
Intercept-Variance	0.584	0.618	0.623	0.539	0.777	0.763	0.216	0.214	0.200	0.235	0.248	0.229

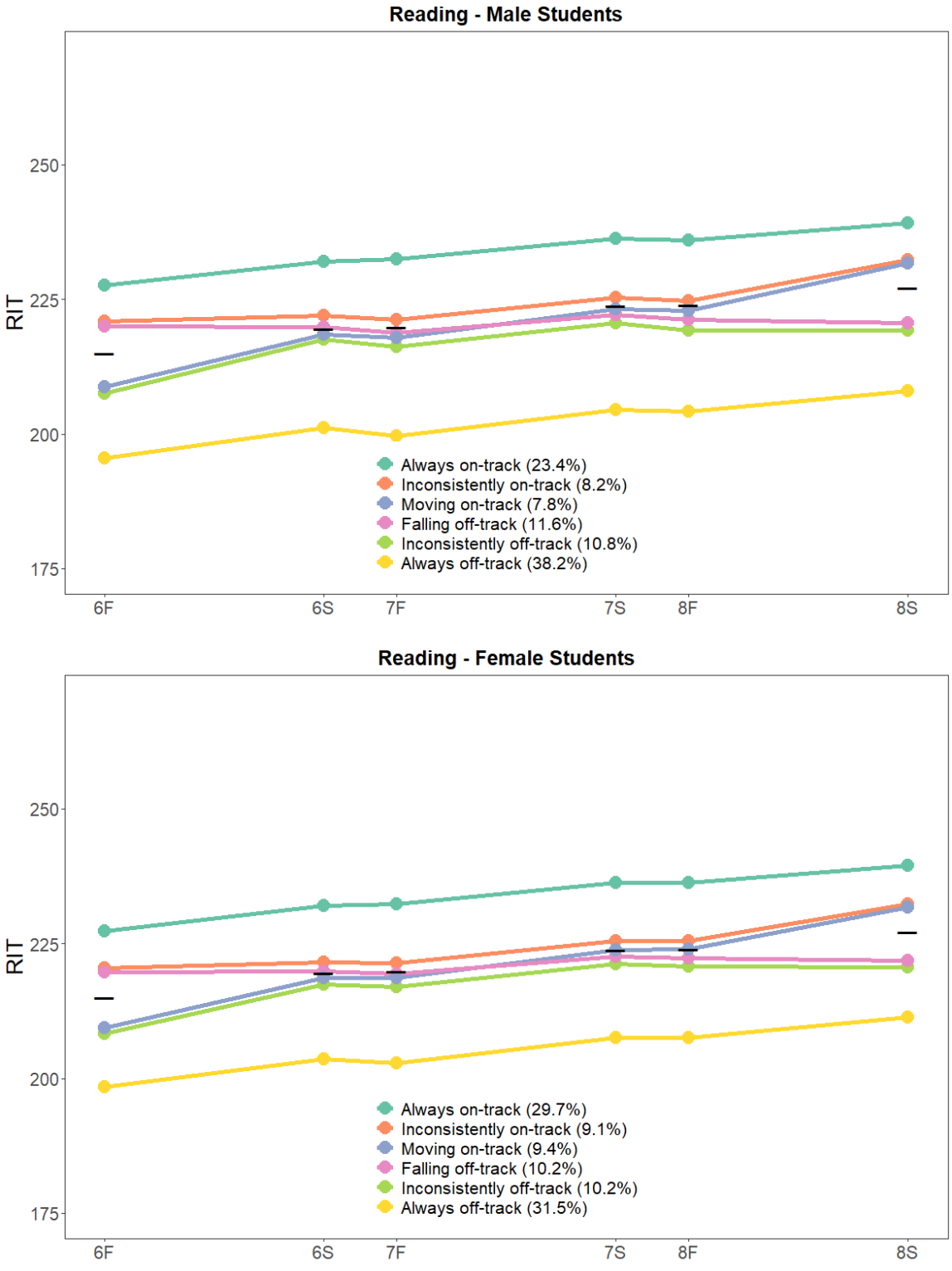
Odds ratio robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Samples for Panels A and C include students who were on-track in fall of 6th grade. Samples for Panels B and D include students off-track in fall of 6th grade. Dependent variables are binary (changed=1). Columns (1)-(3) correspond to models (1)-(3) described in the Analysis. The imputed full sample was constructed using all students who had any test score between 6th and 8th grade. Missing scores were imputed using Stata's -mi impute- command. The mean RIT and standard error of measurement from 10 imputed data sets were averaged, then, using the average scores, students were assigned to trajectory groups. The analytic sample includes students who had test scores for fall of 6th grade, at least one score in 7th grade, and spring of 8th grade. The complete-data subgroup refers to students who had test scores for all 6 terms (fall of 6th grade through spring of 8th grade).

Appendix Figure A1. Growth Trajectories by Gender

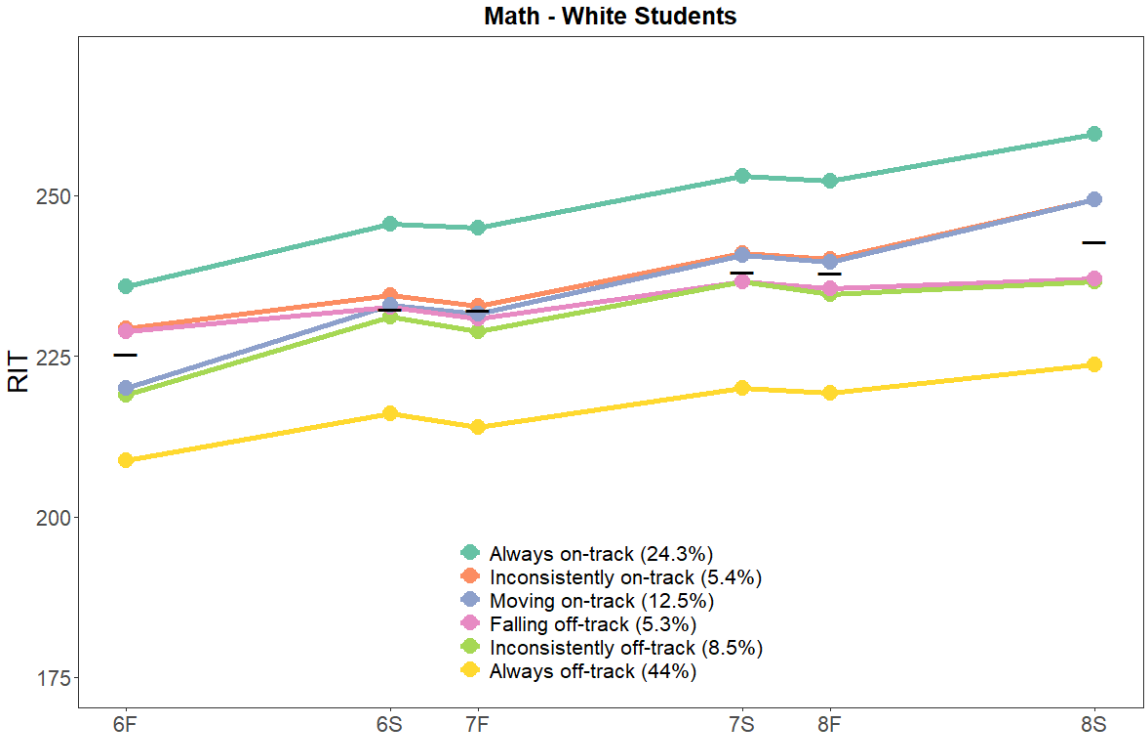


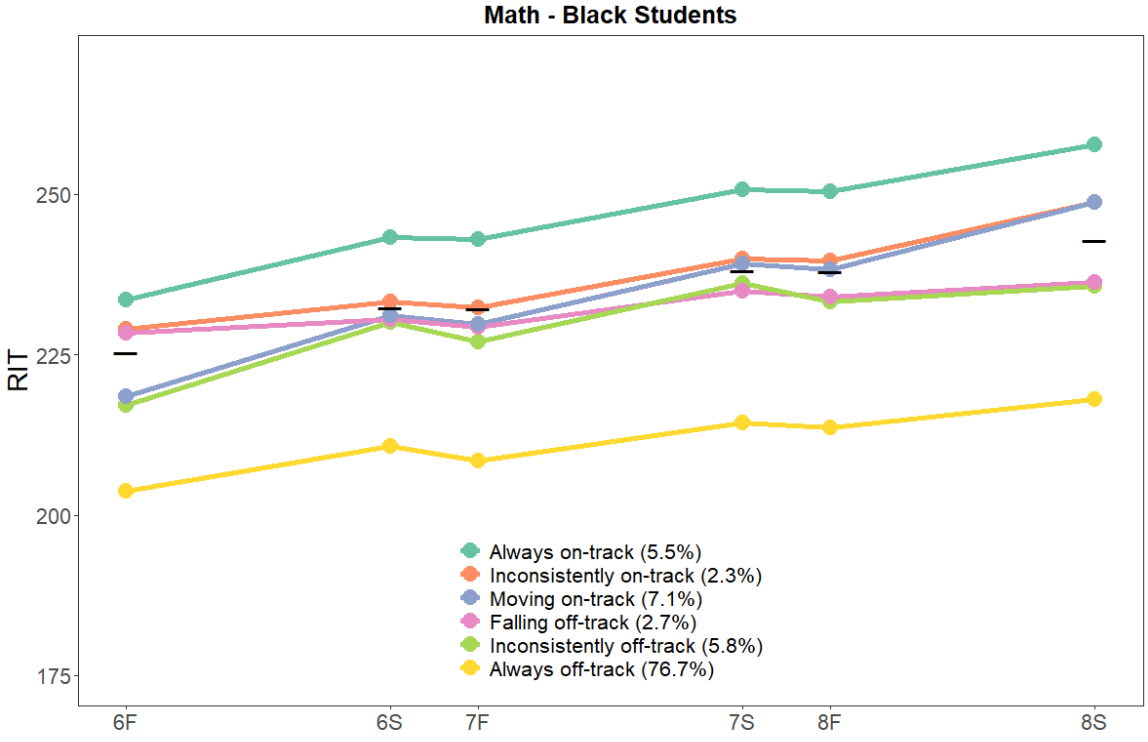


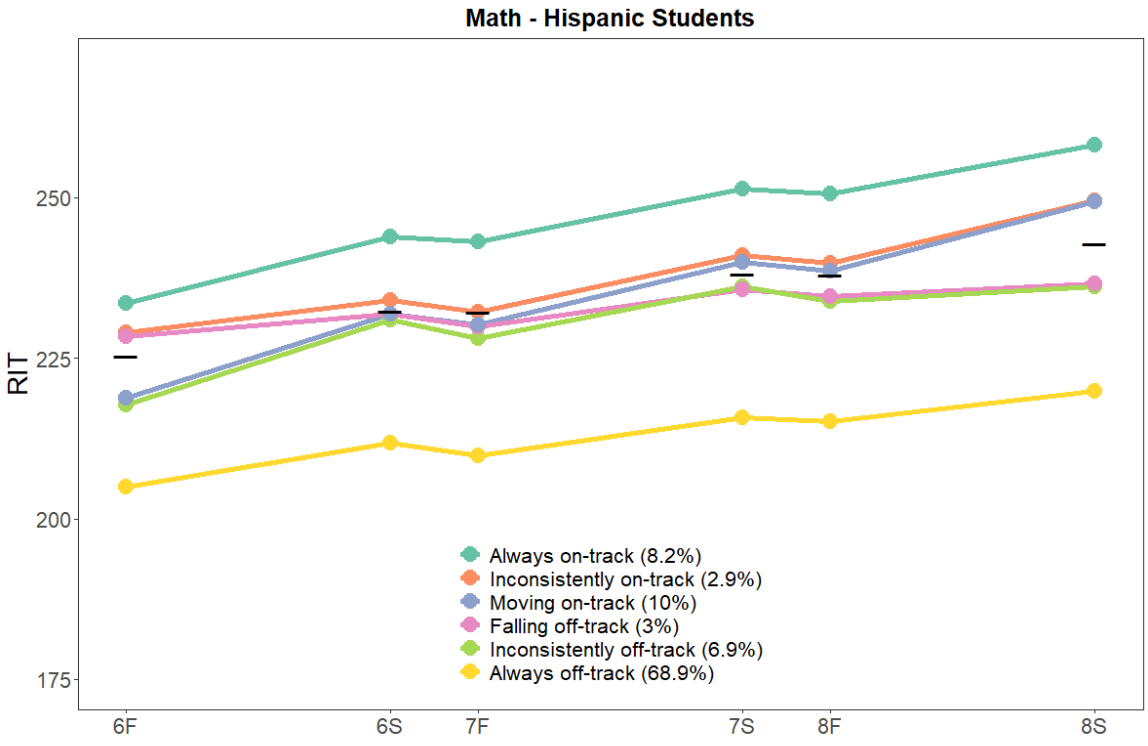
Appendix Figure A1. Growth Trajectories by Gender

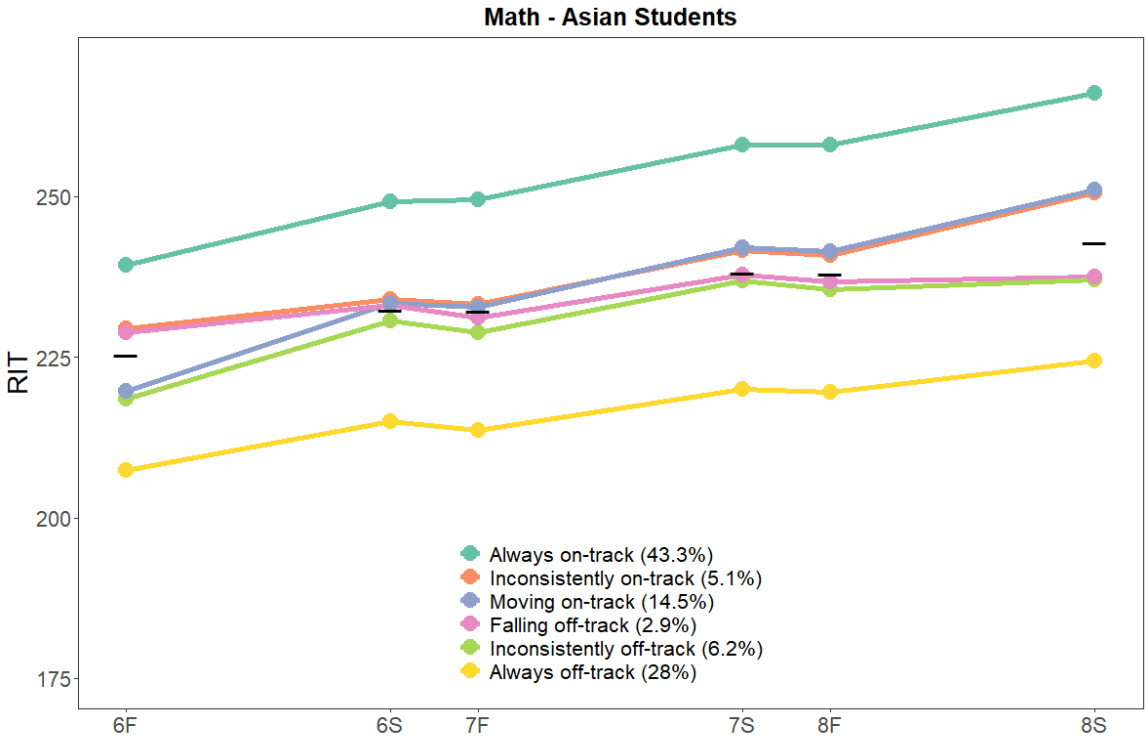


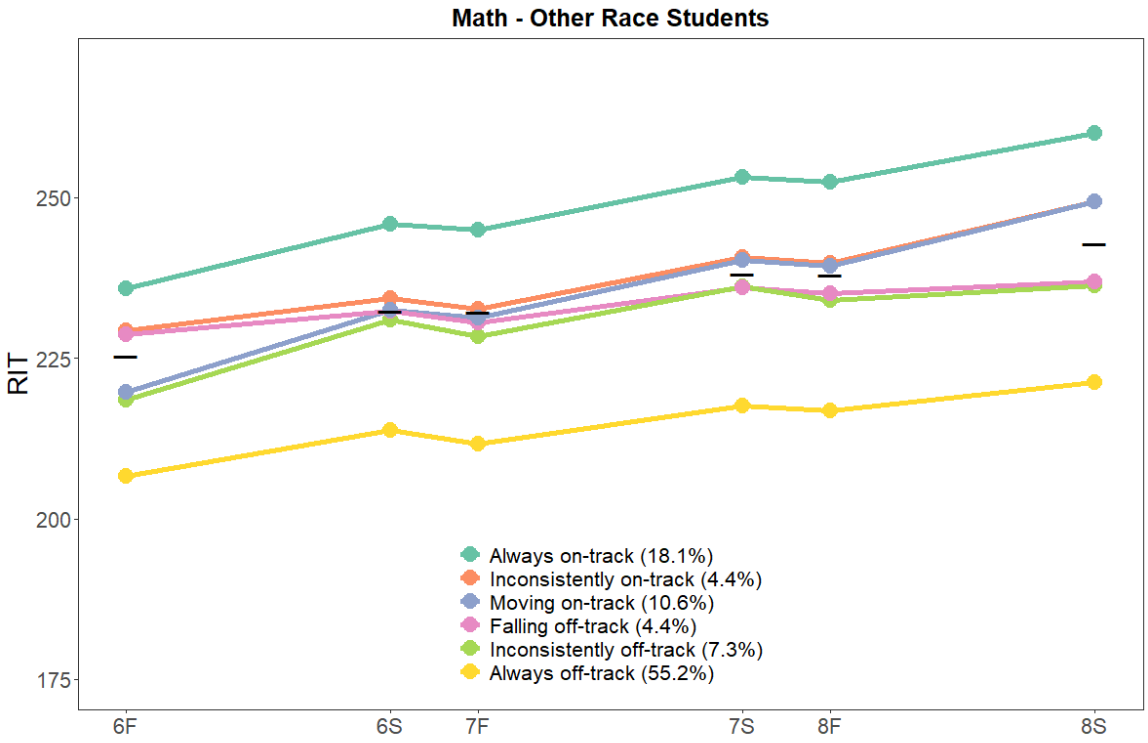
Appendix Figure A2. Math Growth Trajectories by Race/Ethnicity

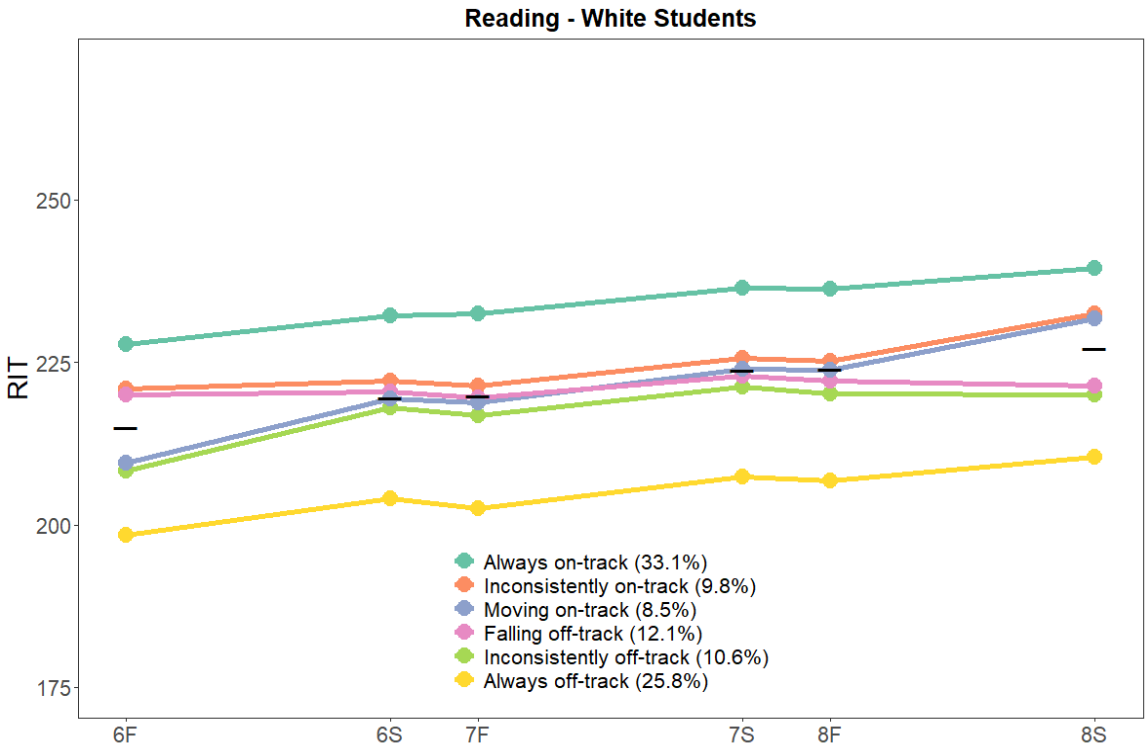


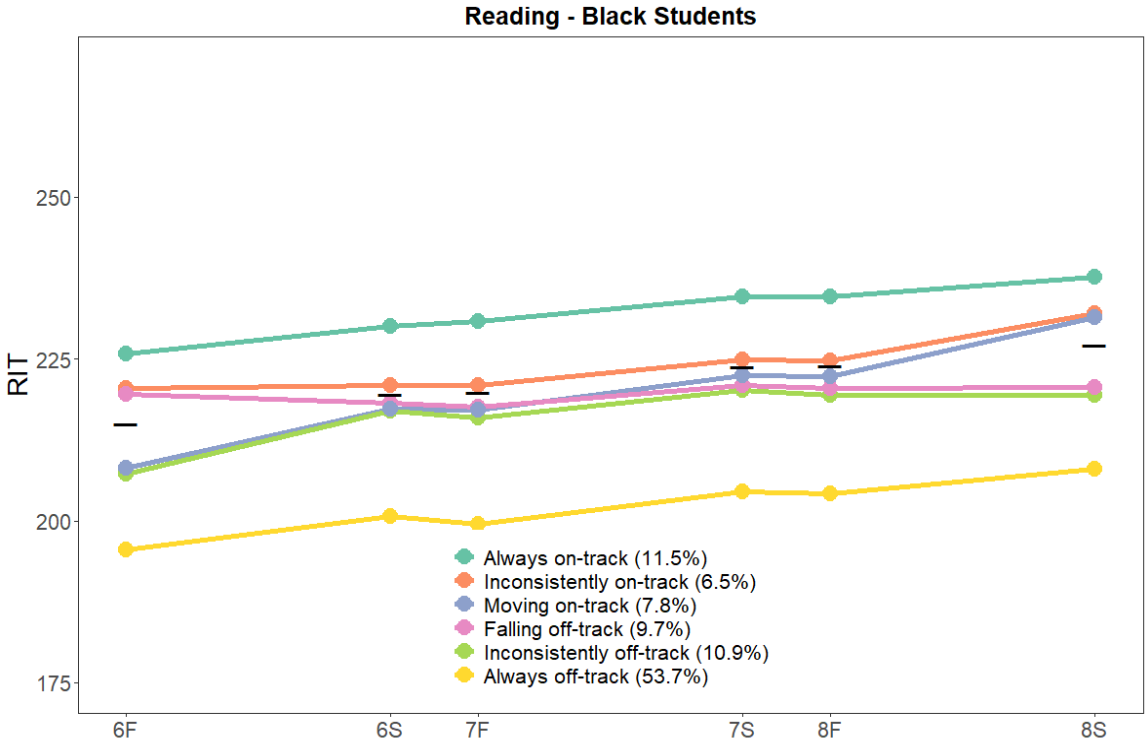


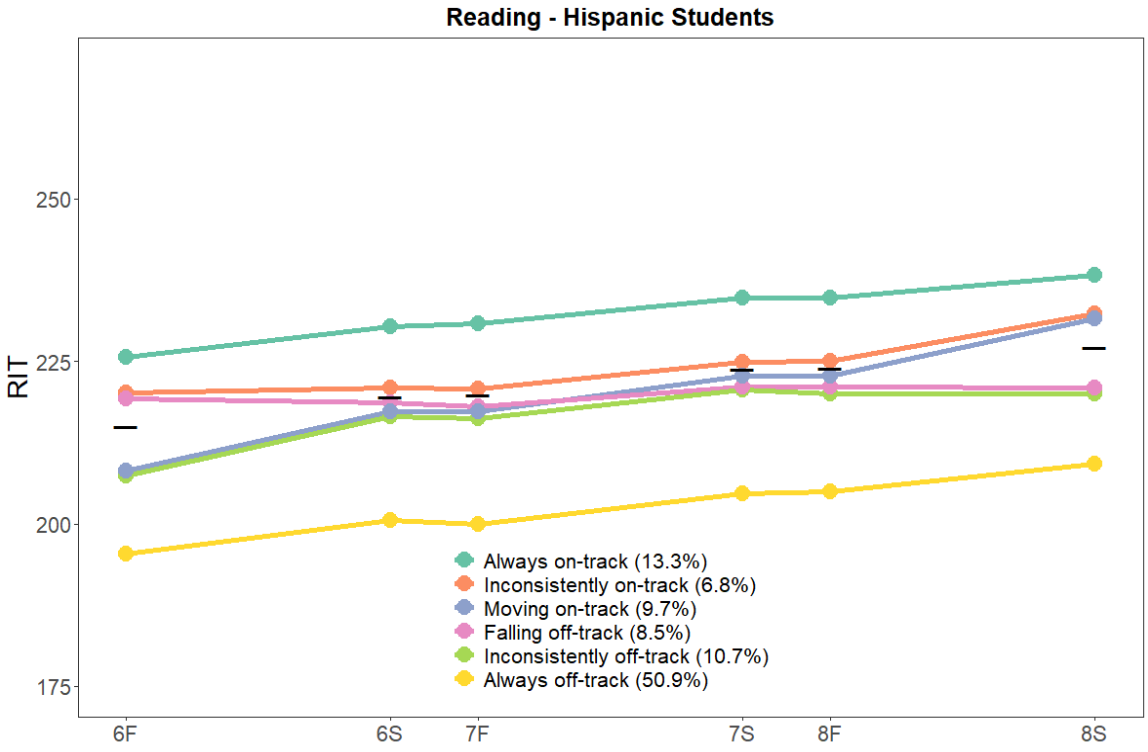

Math - Hispanic Students
RIT
250
225
200
175
6F
6S
7F
7S
8F
8S
Always on-track (8.2%)
Inconsistently on-track (2.9%)
Moving on-track (10%)
Falling off-track (3%)
Inconsistently off-track (6.9%)
Always off-track (68.9%)

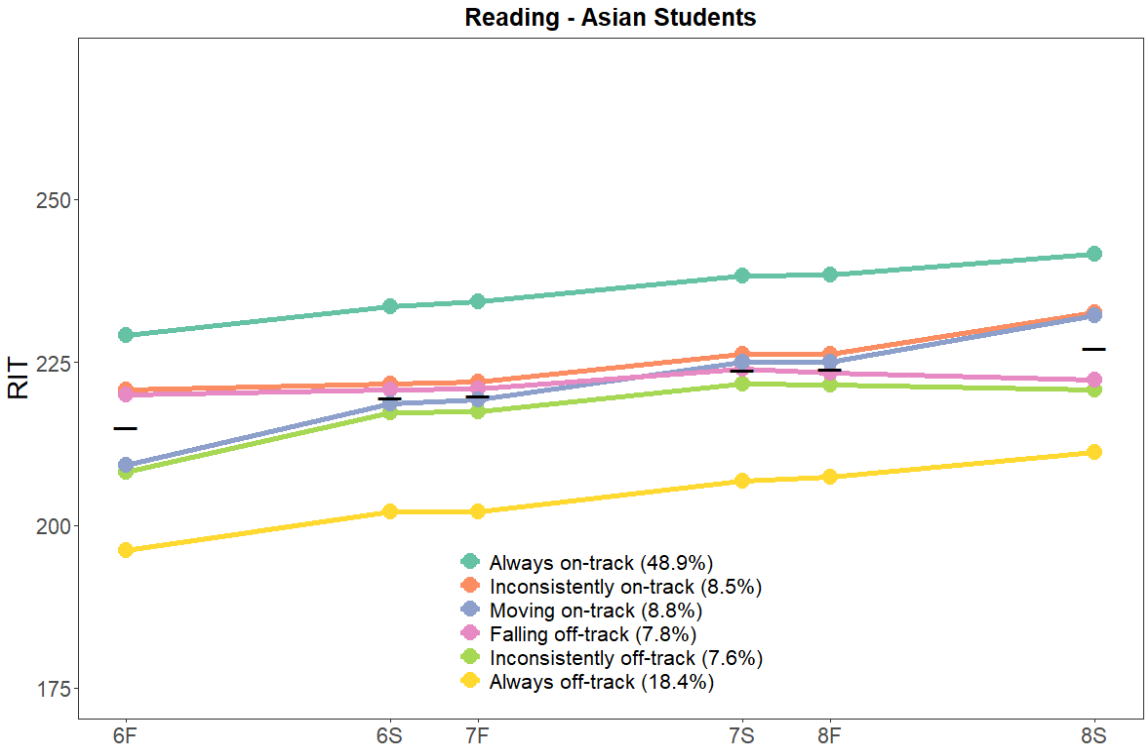

Math - Asian Students
RIT
250
225
200
175
6F
6S
7F
7S
8F
8S
Always on-track (43.3%)
Inconsistently on-track (5.1%)
Moving on-track (14.5%)
Falling off-track (2.9%)
Inconsistently off-track (6.2%)
Always off-track (28%)

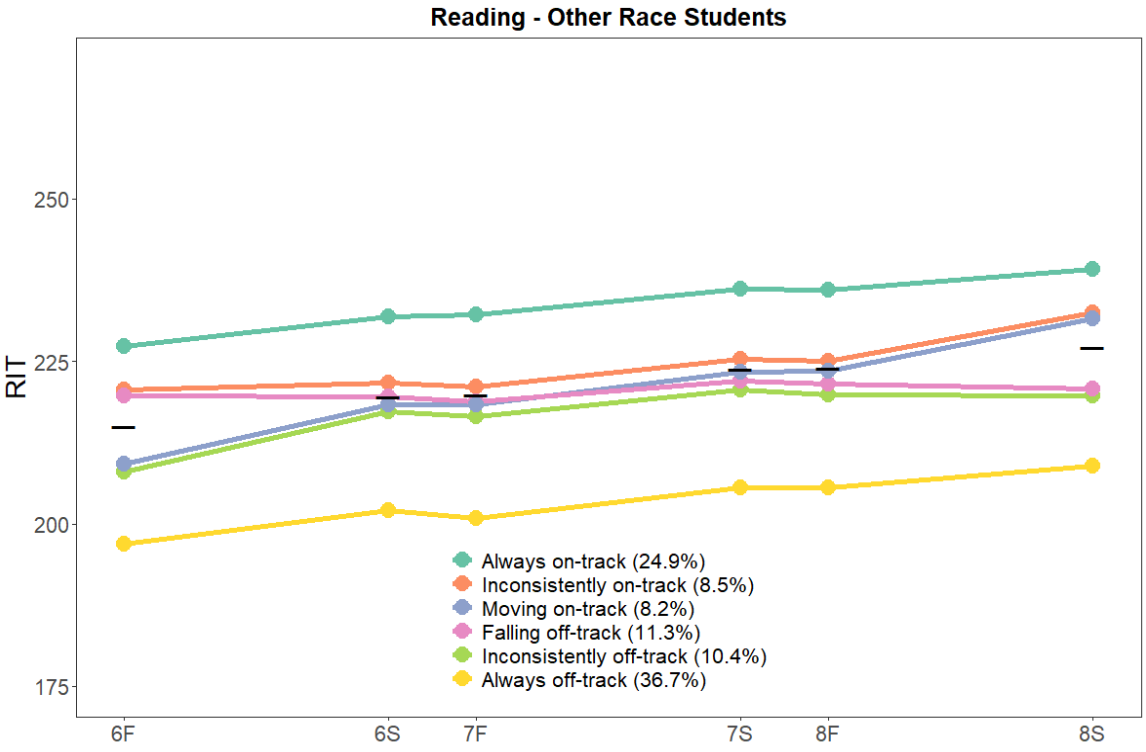

Math - Other Race Students
RIT
250
225
200
175
6F
6S
7F
7S
8F
8S
Always on-track (18.1%)
Inconsistently on-track (4.4%)
Moving on-track (10.6%)
Falling off-track (4.4%)
Inconsistently off-track (7.3%)
Always off-track (55.2%)


Reading - White Students
RIT
250
225
200
175
6F
6S
7F
7S
8F
8S
Always on-track (33.1%)
Inconsistently on-track (9.8%)
Moving on-track (8.5%)
Falling off-track (12.1%)
Inconsistently off-track (10.6%)
Always off-track (25.8%)


Reading - Black Students
RIT
250
225
200
175
6F
6S
7F
7S
8F
8S
Always on-track (11.5%)
Inconsistently on-track (6.5%)
Moving on-track (7.8%)
Falling off-track (9.7%)
Inconsistently off-track (10.9%)
Always off-track (53.7%)


Reading - Hispanic Students
RIT
250
225
200
175
6F
6S
7F
7S
8F
8S
Always on-track (13.3%)
Inconsistently on-track (6.8%)
Moving on-track (9.7%)
Falling off-track (8.5%)
Inconsistently off-track (10.7%)
Always off-track (50.9%)


Reading - Asian Students
RIT
250
225
200
175
6F
6S
7F
7S
8F
8S
Always on-track (48.9%)
Inconsistently on-track (8.5%)
Moving on-track (8.8%)
Falling off-track (7.8%)
Inconsistently off-track (7.6%)
Always off-track (18.4%)


Reading - Other Race Students
RIT
250
225
200
175
6F
6S
7F
7S
8F
8S
Always on-track (24.9%)
Inconsistently on-track (8.5%)
Moving on-track (8.2%)
Falling off-track (11.3%)
Inconsistently off-track (10.4%)
Always off-track (36.7%)