TRAJECTORIES OF ADVANCED MATH TAKING FOR LOW-INCOME STUDENTS OF COLOR IN MIDDLE AND HIGH SCHOOL

by

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A Dissertation
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of
Doctor of Philosophy
Psychology

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George Mason University
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DEDICATION

This is dedicated to my parents, John and Champayne.

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I would like to thank the many friends, relatives, and supporters who have made this happen. Drs. Winsler, Kornienko, and Frank for their constant support and guidance. Alenamie and Jordan for the thousands of conversations that improved my work and my life. Jerry, Angelique, and Naomi for being friends, cheerleaders, and teachers throughout this journey. My parents, my brother, Ben, and Laurel – my family without whom none of this would be possible. And finally, to my village, too large to be named but who have been invaluable at every step of this process. Thank you.

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ABSTRACT

TRAJECTORIES OF ADVANCED MATH TAKING FOR LOW-INCOME STUDENTS OF COLOR IN MIDDLE AND HIGH SCHOOL

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George Mason University, 2021

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Differential access to and enrollment in advanced mathematics for historically underrepresented groups is a pervasive problem in education. Access to advanced coursework is associated with positive postsecondary outcomes including college acceptance, retention, graduation and more. However, current research examining this problem primarily focuses on achievement in this domain rather than access. This necessitates an examination of who is accessing advanced coursework and what differentiates the course trajectories students follow across middle and high school.

This dissertation sought to explore what pathways students were following in advanced math coursework across middle and high school and how demographics, school readiness, and prior academic achievement related to pathways followed. These questions were answered using a large-scale (N = 18,841), majority Latinx (57.6% Latinx, 35.5% Black, 6.1% White/Other, and .6% Asian/Pacific Islander) and low-income sample

(77.3% on free or reduced-price lunch in 6th grade) from the Miami School Readiness Project. Latent class analysis (LCA) was used to categorize students into 6 classes, which in this study represented the commonly followed pathways of advanced math taking. The 6 class pathways which emerged were *Always Standard* (standard math in middle and high school), *Early Advanced Tryer* (advanced in middle school, standard in high school), *Late Honors Tryer* (standard in middle school, honors in high school), *Consistently Mid-level Advanced* (advanced in middle school, honors in high school), *Primarily Advanced with some College Level* (advanced in middle school, standard with some college level in high school), and *Most/Earliest Advanced* (honors in middle school, standard and some college level in high school).

Following this, multinomial logistic regression was used to connect individual demographics, school readiness skills, and prior academic achievement to the likelihood of being assigned to a particular class trajectory. Results revealed that prior academic performance was most strongly related to advanced math pathway assignment, but even when controlling for this variance, gender, special education status, and cognitive and fine motor skills at age 4 also impacted what math pathway a student was likely to follow in middle and high school. Race/ethnicity was a significant differentiator when comparing the two most advanced pathways. These findings highlight the importance of early school readiness skills and demonstrate how early opportunity gaps impact later student outcomes. Furthermore, this project illustrates how tailored intervention and supports are necessary to ensure equitable access to coursework and programming which expands a student's opportunities and chances for postsecondary success.

INTRODUCTION

Access to advanced coursework has become a topic of great interest in recent years. Though advanced coursework is considered integral to the successful application process at many colleges and universities (Conger et al., 2009), access to these spaces of excellence have historically, and currently, been distributed disproportionately. Research around advanced course taking and the excellence gap – the notion that there are disparities in the highest levels of achievement – thoroughly documents gaps in identification for gifted programs (Yaluma & Tyner, 2018), in scoring among the top percentiles on international tests (Plucker & Peters, 2016), and in access to and success in advanced coursework itself (Graefe & Ritchotte, 2019; Ricciardi & Winsler, 2021). What many of these studies don't or can't account for however, is the fact that students must first be present in advanced courses/programs before they can be successful in them and that without access to advanced spaces early, they can't reach or achieve higher levels later. Thus, this study aims to address this critical gap by focusing on early access to advanced mathematics in middle and high school, longitudinally.

By focusing on enrollment in advanced courses, I aim to illuminate major pathways in advanced mathematics that students are currently following, and then break those down to understand the common characteristics of students on each path and which child-level factors influence path membership. This way, pathway-specific intervention can be designed to support the pursuit of advanced coursework among those qualified – regardless of background. To do this, I integrated person- and variable-centered methods to first organize advanced mathematics taking into pathways via latent class analysis, and then to understand how child-level variables impacted the odds of class membership through multinomial regression.

Although gaps in accessing spaces of advanced academics are widely discussed as a problem in education, it is important to note that these spaces reflect a definition and a system for success shaped by institutional racism, classism, and sexism. In essence, schools are White, institutionalized spaces that have been historically shaped by – and continue to be shaped by – systemic and institutional racism (McGee, 2020). Furthermore, advanced courses and pathways have been used as tools to perpetuate informal segregation within schools (Lucas, 2001). Given this, the focus of this dissertation will be on advanced coursework as an opportunity for skill development and as a gateway to postsecondary access and success. Further, this work centers potential structural-level solutions rather than focusing on student agency.

What is the Excellence Gap and Why is it Important?

The excellence gap refers to disparities in representation in spaces of, and on measures of, academic excellence (Plucker & Peters, 2016). The excellence gap encompasses differences among top test scorers on national and international tests, differences in proportions of students who attend elite colleges, and differences in the likelihood of maintaining advanced statuses once obtained. Evidence of the excellence gap can be seen along economic lines (Theokas & Saaris, 2013), racial lines (Kolluri, 2018), urban-rural lines (Hernández-Torrano, 2018) and English language learner status lines (Kanno & Kangas, 2014). For example, Black students comprised 14.5% of high school graduates, but only 9.2% of Advanced Placement (AP) test takers in 2013, while Asian students comprised 5.9% of the student population and 10.7% of AP test takers in 2013 (College Board, 2014). Likewise, Wakelyn and the National Governors Association (2010) reported that only 16% of low-income students have taken an AP or IB course, while 51% of non-low-income students take these courses (Moore & Slate, 2008). Ramifications of these and similar disparities in excellence are far reaching.

AP is considered the most widespread opportunity for college preparation in the United States (James et al., 2017), but access to it is not equal. Contemporaneously, it is expected that over 60% of new jobs will require postsecondary education by 2025 (The Lumina Foundation, 2016). If access to the coursework and preparation which aids both admittance and persistence in college (Mattern et al., 2009; Scott et al., 2010) continues to exclude students who have been historically underrepresented in these courses, it is unlikely that these jobs will be filled. Highlighting this, over two million jobs in STEM fields went unfilled due to lack of qualified applicants in 2018 (Smithsonian Science Education Center, 2019).

The excellence gap is also important because adolescence is a critical time for identity development (Dahl et al., 2018), and school is a critical setting in which academic development occurs (Crosnoe & Benner, 2015). Students should have every opportunity to build their self-conceptions and sense of academic belonging in this critical time. Academic belonging refers to student’s perceptions of their own ability to meet high academic standards and their sense of belonging among intelligent peers (Bjorklund, 2019). Access to advanced classes can promote the development of academic belonging through encouraging confidence and equipping students with experiences they can leverage for future success. To illustrate, teachers of AP courses prioritize fostering confidence and facilitating college-level experiences for students, and AP coursework is characterized by assignments that foster critical thinking (Judson, 2017; Judson et al., 2019).

In this dissertation, I shift from the more popular definition of the excellence gap, which is focused on traditional measures of *achievement*, to the occupation of spaces labeled as excellent. I am not the first to conceptualize the excellence gap this way. Though many excellence gap studies focus on top test scores, some do emphasize occupation of advanced spaces, such as differences between groups of students who pursue advanced degrees or attend top-tier universities (National Assessment of Education Progress, 2015). For the purposes of this study, advanced math courses include middle school advanced courses (ADV), honors courses, advanced placement (AP), and dual enrollment (DE) courses. These courses move faster and cover more material than traditional courses. AP and DE courses are considered equivalent to college-level in difficultly and can result in college credit. Occupancy of these spaces is significant because they are a societal marker of merit and because they function as a gateway to opportunity. In this way, enrollment in advanced math courses is a representation of the excellence gap as both a measure of achievement itself and as a facilitator of further opportunities for excellence (Domina et al., 2016).

A Marker of Achievement. Advanced coursework is used as a marker of achievement and academic rigor by universities and colleges when making admissions decisions (Conger et al., 2009; Solorzano & Ornelas, 2004). AP course enrollment specifically is frequently considered an indicator of excellence in a subject area (Hallett & Venegas, 2011). A societal shift toward emphasizing math education (Warburton & Buendia, 2016) and preparing students for STEM careers (Smithsonian Science Education Center, 2019) means that advanced math taking has become a more important marker of excellence than ever.

A Gateway to Opportunity. At the same time, advanced courses are critical to accessing later opportunities for achievement. To gain admission to AP and DE courses, students need to be prepared and have accessed advanced courses in early grades like ADV and honors (Plucker & Peters, 2018). In turn, taking advanced courses is related to higher college readiness test scores (Warne et al., 2015), college admission (Warne et al., 2015), college performance and persistence (Mattern et al., 2009; Scott et al., 2010) and postsecondary careers and income (Domina et al., 2016; Flowers, 2008).

Advanced Math Taking as a Measure of the Excellence Gap

I focus on pathways of advanced math taking for two main reasons. First, because math is considered an increasingly important subject in today's society (Warburton & Buendia, 2016). To illustrate, Algebra 1 is often considered a gatekeeper to later academic achievement both in general and in STEM specifically (Adelman, 2006; American Institute of Research (AIR), 2017; Moses et al., 1989; Riegle-Crumb, 2006; U.S. Department of Education, 2019). In addition, the timing of enrollment in Algebra 1 has also been linked to postsecondary enrollment rates, suggesting that timing of math courses has a real impact on students' futures (U.S. Department of Education, 2019).

Second, I focus on math because doing so facilitates the cleanest analyses for this project. The generally linear progression of math, where most students in this district will follow the same or exceptionally similar sequences of mathematics coursework, reduces the variation in course content and allows us to better capture variation in levels of advancement specifically. Further, in many school districts in the United States, math is required in most if not all years a student is enrolled in school. Together, these structural aspects of math make it a good place to begin to understand how students progress through courses over time.

Theoretical Framework

The actiotope model of giftedness is a model of excellence development which focuses on actions rather than traits and emphasizes the dynamic nature of action and the environment (Ziegler, 2005). The goal of this model is the development of a pathway to excellence (Ziegler, 2005). Following principles of dynamic systems theory and mirroring aspects of the bioecological model, the actiotope model of giftedness places a child, or "unit," at the center of a series of nested environments and systems. This child has an action repertoire, or a set of actions they can choose from. The action chosen from the repertoire is motivated by that child's goals and is enabled or prevented by the child's environment (Ziegler et al., 2013).

In this model, an action repertoire is determined by different types of capital. Capital is used here to denote social, mental, and physical resources that can help or hinder a student on their pathway to excellence. While the first part of this paper aims to explore what trajectories students are currently following, the second portion of this paper is dedicated to understanding how child-level variables influence pathway membership – or how capital shapes actions. To choose which child-level variables to include in analyses, I follow the types of capital outlined within the actiotope model. Following the recommendation of (Veas et al., 2018), only 3 types of capital will be included.

First is economic educational material. This refers to money that can be invested in the "initiation and maintenance of educational and learning processes" (Ziegler et al., 2017, p. 27). This includes money that can be spent on tutors, to access private education, and to access enrichment materials like computers (Hardesty et al., 2014). Though economic education material affects a child's ability to succeed at both the individual and institutional level, only the individual level will be assessed in this project through family-level socioeconomic status (measured by free or reduced-price lunch status - FRL).

Second, actional learning capital consists of the actions for which a child is mentally or physically capable. This can include cognitive skill, social skill, or the physical capability to do an action. In this project, actional learning capital will be represented by the skills a student demonstrates prior to selecting whether to enroll in an advanced course. More specifically, this will include early life skills, as measured through school readiness skills at school entry, attendance at particular types of preschool/early educational programs at age four, and prior school achievement measures including standardized test scores, GPA, and gifted status.

Finally, we include infrastructural educational capital, or the structural possibilities for action. In this case, infrastructural educational capital includes advanced math courses being offered in each child's school, and that student's presence in school. Therefore, school policies which take students out of the classroom like suspension, or reduce the number of course taking options a student has, like grade retention will also be included.

The actiotope model is a good theory for understanding advanced course taking as a measure of the excellence gap because it is resource and action focused, rather than trait focused, and therefore more in line with developing pathways forward, rather than simply describing disparities (i.e. "gap gazing," Gutierrez, 2008). Further, this model is also a good place to ground our choice to utilize advanced course *taking* rather than performance as the primary outcome of interest as the actiotope model emphasizes measuring actions chosen from the repertoire as a representation of excellence, rather than performance (Ziegler et al., 2017).

Previous Literature on Advanced Course Pathways

Pathways of Math Taking

While no research to date has explored variations in patterns of advanced math taking as we propose to here, a few previous studies do address pathways of math taking in similar ways. Riegle-Crumb (2006) assessed where students started and ended within the high school math curriculum and how that varied by race and gender. The findings from this study indicate that Latinx and Black girls started high school at lower levels of the math curriculum than their White peers, but for those who did start high school at Algebra 1, they went as far along the curriculum as White girls on average. The same was not true for Latinx and Black boys. Including academic performance in the model accounted for some, but not all, of the variation in math pathway by gender and race. These findings suggest that our pathways will likely also vary by race, gender, and academic performance. However, as noted in the study, trajectories of mathematics often begin in middle school. As such we will be including middle school math taking in addition to high school.

More closely aligned with the current work, McFarland (2006) used affiliation matrices to map the pattern of participant pathways through math course work in high school. This produced a set of probabilities representing the likelihood of different course movements across high school. The results suggested that achievement was most strongly related to math course taking decisions (outside of structural barriers), but that student's backgrounds were related to the likelihood of non-traditional course moves like dropping out or repeating a class. Both aforementioned studies conceptualize math content (i.e. Algebra, Geometry) as math level. In the current study we will be using advanced status (i.e. ADV, honors, College Level) to indicate level of math regardless of the course content. In addition, both studies utilize populations who attended high school in the late 1990's. Given the widespread structural changes in advanced course availability over time and the growing interest in math achievement, work with students more recently in high school should build off of these previous studies.

Factors which promote access to and persistence in advanced course taking

Although the conceptualization of our study is novel, previous research on access and persistence in advanced academics provides insight on what factors might impact patterns of advanced math taking. These factors generally fall into 3 categories: child-level demographics, child-level achievement, and school policies like suspension and retention.

The extant literature suggests that students of color and students from low-income backgrounds begin taking advanced coursework later than their advantaged peers (Riccardi & Winsler, 2018). Contemporaneously, these same students are more likely than their advantaged peers to lose advanced statuses over time (Reardon, 2008; Wyner et al., 2007). Consequently, I expected that students of color and students from low-income households would follow different trajectories of advanced math taking than their White peers from non-impoverished backgrounds. Likewise, I expected to see gender-based differences in math pathways. The so called "leaky pipeline" literature documents a pattern of women leaving STEM programs at a higher rate than boys (Heaverlo et al., 2013; Microsoft Philanthropies, 2019).

Prior academic achievement likely impacts which trajectory of advanced math taking a student follows. Evans (2019) found evidence that academic success is positively related to persistence in advanced course taking. Other work drew similar conclusions about the link between academic achievement and persistence in advanced academics (Ricciardi & Winsler, in preparation; Simpkins et al., 2006; Updegraff et al., 1996). Along with more traditional measures of academic achievement (i.e. GPA, standardized test scores), Ricciardi and Winsler (2021) identified school readiness skills at age 4 as additional academic predictors of later access to advanced coursework. Those findings correspond with the general school readiness literature which suggests that school readiness is positively related to later academic success (Davies et al., 2016; DiPerna et al., 2007; Duncan et al., 2007).

Suspension has been consistently linked to negative social and academic outcomes including behavioral issues (Skiba & Losen, 2016), dropping out (Cholewa, 2017), and impaired future academic performance (Burke et al., 2020). Moreover, racially biased school discipline policies mean that students of color are more likely to face these negative consequences of suspension than their White peers (Hilberth & Slate, 2014). School retention is also related to dropping out (Hughes et al., 2018) and poorer academic and non-academic outcomes (Xia & Kurby, 2009). In accordance with the research around retention and suspension, I anticipated that both school policies would negatively impact which math pathways a student follows.

Person-Centered Methods

Person-centered analyses consider an individual as the unit of analysis and *people* are studied for patterns of characteristics or actions (Bauer & Shanahan, 2007). When using person-centered analyses, variables are not considered alone, but rather as a piece of a complex whole. Specifically, person-centered analyses focus on how patterns of variables emerge rather than controlling for variance attributable to other variables (Bauer & Shanahan, 2007). In this way, all included variables are considered in tandem, resulting in different groupings of people (Bergman & Magnusson, 1997; Lanza &

Cooper, 2016). Modelling complex and interconnected systems would be a major addition to our understanding of differential access to advanced courses.

In addition, person-centered methods are predicated on the idea that a population is heterogenous. It is important to bring this idea into research because it allows for variance within demographic groups to be acknowledged and assessed (Masyn, 2013). Given that I aimed to understand what course taking choices people are making over time, utilizing person-centered methods allowed me to focus on people's overall pathways by accounting for their enrollment decisions as a unit rather than individually. To illustrate, students who enrolled in ADV and honors courses might be considered quite different than students who enrolled in honors and college level courses.

The Current Study

The current study sought to add to the current excellence gap literature by examining existing pathways in advanced mathematics and then exploring how child-level variables are linked to belonging within these paths. By integrating both person- and variable-centered methods, I modeled heterogeneity in advanced course taking and improved our ability to effectively address excellence gaps based on the unique capital students bring to the table. In addition, this study utilized data from an ethnically, racially, and linguistically diverse region and sample enabling me to examine excellence gaps among those who are historically underrepresented. In this dissertation, I specifically asked:

1) What pathways are students following through advanced math taking?

2) How does pathway membership vary by race/ethnicity, SES, gender, and ELL status?
3) What child-level factors are most discriminating in track membership?

METHOD

Participants

Through a university-community partnership between Miami Dade county public schools and George Mason University and Florida International University, I have access to a selection of preschool measures and administrative data on nearly 50,000 students – approximately 92% of those who received childcare subsidies for low-income families to attend childcare in the community and those who attended public school pre-K in Miami-Dade County between 2002 and 2006. These children were matched to school administrative data and followed through high school. At the time of data analysis (academic year 2017/2018), all 5 cohorts were at least in 9th grade. Three cohorts had completed 12th grade, while two remained in school (cohort D students were in 12th grade and cohort E students in 11th). Only the three cohorts whose students had completed 12th grade at the time of analysis will be incorporated in this study. Within these cohorts, only students with data in at least one grade 6-12 were included (N = 18,841). This sample is 51.4% male, 77.3% on free or reduced-price lunch in 6th grade (68.7% free lunch, 8.6% reduced-price lunch), 57.6% Latinx (N = 10,847), 35.5% Black (N = 6,691), 6.1% White/Other (N = 1,153), and .6% Asian/Pacific Islander (N = 114).

Procedure

To create pathways of advanced mathematics taking, “flags” were created to denote which students took an advanced math course and when. Flags were based on the transcript data listing all course titles and grades each participant enrolled in every year.

These courses were identified by generating a list of every possible advanced course, categorizing it into a larger group (i.e. “Algebra 1 Hon” into “Math Honors”), and converting it from an academic year form (“Math Honors 2017-2018”) to a grade-based form (“Math Honors Grade 8”). Exact course titles were checked against Miami-Dade’s online resources whenever possible to verify correct classification. Types of advanced courses included are middle school advanced (ADV), honors, Advanced Placement (AP), and Dual Enrollment (DE). AP and DE courses were considered in tandem as college-level math courses (CL). Other forms of advanced courses like IB and the Cambridge program, were excluded based on their programmatic nature, requirements to attend specific schools, and their overall low numbers in our sample. For the purposes of this study, math courses included those with math, calculus, statistics, algebra, geometry, trigonometry, or differential equations in the course title. A complete list of the exact courses included in the math flag is available in the appendix. Though courses like computer science and physics may include components of math, only courses which count toward the mathematics graduation requirement for the school system were considered math courses in this study.

Measures

Advanced Math Types

Middle school advanced (ADV). Middle school advanced (ADV) is a level of advanced specific to Miami-Dade County. This is the lowest level of advanced included in this project and is used by the county to prepare students for honors level coursework. To avoid confusion, the remainder of this paper will use the term “advanced” to mean the broader category of any high-level coursework, while "ADV" will be used to indicate this particular type of middle-school advanced course. Courses were considered as ADV if their course name includes the term "adv" at the beginning or the end of the course name.

Honors. Honors is a general term applied to advanced courses across the nation. Generally, this designation is meant to indicate that a course moves at a faster pace and/or covers more material than a regular class (CollegeData, 2016). Honors courses are not considered equivalent in difficulty to a college course, nor can an honors course result in college credit. Honors courses were also measured through the use of course names. All courses which included "Hon" or "Honors" were categorized as an honors course.

Advanced Placement (AP). AP courses are administered by the College Board and move at a faster pace and cover more material than in a regular or honors level course (College Board, 2016). AP courses are considered equivalent to college-level courses in difficulty, and the completion of the corresponding College Board administered exam can result in receipt of college credit. Math courses were considered AP if they included the notation "AP", "Adv P", or "Adv Pl".

Dual Enrollment (DE). Like AP, dual enrollment courses also move at a faster pace and cover more material than regular or honors classes (Arnold et al., 2017). In fact, DE courses can also grant college credit to those who pass the class itself (rather than a corresponding exam). The major differences between DE and AP courses are that DE courses are often taught at local colleges and not strictly on high school campuses like AP, and that DE is not held by the same national oversight and regulations as AP. Math courses will be coded as DE only if they use the notation "DE" in their name. The overall low incidence of enrollment in these courses (see Table 1) led us to collapse them into a larger category referred to as "college-level (CL)" math taking throughout the remainder of the paper.

Advanced Course Trajectories

Miami-Dade County has three formally defined tracks that are primarily determined by when a student takes Algebra 1. The term "tracks" is used here to denote academic pathways that differ in degree of acceleration and difficulty. Traditional students take Algebra 1 in 9th grade, advanced students take Algebra 1 in 8th grade, and "accelerated/gifted" students take Algebra 1 in 7th grade (Miami-Dade County Public Schools, 2018). Membership in these tracks structurally influences one's later advanced course taking options, and thus advanced course trajectory – or pathway/order of advanced mathematics courses taken. The expectation expressed by the school system is that students will take an ADV, then an honors, and finally a college-level course.

Though these are the patterns reportedly expected, we don't currently know if the reality of students' experiences aligns with this suggestion. In my prior work on this topic, I found that while some advanced math takers skipped ADV math (16.6% of students who took any advanced math), less than 1% of students took an AP math without taking an ADV math and no students who took an AP math skipped honors math. In addition, many desisted their course taking at honors math (66.9% of advanced math takers), and even after ADV for some (32.3%). However, my prior work (Riccardi & Winsler, 2020) did not include DE math taking or account for in which grade the course was taken, or for how many years students took math at each level. Including these new factors opens the number of potential advanced math trajectories to thousands of options.

Child-Level Variables

Demographics. Independent variables in this study were primarily taken from 5th grade or are measured as a dichotomous yes/no in elementary school. Exceptions are noted below. This allows all predictors to be proximal to the outcome of interest without being concurrent with said outcome (advanced course pathway membership).

Poverty Status. Poverty status was measured through receipt of free/reduced lunch in 6th grade (Three levels: 1) did not apply/receive (17%), 2) reduced-price lunch (8.6%), or 3) free lunch (68.7%)). This service is available to those who receive food stamps, Temporary Assistance to Needy Families (TANF), or whose family income falls within a specified low range based on federal poverty lines (US Department of Agriculture, 2017). Though this is technically a time-varying covariate, there is very minimal movement between the did not apply/receive and the free categories. However, there is some year-to-year variation in and out of the reduced-price lunch category.

Race/Ethnicity. Race/Ethnicity was coded into 4 groups; 1 for Latinx (*N* = 10,847, 57.6%), 2 for Black (*N* = 6,691, 35.5%), 3 for White/Other (*N* = 1,153, 6.1%), and 4 for Asian (*N* = 112, 0.6%). This coding is based on student/family-declared ethnicity according to school records.

Gender. Gender was coded as either 0 for female or 1 for male (male 51.6%) as specified by the school district without (at the time) an option for nonbinary responses.

ELL Status. English language learner status was assigned based on parent-reported home language. Upon kindergarten entry, if parents reported a language other than English was the primary language at home, participants were considered ELLs by the school district (N = 10,804, 57.3%). All students in the sample have reached "English proficiency" as measured by district standards by 6^{th} grade.

Disability Status. Students who were identified by the district as having an intellectual disability, speech/language disorder, visual impairment, deafness, specific learning disability, autism, emotional disturbance, brain injury, or other health impairment were coded accordingly each year (with the exception of gifted status discussed below). An overall code indicating disability status where 0 equals none of these codes and 1 equals the presence of at least one of these codes was used to assess disability status. If a student was coded 1 in 6^{th} grade, they were considered to have a disability (N = 2,687, 14.3%).

Preschool Type. All students in the sample were recruited through their preschool. As such all children in the sample attended either community-based care on subsidies for low-income families (family or center-based childcare; N = 7,139) or public-school pre-K (N = 11,064).

School Readiness.

Cognitive, Language, and Motor Skills. Children's cognitive, language, and motor skills were assessed individually and directly through the Learning Accomplishment Profile- Diagnostic (LAP-D) (Nehring et al., 1992). The LAP-D is a norm referenced assessment that was given individually to pre-K students. Children were assessed both at the beginning (September/October) and again at the end of the school year (April/May) when they were 4 years old. The latest timepoint available for each student was used in analyses. This was administered by master's level, trained, bilingual assessors (in whichever language, English or Spanish, was stronger for the child) for those children enrolled in community-based care. For those in public school pre-K, the child's teacher administered the LAP-D after receiving the same intensive two-day training from the publisher. Alphas for internal consistency on the LAP-D subscales range from .76 to .92 (Winsler et al., 2008). LAP-D and Dial-3 scores correlations ranged from .50 to .92 indicating moderate to strong predictive validity (Redesetgrow, 2016). Age-normed percentile scores are used.

Social Skills and Behavior Problems. The Devereaux Early Child Assessment (DECA) (LeBuffe & Naglieri, 1999) is a 37-item measure that has an identical teacher and parent report form. Like the LAPD, it was administered both at the beginning and the end of the preschool year (age 4). The latest time point available for each student was used. The DECA was used to evaluate the social-emotional competence of participants at school entry and is appropriate for ages 2 through 5 (LeBuffe & Naglieri, 1999). Both teacher- and parent-reported DECA scores were included as predictors. Within the DECA, the subscales are initiative, self-control, attachment, and overall behavioral concerns. Initiative, self-control, and attachment are combined into an overall measure of 'total protective factors' (TPF). The DECA is a reliable and frequently used measure of social emotional skills, and it is known to maintain its integrity when evaluating ethnically diverse and low-income children; particularly, alphas for internal consistency ranged from .71 to .94 in this sample (Winsler et al., 2013). DECA validity was supported by the authors (Lebuffe & Naglieri, 1999).

Early Achievement.

Standardized Test Scores. Students in the district/state take a standardized, high-stakes assessment of reading and math aligned with state education benchmarks (Human Resources Research Organization & Harcourt Assessment, 2007) each year. In multivariate analyses, only the reading test was included because the highly correlated (r = .73) nature of these tests could lead to collinearity problems. Reading was chosen because it has stronger relationships to advanced course taking univariately, and because it is the major test used for high stakes decisions in the state. These factors indicated that the reading test was more commonly used as a measure of academic functioning by the school system and thus was a more authentic measure of academic achievement in this context. Supplementary analyses were run using the standardized math test to address the direct connection between math performance assessed in 5^{th} grade and later advanced math taking decisions. Results can be seen in Appendix B. Internal consistency reliability coefficients range from .88 to .92. Criterion-related validity obtained by correlating test scores to Stanford Achievement Test 10 scores are .79 and .71 for math and reading respectively (Human Resources Research Organization & Harcourt Assessment, 2007)

The test changed versions and corresponding scoring metrics during this longitudinal study (in 2011-2012). However, the state maintained a consistent ordinal scoring system which ranged from 1 to 5. In this metric, scores of 1 or 2 were considered as failing to meet statewide standards. A score of 3 equated proficiency, and scores of 4 and 5 indicated the standards had been exceeded. Thus, this ordinal score was utilized and treated as continuous to maintain power and reduce potential bias due to variations in the test.

GPA. Another authentic measure of student academic performance are the grades received at the end of the year by teachers in all their subjects. These grades were converted to a 5-point scale where A= 5, B=4, C=3, D=2, and F=1. The grades were then averaged across all subjects to create a composite measure of academic performance for the 5th grade school year.

Gifted Status. Gifted status was coded as a "1" if the student ever had "gifted" as their primary exceptionality in elementary school (K-G5) (N = 2,737, 14.5%). This means that their school has marked the student as gifted/talented and they were likely, but not necessarily, receiving some type of services for gifted students. According to the Exceptional Student Education Policies and Procedures Handbook set by the school board (Florida Department of Education, 2020) a student is eligible for participation in gifted programs if the student meets the following criteria: 1. The student demonstrates the need for a special program, possesses a majority of characteristics of gifted students according to a standard scale or checklist, or has superior intellectual development as displayed by an intelligence quotient of at least two standard deviations above the mean (a score of 130 or higher) on an individually administered standardized IQ test. Alternative criteria are also used to increase low-income students' access to gifted programs and include standardized test scores at the 89th percentile or higher, a level 4 or 5 on the state comprehensive assessment test, or A's or B's on coursework. This is not an exhaustive list but are the primary identifiers of academic excellence that lead to being identified as gifted in this district.

Retention in Elementary School. If a child completed a grade, repeated that grade, and had final, end-of-year grades for that grade a second time, the child was coded as having been retained that year (*N* = 3,257, 17.3%). If this occurred in elementary school (K-G5), they were considered as having been previously retained.

Suspension in Elementary School. If a child ever received (in grades K-G5) in-school or out-of-school suspension according to school records, they were coded as having been previously suspended. (*N* = 2,011, 10.7%).

Suspension in Middle or High School. Given the prevalence of suspension in middle and high school, an additional suspension variable will also be included in the model. If a child ever received (in grades 6-12) in-school or out-of-school suspension according to school records, they were coded as having been suspended in middle or high school (*N* = 8,040, 42.7%). Of those who were suspended in middle or high school, 20.3% (*N* = 1,636) were previously suspended in elementary school.

Missing Data

To assess missing data, I first examined how many students remained in the school system across middle and high school. Of those who completed 6th grade, about 73.9% also completed grade 12 or the highest grade available if that student had been retained (*N* = 12,845). Although this sample includes only the three cohorts who had a chance to graduate, students who were once or twice retained may not have yet reached 12th grade. Thus, retention status and cohort were used to establish if a student had progressed through school as far as was structurally possible at that point in time (i.e. a once retained student in Cohort C could have only completed 11^{th} grade in the included year). Of Black students, 69.1% of students completed 12^{th} grade, while between 75 and 90% of Latinx, White, and Asian students completed 12^{th} grade. More females completed high school than males (77.6% of females and 70.5% of men) and fewer students who received free lunch completed than those on reduced-price or regular lunches (71.2% versus roughly 80%). Among those identified as English language learners 76.7% completed 12^{th} grade (while 70.1% of those not identified as ELL completed 12^{th} grade). Non-disabled students were significantly more likely to complete high school than those with a disability (76.8% completed high school versus 57.4% of those with a disability who completed high school). Similarly, students who were suspended were less likely to complete high school. Those who remained in school through 12^{th} grade scored higher on math and reading tests in grade 5 (by about 1 ordinal unit), received higher GPAs in grade 5 (by roughly a third of a GPA point), scored higher on all school readiness measures (by 5-10 percentile points) and were perceived to have fewer behavior problems by both parents and preschool teachers at age four (by 5 - 8 percentile points). It is important to note that due to our large sample size, even slight variations result in statistically significant findings.

Percent missing on most demographics was less than 1% (race/ethnicity, gender, ELL status, elementary school suspension, middle/high school suspension, retention, and gifted status). Poverty status, exceptionality code, and preschool type have missing data ranging from 3.5 to 7%. Less than 10% of students were missing data on 5th grade GPA and standardized test scores. School readiness assessments exhibited the highest rates of missingness ranging from 22.6% missing to 34.5% on LAP-D subscales and 14% to 20.4% missingness on DECA subscales. To handle missing data on the predictors, I used full-information maximum likelihood (FIML) estimation in Mplus. This procedure uses all available information in the model, including the covariates which we know are related to patterns of missingness, to produce more stable estimates (Acock, 2005; Enders, 2013).

Data Analysis

Math taking pathways were established using latent class analysis (LCA). LCA is a type of finite mixture modeling in which a series of manifest, or observed, variables are used to assign people to latent classes. In this case, one indicator, a 3-level advanced math status indicator, was measured at 7 time points, grade 6 through grade 12. At each aforementioned time point, students could be enrolled in a non-advanced math, a mid-level advanced math, or a highly advanced math. In middle school, these options are standard/non-advanced, ADV, and honors respectively. In high school, the levels are standard/non-advanced, honors, and college level (AP or DE - see Figure 1 for an overview). Table 1 presents the frequencies of enrollment in each course across the middle and high school years for the sample as a whole.

The LCA models were estimated using M*plus* (Muthén & Muthén, 2017). LCA model parameters were estimated using maximum likelihood estimation with the expectation-maximization (EM) procedure using 500 starts and 50 optimizations. LCA estimates the model using all available data under the assumption that data are missing at random (MAR) through a process known as full information maximum likelihood or FIML (Muthén & Muthén, 2017; Nylund-Gibson & Choi, 2018). Rather than listwise deleting cases with missingness on indicators, FIML uses existing information to generate parameter estimates (Acock, 2005; Enders, 2013).

When implementing LCA, the researcher must evaluate numerous metrics of model fit to determine the best and most interpretable results (Masyn, 2013). The relative fit indices employed in this analysis included Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and Sample Size Adjusted Bayesian Information Criterion (SSABIC). Across these indices, smaller numbers indicate better relative fit. In conjunction with these relative fit statistics, adjusted likelihood ratio tests (Lo et al., 2001) were used to evaluate improvement between two nested models. A significant adjusted-LRT value indicates that a k class model has statistically better fit then the k-1 class model. These metrics suggest a likely class solution which can be further evaluated using entropy and the average latent class probabilities for most likely latent class membership. Entropy is an estimate of how distinct the identified classes are where values closer to 1 are considered better and entropy values above .80 indicate good class separation (Masyn, 2013; Ramaswamy et al., 1993). Average latent class probabilities were also examined to aid in understanding class separation (Tavassolie et al., 2020).

Once the LCA was complete, descriptive statistics were used to describe class membership. Specifically, chi-square analyses were run to determine if class membership varied by race/ethnicity, SES, gender, and ELL status. Then results were depicted in table and figure form to illustrate the how demographic factors vary across classes relative their proportion in the sample as a whole. Finally, multinomial regression was used to examine the relationship between demographics, school readiness, and prior academic achievement on class trajectory assignment.

RESULTS

Research Question 1

I first generated an unconditioned LCA model with 1 class, then increased the number of classes until adjusted-LRT values showed insignificant model improvement 3 successive times. Model fit for each of these solutions can be seen in Table 2. The 6-class solution emerged as the best model regarding relative model fit and interpretability. Adjusted-LRT values indicate that the 6-class model has significantly better fit than the 5-class model and entropy is improved relative to the 3 through 5-class models. The 6-class solution also has the lowest AIC, BIC, and SSABIC among the first 6 models.

The 7-class model was also examined as it has lower AIC, BIC, and SSABIC, as expected given the general improvement of these fit indices with the inclusion of additional classes, and its improved entropy (p = .073). Examination of item response probabilities and average latent classes does not suggest that homogeneity within classes or distinctions between classes was improved enough to justify the loss of parsimony. In addition, the added class in the 7-class model relative to the 6-class model captures less than 3% of the population and does not add to theoretical interpretations.

Examining the average latent probability by latent class table for the 6-class model suggested that one particular class had classification overlap with others (# 5 vs. #6). As such, the 5-class model solution was also compared in depth to examine the potential for this solution to address that problem. In line with the overall lower entropy and worse fit statistics, the 5-class model did not address this issue and as such was not selected as the final model. Once the number of classes were determined, students were assigned into their most likely class. The assignment is based on the relative probabilities of belonging to the existing classes. Each individual is assigned into the class they have the highest probability of belonging to and no individuals are left unclassified (see Table 3).

Each class is described by the most common trajectory of students in that class (Tables 4 and 5). In Table 4, you can see the probability of enrolling each level of advanced by latent class. Table 5 is structured similarly, but reflects the course taking decisions of those in our actual sample by class. Thus, Table 4 depicts the probabilities of course taking while Table 5 depicts the actual proportions of our sample who made each course taking decision by class. These tables were used to determine what the most frequent course enrollment decisions were for each latent class, Thus the most common patterns of enrollment for each class constitute that class's distinct pathway (see Figure 1 for visual representation of class pathways). To denote the pathway students in each class followed, the course level most commonly enrolled in is shaded in a darker color than the non-most common option. In instances where students' pathways split such that there was a 10% or smaller difference in the percentage of students who enrolled in two options, both were shaded in. Given the thousands of possible combinations of math courses a student can take over time across middle and high school, there is some non-ignorable heterogeneity within classes. Thus, if 20% or more of the students in a particular latent class pathway took a math level other than the one most characteristic of the class trajectory, this was noted in the figure by shading the course bright yellow. It is important to note that none of the classes that emerged in the LCA process were typified by enrollment in the highest levels at all times, and across all classes, the most common enrollment in 12^{th} grade was standard math, even among the otherwise more advanced class pathways (see Table 1).

The first class which emerged is the *Always Standard* (standard MS, standard HS) class pathway. This pathway is typified by enrollment in a non-advanced version of math in each year G6 through G12. This class makes up the largest portion of the sample (N = 9,504, 50.44%) and constitutes the portion of the sample who did not enter any kind of advanced mathematics at any point in middle or high school.

Those belonging to the second class, referred to throughout as *Early Advanced Tryers* (advanced MS, standard HS), students usually enroll in ADV math courses in 6^{th} and 7^{th} grade and then split between taking standard or honors math in 8^{th} grade. Typically, students belonging to this class take non-advanced math courses for their entire high-school careers. These students appear to be characterized by starting on an advanced math trajectory, but retreating from it for standard math coursework later (N = 1,943, 10.31% of the sample).

The third class, *Late Honors Tryers* (standard MS, honors HS), typically did not enroll in advanced math coursework in middle school, but did attempt honors coursework at some point in high school. Most frequently this attempt at honors happened between G8 and G11. While students in both the *Always Standard* and *Late Honors Tryers* did not participate in ADV (middle school advanced) math at any time, *Late Honors Tryers* did attempt some advanced coursework at the honors level in G8. In essence, these students attempt honors briefly and then return to standard math coursework (*N* = 2,074, 11.01% of the sample). These students sort of represent the opposite pattern of advanced math taking as the *Early Advanced Tryers*.

Those in class four, *Consistently Mid-Level Advanced* (advanced MS, honors HS) also typically enroll in ADV math in 6^{th} and 7^{th} grade, but rather than retreating toward standard math for high school, these students enroll in mid-level honors math coursework for most or all of their high school careers (*N* = 527, 2.80% of the sample). This means that in each grade G6 through G12, students in this class tend to take the middle level of advanced available to them (i.e. ADV in middle school and honors in high school).

Although no class was characterized by consistent highest or college-level math taking, students who took at least 1 college-level math course in our sample primarily belonged to one of the remaining 2 classes. The fifth latent class pathway is *Primarily Advanced with some CL* (advanced MS, honors with some CL in HS; *N* = 3,080, 16.35%). Students in this class typically took ADV math in 6^{th} and 7^{th} grade, and then transitioned to honors-level math courses in 8^{th}, 9^{th}, and 10^{th} grades. Following this trajectory, students in this class retreated to standard math for grades 11 and 12, but a sizable minority, 23%, took a college-level math course in 12^{th} grade.

The sixth and final class is the *Most/Earliest Advanced* class (*N* = 1,713, 9.09%). These students generally take the highest level of math available as early as possible in middle school. Although honors math taking in 6^{th} grade is technically available, very few students in the sample take this option. As such ADV in 6^{th} grade and honors in 7^{th} and 8^{th} grade represents enrolling in the highest version of math available across middle school (Algebra 1 Honors in 7th grade and Geometry honors in 8th grade makes up the school district's highest "accelerated/gifted" math track). These students generally also enrolled in honors math in grade 9 and standard math in grade 10. Students in this class were roughly split in grades 11 and 12, where about 60% of those in the class took standard math courses and 30-40% of the class took college-level math courses in grades 11 and/or 12. Thus those in the *Most/Earliest Advanced* class are enrolling in higher levels of advanced coursework early on and are the most likely to take college-level math coursework later and more so than those in the *Primarily Advanced with some CL* class.

Research Question 2 – Bivariate Results

To understand how class membership varies by race/ethnicity, SES, gender, and ELL status, I ran a series of chi-square analyses (Table 6). The results are presented such that the proportion of students within each class can be compared to the proportion of students in the sample as a whole. For example, these analyses revealed that race/ethnicity varied significantly across classes ($\chi^2(15) = 828.013$, $p < .001$). Table 6 and the corresponding Figure 2 display that relative to their proportion in the sample as a whole, Latinx students were overrepresented in the *Most/Earliest Advanced* (class 6) and Primarily Advanced with some CL (class 5) classes and were underrepresented in the *Always Standard* (class 1) class. This can be determined by comparing the proportion of Latinx students in the *Most/Earliest Advanced* class (66.9% of those in class 6) relative to the 57.7% of students in the sample as a whole who are Latinx. Similarly, Latinx students are underrepresented in the *Always Standard* class (class 1; 54.4%) relative to their overall proportion in the sample (57.7%).

Black students were overrepresented in the *Always Standard* (class 1) class, and underrepresented in all other classes relative to their proportion in the overall sample. White/other students were overrepresented in the *Most/Earliest Advanced* (class 6), *Primarily Advanced with some CL* (class 5), and *Consistently Mid-level Advanced* classes (class 4). White/other students were underrepresented in the *Always Standard* (class 1) and *Late Honors Tryers* classes (class 3). Finally, Asian students were overrepresented in the *Most/Earliest Advanced* class (class 6).

Poverty, as measured by free or reduced lunch status, was also significantly related to class membership ($\chi^2(10) = 867.786$, $p < .001$). The proportion of students who receive reduced-price lunch is relatively equivalent across classes and similar to the overall at around 9% (see Table 6 and Figure 2). However, those who did not receive free or reduced-price lunch are overrepresented in the *Most/Earliest Advanced*, the *Primarily Advanced with some CL*, and the *Consistently Mid-level Advanced* classes and underrepresented in the *Always Standard* class. The reverse is true when examining the proportions of students who receive free lunch across classes.

Although gender is almost evenly split in the overall sample (51.6% male), this was not the case in all classes ($\chi^2(5) = 138.576$, $p < .001$). A slight majority of students in the *Most/Earliest Advanced, Honors Tryers, Primarily Advanced with some CL,* and *Consistently Mid-level Advanced* classes were female. Males were overrepresented in the *Always Standard* class. Additionally, class membership also varied significantly on the basis of English Language Learner status ($\chi^2(5) = 74.443$, $p < .001$). ELLs were overrepresented in the *Most/Earliest Advanced* class relative to their proportion of the sample. Finally, disability status also varied significantly by latent class ($\chi^2(5) = 1500.194$, $p < .001$). Those with a disability were overrepresented in the *Always Standard* class (class 1) and underrepresented in all other classes relative to the sample as a whole.

Research Question 3

The final research question asked how all covariates - demographic characteristics, school readiness, and prior academic performance predicted class membership. Multinomial regressions were used to examine the likelihood of being assigned to a particular class trajectory relative to a reference class trajectory. This procedure is similar to running a series of logistic regressions but reduces potential error and maintains a consistent sample size (Tabachnick et al., 2019). Importantly, multinomial regression enables the researcher to examine a particular independent variable on class membership while controlling for other predictors. Given the scope of this analysis, only specific contrasts were selected for comparison and discussion. First, all class trajectories were compared to the *Always Standard* class (Table 7). The *Always Standard* class trajectory was chosen because no class emerged with an always highly advanced trajectory. Furthermore, this was our largest class. Following this, additional contrasts were drawn to highlight specific, theoretically important comparisons.

All Classes vs Always Standard

Table 7 presents the results of the multinomial regression using *Always Standard* (class 1) as the comparison group. Each column represents the odds of being assigned to the focal class in comparison to the odds of being assigned to the *Always Standard* class. Only one demographic characteristic consistently influenced class assignment when comparing the class trajectories which include advanced math taking to the *Always Standard* class trajectory. Special education status (having a disability) was consistently associated with a decrease in the odds of enrolling in a class which included at least some advanced math coursework. To illustrate, students having a disability are roughly 80% less likely than students who don't have a disability to belong to the *Most/Earliest Advanced* latent class (class 6; OR = .218). This pattern was consistent for all latent classes compared to the *Always Standard* class (class 1). Being male was associated with an increase in the odds of being assigned to a class trajectory which included advanced math taking, after controlling for skills at school entry and prior academic achievement. The exception to this pattern, was that gender was unrelated to the odds of being in the *Late Honors Tryer G8-11* class (class 3) relative to the *Always Standard* class (class 1) trajectory.

Race/ethnicity affected the odds of class membership when comparing the *Most/Earliest Advanced* class trajectory to the *Always Standard* (class 1) class trajectory. Holding all other predictors constant, those who identified as Asian were nearly 4 times more likely than Latinx students to belong to the *Most/Earliest Advanced* class (class 6) rather than the *Always Standard* class (class 1). Additionally, White students were statistically more likely to be assigned to the *Primarily Advanced with some CL* class (class 5) than the *Always Standard* class (class 1) trajectory, holding all other predictors constant. SES was associated with the odds of class assignment such that those not in poverty were less likely to be assigned to the *Early Advanced Tryers* class trajectory (class 2) relative to the *Always Standard* class (class 1). Preschool type (public verses center-based) was never significantly related to class membership.

Some measures of school readiness at age 4 were consistently and significantly related to class assignment. Namely, cognitive and fine motor skills at age 4 were generally related to in an increase in the odds of being assigned to one of the classes that include some advanced math coursework relative to the *Always Standard* class (class 1; specific odds ratios can be seen in Table 7). Language skills, gross motor skills, and teacher perceived behavioral concerns were intermittently associated with a decrease in the odds of being assigned to a class trajectory that includes advanced math coursework. Specifically, those with higher language skills at age 4 were less likely to be in the *Consistently Mid-Level Advanced* class trajectory (class 4) than the *Always Standard* class trajectory (class 1). Those with higher gross motor skills at age 4 were less likely to belong to the *Most/Earliest Advanced* class trajectory (class 6) or the *Primarily Advanced with some CL* class trajectory (class 5) than the *Always Standard* class trajectory (class 1). Higher teacher-perceived behavioral concerns were related to decreased odds that a student would be assigned to the *Early Advanced Tryer* class trajectory (class 2) relative to the *Always Standard* class trajectory (class 1).

Prior academic achievement was the most consistent and strongest predictor of advanced math class trajectories. Students who were assigned to class trajectories that included at least some advanced math courses scored higher on the state standardized reading test in grade 5, had higher 5th grade GPAs, were more likely to have been identified as gifted, and were less likely to have been suspended in middle or high school

(G6 - G12). Unexpectedly, being suspended in elementary school (K-G5), was related to an increase in the odds that an individual would be classified as *Primarily Advanced with some CL* (class 5) or *Most/Earliest Advanced* (class 6) relative to *Always Standard* (class 1). Relatedly, being retained in elementary school, or repeating a grade K-G5, nearly doubled the odds that an individual would be classified in the *Most/Earliest Advanced* (class 6) or *Early Advanced Tryer* (class 2) class trajectories relative to the *Always Standard* class (class 1). Contrary to this effect, retention in elementary school was related to a decrease in the odds that a student would be assigned to the *Consistently Mid-Level Advanced* class trajectory (class 4) rather than the *Always Standard* class (class 1).

Early Advanced Tryers vs Later Honors Tryers

The first additional contrast assessed describes the difference between students assigned to the *Early Advanced Tryers* class trajectory vs the *Late Honors Tryers* class trajectory (Figure 3). These classes both involve students taking one to three years of mid-level advanced math. For *Early Advanced Tryers* this is ADV math in middle school and then regressing back to standard math for high school. For *Late Honors Tryers*, this is taking standard math through middle school and taking 1 to 3 years of honors math between grade 8 and grade 11. Accordingly, the leftmost column of Table 8 represents the differences between those who started advanced math taking early and left vs those who started at standard and experimented with honors math later in their academic career. Those who attempted honors math later were more likely to be female, to have received special education services, and to be in poverty. Having higher preschool teacher-perceived behavioral concerns was related to an increase in the odds of being a *Late*

Honors Tryer relative to an *Early Advanced Tryer*. Furthermore, students who were identified as gifted, performed better on the state standardized reading test, or had a higher GPA in grade 5 were more likely to be assigned to the *Early Advanced Tryers* than the *Late Honors Tryers* class trajectories. Students who were retained in elementary school or suspended in middle or high school were more likely to be classified as an *Early Advanced Tryer* than a *Late Honors Tryer*. In essence, students who were performing better academically in elementary school were more likely to go into advanced math coursework in middle school. Among equivalently performing students, girls and those with disabilities were more likely to attempt honors math coursework later.

Early Advanced Tryers vs Consistently Mid-Level Advanced

The middle column of Table 8 represents the difference between students who start with mid-level advanced courses and then retreat to standard courses vs. students who enroll in mid-level advanced math and remain there all the way through their academic careers (Figure 4). Notably, there is no significant difference in the odds of class membership (early vs consistent) based on demographic factors. Higher teacher-perceived behavioral concerns in preschool increased the odds that a student would consistently enroll in mid-level advanced courses rather than retreat to standard courses. Students were more likely to be classified as *Consistently Mid-Level Advanced* if they scored higher on the state standardized reading test or had higher GPAs in grade 5. Relatedly, being retained in elementary school decreased the odds that a student would be a consistent mid-level advanced taker. In essence, students who start advanced math taking early and leave are not different at arrival to school than those who consistently take advanced math coursework. Where they differ is in their elementary school performance such that better school performance increased the odds of continuing along the mid-level advanced math trajectory.

Primarily Advanced with some CL vs Most/Earliest Advanced

The final contrast in Table 8 depicts how those who follow the *Primarily Advanced with some CL* class trajectory differ from those that follow the *Most/Earliest Advanced* class trajectory (Figure 5). Females (compared to males) and Asian students (compared to Latinx students) were more likely to be classified as *Most/Earliest Advanced* in comparison to *Primarily Advanced with some CL*. White students (compared to Latinx students and to Black students) were more likely to be assigned to the *Primarily Advanced with some CL* class trajectory than the *Most/Earliest Advanced* class trajectory holding all other predictors constant. Students assigned to these categories did not differ significantly in terms of school readiness skills at age 4. Being retained in elementary school, receiving gifted identification, or having a higher GPA in grade 5 increased the odds being classified as *Most/Earliest Advanced* rather than *Primarily Advanced with some CL*. To summarize, our results suggested that higher academic performance was associated with being in the most advanced category relative to the second most advanced category. Likewise, among those with equivalent achievement gender and race/ethnicity played a significant role in determining the odds of which advanced class trajectory would be followed.

Supplemental Math Analyses

In addition to the primary analyses discussed above, all multinomial regressions associated for Research question 3 were rerun using standardized math scores in grade 5 rather than standardized reading scores (see Appendix B). The overall pattern of results stayed the same, however most effects had reduced effect sizes and some effects were no longer significant. Specifically, gender and school readiness effects largely disappear. Only when contrasting *Most/Earliest Advanced* from *Always Standard* and *Consistently Mid-level Advanced* from *Early Advanced Tryers* do gender effects persist (or appear as is the case for *Mid-Level Advanced* vs *Early Advanced*). The *Most/Earliest Advanced* versus *Always Standard* contrast remains the same as in the standardized reading version of the assessments, but with a slightly smaller effect size (OR = 1.953 vs OR = 1.182). New to the math models, is a significant gender effect when comparing those who take advanced math early and leave versus those who take advanced math early and persist. Here we see that males are less likely than females to belong to the persisting latent class relative to the desisting latent class (OR = 0.793). This suggests that girls who are scoring equivalently on math standardized tests, are actually more likely to persist in mid-level advanced math taking.

Besides gender effects, some other demographics (including ELL status and White versus Latinx contrasts) and most school readiness skills lost significance in the math models. A persistent school readiness effect was the influence of teacher-perceived behavioral concerns at age 4, and newly significant was the role of parent-perceived behavior concerns. These relationships influenced course taking in the same direction as in the reading models, such that more behavior problems decreased the odds of advanced math trajectories. This highlights the critical role of perceptions of behavior in advanced math access.

DISCUSSION

This dissertation sought to examine what pathways of advanced math taking ethnically and economically diverse students were following in middle and high school, which types of students were following each pathway, and what early life skills and experiences influenced later pathway followed. Results generally suggested 6 latent class pathways of advanced math taking. Students were not distributed evenly among the latent classes by race/ethnicity, poverty, gender, ELL status, or disability status. The pattern of bivariate results suggested that Asian students, girls, those not in poverty, and those without a disability were more likely to be in one of the 3 most advanced latent class trajectories. However, multivariate analyses presented a pattern of findings where academic achievement was most strongly related to which course trajectory a student followed. Cognitive and fine motor skills at age 4 also promoted membership in more advanced classes even controlling for elementary school academic achievement. Demographic factors only sporadically influenced path membership once academic achievement was controlled for. This research enables us to examine what common trajectories are for students and provide potential for designing more specific and targeted intervention.

Latent Class Pathways

In general, 6 latent class pathways emerged representing 6 distinct and commonly followed pathways of advanced math taking for students in the Miami School Readiness Project. The largest of these was the *Always Standard* (class 1) course trajectory which encapsulated those who did not ever take advanced math coursework in middle or high school. The roughly 50% of students total who belonged to this group aligns with the nearly 40% of students in the sample who never enroll in any advanced coursework across all subjects and levels and the 46.3% of students who earn credit for an AP, IB, or DE course nationwide (Burns & Leu, 2019; Ricciardi & Winsler, 2021).

Early Advanced Tryers (class 2) represent students who started on the same path as those who went on to take advanced math in high school, but eventually left this trajectory for more standard math coursework. Whether or not students belong to this track, or go on to further advanced coursework, seems to primarily be determined by elementary school performance. For example, those with higher GPAs and test scores in 5^{th} grade were more likely to continue taking advanced coursework in high school than to retreat to standard courses after middle school. In addition, among those with similar prior academic performance, having been retained appears to relate to an increase in the odds leaving the advanced track relative to staying in it.

Late Honors Tryers (class 3) share the most demographic and performance similarities to those in the Always Standard class. In fact, among demographic factors, only disability status was significantly related to the odds of attempting some honors coursework late in high school relative to remaining in standard coursework. Notably, those in this class never take middle school ADV courses, the initial scaffolding step toward honors coursework. This may be related to why those in this class tend to only "try" honors coursework for a year or two.

Those assigned to the *Consistently Mid-level Advanced* class pathway (class 4), the *Primarily Advanced with some CL pathway* (class 5), and the *Most/Earliest Advanced* pathway represent those who took at least some advanced math courses in middle school and in high school. While those in the *Consistently Mid-level Advanced* class are the most consistently enrolled in advanced coursework, those from classes 5 and 6 are more likely to reach the highest levels of advanced math. Classes 5 and 6 generally align with the advanced and honors/gifted trajectories set forth by the school district (Williams-Pinnock & Winsler, 2020). These district-set trajectories are primarily determined by when a student takes Algebra 1, and when taken in middle school, this class is almost always taken at the honors level (MDCPS, 2018). Thus class 5 generally aligns with the district's advanced trajectory and class 6 generally aligns with the district's accelerated/gifted math trajectory.

In general, these paths demonstrate that while the district specifies 3 course taking trajectories (standard, advanced, accelerated/gifted; MDCPS, 2018), the reality faced by students involves more variation. In some ways this is beneficial, as those who don't fall into the district advanced or gifted tracks clearly still take some advanced course work (i.e. those in the *Consistently Mid-level Advanced* class). However, those who don't belong to one of these district-defined pathways are highly unlikely to take a college-level math course in high school. Supports for students without these district advanced labels but who wish to attempt college-level math taking should be available to students.

The Role of Middle School

One of the major findings of this dissertation was the role of middle school in determining advanced course pathways. Of the 6 latent class trajectories found, 4 included advanced mathematics in middle school and 2 did not. The classes which did not include advanced coursework in middle school either went on to never attempt advanced math or to attempt only a few years of honors math in high school. No trajectory without advanced math in middle school went on to take college-level math in high school. This suggests that students who don't begin their advanced trajectory in the middle school years are unlikely to access the highest levels of advanced math coursework offered to them.

This is a problem for two reasons. First, college-level course work is generally what is considered when examining relationships between advanced academics and post-secondary outcomes (Burns et al., 2019; Evans, 2019). This means that students who don't access these college-level math courses may not be reaping the same college admissions and college credit benefits even if they participate in some lower-level advanced course taking. Second, access to advanced coursework in middle school varies systematically. To illustrate, Black students in the sample were overrepresented in trajectories which did not include advanced math in middle school and underrepresented in course trajectories which did include middle school advanced. Thus, differential enrollment in AP and DE math may be partially due to what courses students enrolled in during middle school.

This aligns with my previous work which demonstrated that only 5% of students in the sample who ever took an advanced course, took their first course in high school and that timing varied such that Black students started advanced course taking after their Latinx and White peers (Ricciardi & Winsler, 2018). Though there is some existing work on advanced and math taking trajectories, these almost exclusively include the high school years (McFarland, 2006; Riegle-Crumb, 2006). However, these results indicate that some of the most important years in determining high school course taking are actually happening *before* high school.

Given that students who don't take advanced coursework in middle school don't go on to take the college-level coursework so valued in college admissions decisions, one potential school or district-level intervention for promoting postsecondary access is to increase the number of students accessing advanced coursework in middle school. Importantly, this does not mean accelerating the timetable for algebra taking, but rather ensuring that students have access to accelerated or advanced levels of the foundational math classes they need in the future and instituting policies and practices which promote enrollment in advanced coursework in the middle school years.

One such policy could be assessing and adjusting the way in which course taken decisions are made within a school or school district. For example, in the included school district, teachers make course recommendations for students. While students can choose not to follow this recommendation, doing so often requires parent involvement and conversations with school administration. As such, teacher recommendation presents an important intervention point for promoting equitable access in advanced mathematics. Specifically, this calls into question the system by which course recommendations are being made and whether or not this system is equitable. Perhaps shifting to a system in which students choose their subsequent courses, rather than teachers, would help increase access to advanced coursework in the crucial middle school years.

Gender

The role of gender was particularly significant in this study. Given the growing societal focus on gender disparities in STEM fields (Microsoft Philanthropies, 2019) and literature which demonstrates that girls tend to leave STEM fields and STEM coursework before boys (Heaverlo et al., 2013), it was clear that gender was likely to be salient in determining pathways of advanced math taking. Our findings aligned with this general body of literature as girls were bivariately overrepresented in advanced trajectories before conditioning on performance, and less likely than males to be in more advanced latent class trajectories once academic achievement was controlled for. This indicates that girls are generally performing better than boys in elementary school and are more likely to enroll in advanced math coursework in middle and high school – but when performance is similar, boys are more likely to take advanced versions of math courses than girls. This may reflect gendered expectations, or the influence of math stereotypes, about who should be in advanced math classrooms (Casad et al., 2017).

However, the loss of a significant gender effect when controlling for standardized math scores in grade 5 (see supplemental analyses) presents additional complexity. It is possible that grade 5 math assessment performance may be a more precise measure of math specific aptitude and thus a stronger predictor of math course selection than standardized reading score in grade 5. Supporting this notion, the overall effect size for standardized test score in G5 increased when shifting from the reading to the math scores.

However, this does not preclude the possibility that the social influence of gender is impacting math course enrollment. Specifically, evidence that math anxiety and gendered math stereotypes are evident in elementary school (Goetz et al., 2013) suggests that gender may be influencing course selection *through* standardized test scores in this model.

Interestingly, there was no significant gender effect when looking at *Early Advanced Tryers* compared to *Consistently Mid-level Advanced* math takers. Likewise, there was no significant gender effect when comparing the odds of belonging to the *Late Honors Tryers* relative to the *Always Standard* latent class. Together these findings suggest that gender differences in course trajectories may be a result of middle school course taking patterns because only contrasts that differ in middle school mathematics taking were significantly influenced by gender. This is important because research suggests that girls' engagement in STEM begins to decline in the middle school years (Heaverlo et al., 2013; VanLeuvan, 2004). Access to a female role model in a STEM field has been shown to increase interest in STEM areas and help buffer this declining interest (Microsoft Philanthropies, 2019). Accordingly, connecting girls to such role models in the middle school years may be important for promoting advanced mathematics enrollment for girls.

Race/Ethnicity

The bivariate findings for race/ethnicity align with general literature which suggests that White and Asian students tend to take higher levels of advanced math coursework over time than Latinx and Black students. In this primarily Latinx community, Latinx students were also more likely to belong to highly advanced math trajectories than to standard math trajectories. This could indicate that in schools where there are more race-matched teachers or where students of color are the majority, traditionally underrepresented students are getting increased opportunities for advanced mathematics.

Interestingly, when conditioning on elementary school academic achievement, the results change such that among those achieving equally, Black and Latinx students are all *more* likely than White students to belong to the *Most/Earliest Advanced* class relative to the *Primarily Advanced with some CL* class. This is in line with research which shows that after controlling for previous academic performance, Black students are more likely to pursue and succeed in STEM fields than their White peers (Betancur et al., 2018; Niu, 2017; Riegle-Crumb & King, 2010).

The combination of bivariate and multivariate findings indicates that Black and Latinx students are not selecting out of advanced mathematics if they have the opportunity to enroll, but that earlier barriers may be reducing those initial opportunities to enroll. For instance, cultural load and cultural mismatch in standardized testing experiences (Council of National Psychological Associations for the Advancement of Ethnic Minority Interests [CNPAAEMI], 2016; Cokley & Awad; 2013) may influence the standardized test scores which are used to indicate student aptitude in school settings. Asian students were consistently the most likely to belong to the *Most/Earliest Advanced* class even controlling for academic achievement. This is in line with previous research on advanced mathematics taking (College Board, 2014).

Poverty

Despite the breadth of research that illustrates the impacts of poverty on access and achievement in advanced coursework (Conger et al., 2009; Plucker & Peters, 2018; Theokis & Saaris, 2013), this dissertation found limited evidence of poverty status impacting course trajectories once prior academic achievement was controlled for. In fact, poverty was only multivariately related to advanced math trajectories when comparing between two class contrasts. First, students receiving full-price lunch were less likely to be *Early Advanced Tryers* than *Always Standard* math takers. Second, those who received full-price lunch were more likely to be *Late Honors Tryers* than *Early Advanced Tryers*. Although this is opposite to what the general literature would suggest (Plucker & Peters, 2016, 2018), this aligns with some previous work which demonstrated that once academic achievement was controlled for, students in poverty were actually more likely to take advanced courses than students not in poverty (Ricciardi & Winsler, 2018).

In addition, this study employs a limited definition of poverty (FRL status) and the sampling parameters (those in public school pre-K or subsidized childcare at age 4) result in a reduced range of income where even the small number of those who receive regular-price lunch are not likely to be affluent. Furthermore, the included school district has prioritized promoting educational opportunities, particularly in advanced academics, for those in poverty. One example of this targeted policy in the current school district is the implementation of multiple pathways to gifted identification for those from low-income backgrounds. This unique context could result in different results in a different sample or with a different measure of poverty. Importantly, this demonstrates that district-level policy around identifying academically advanced students from low-income backgrounds can positively impact educational opportunities for such students. This suggests that one structural way to mitigate poverty gaps in access to spaces of excellence is to devise district-level policy which prioritizes this goal.

However, these findings do not indicate that poverty is not affecting student's advanced math pathways. Bivariately, we demonstrate that those who receive full-price lunch are overrepresented in the 3 most advanced class trajectories, indicating that the major way poverty is impacting advanced course taking trajectories is through its effect on early academic achievement in elementary school. Given the large body of literature which demonstrates that poverty is negatively related to academic achievement (Olszewski-Kubilius & Corwith, 2018), this dissertation adds another concerning implication of this relationship and emphasizes the need for early intervention for students from low-income backgrounds.

ELL Status

While there is evidence in the literature that ELLs tend to perform more poorly in school than their English as a first language peers (Shaunessy et al., 2007), this dissertation found a divergent pattern of results. English language learners were overrepresented in the most advanced course trajectories in this sample bivariately, and were also multivariately more likely to belong to the *Most/Earliest Advanced* class pathway than the *Always Standard* class pathway. There is some literature which reports a cognitive advantage for ELLs (Carman et al., 2018) and given that all students in the sample had reached proficiency in English by grade 6, this predictor could be going further and acting as a proxy for a bilingual advantage (Byers-Heinlein et al., 2019; De Feyter & Winsler, 2009). Notably, students in this sample had been attending English schools since the age of 4 and at the time of analysis had reached English proficiency according to the school system. This suggests that English proficiency, not home language, may be what is facilitating the results of other studies. From this perspective, being an ELL in this community appears to be beneficial for students seeking to access advanced mathematics coursework in middle and high school. Notably, this school district is in a predominately Latinx community where Spanish is widely spoken. This community context may promote achievement for ELLs in ways that predominately monolingual, English speaking communities do not.

School Readiness

In line with prior work on the longitudinal outcomes of school readiness (Davies et al., 2016; DiPerna et al., 2007; Duncan et al., 2007), we demonstrated that higher cognitive and fine motor skills as measured at age 4 positively influenced class membership toward class pathways which included advanced coursework, even controlling for demographics and 5th grade academic achievement. This suggests that disparities in access to preschool, and particularly high-quality preschool, which is known to boost school readiness may be perpetuating opportunity gaps for those from disadvantaged backgrounds. However, given the lack of significant findings for preschool type, more intensive readiness intervention may be necessary.

Generally socioemotional measures of school readiness were unrelated to latent class pathways. However, higher preschool teacher-perceived behavioral concerns at age 4 were related to a decrease in the odds of being an *Early Advanced Tryer* relative to an *Always Standard* course taker. It is possible that students who are better behaved are assumed to be a better fit for advanced coursework (Carman, 2011) and are encouraged to attempt advanced coursework when their otherwise similar peers are not. In line with this, higher teacher-perceived behavioral concerns at age 4 were also related to increased odds of being a *Late Honors Tryer* relative to an *Early Advanced Tryer*. Again, suggesting that better behavior may be conflated with academic ability and thus related to early encouragement for advanced coursework. Importantly, teachers tend to perceive students of color, especially boys of color, as having more behavior problems than White, female students (Tenenbaum & Ruck, 2007; Williams et al., 2018). Thus teacher-perceived behavioral concerns may be an unanticipated way that disparities in access to advanced mathematics are being perpetuated.

Retention

Retention presented one of the most surprising patterns of results in this study. In contrast to existing literature on the long-term impacts of retention (Bright, 2012; Xia & Kirby, 2009), this dissertation showed evidence that for those who are achieving equally, retention sometimes bolstered the likelihood of advanced math course enrollment. This pattern wasn't consistent across models, but did occur multiple times in the findings. Specifically, retention was positively related to being in the *Early Advanced Tryers* class and the *Most/Earliest Advanced* class. Notably, across all models, retained students are more likely to be in classes with early advanced taking but not late honors taking. While the *Most/Earliest Advanced* class is characterized by a high likelihood of very advanced math taking, one of the most important and discriminating features of this class is enrollment in honors coursework earlier than in any other latent class. This is similar to the *Early Advanced Tryers* class where students also take advanced early and then take standard courses in later grades. Given this, it is possible our retention variable is operating as a proxy for age. With the introduction of courses like pre-algebra and algebra, students in middle school are often asked to engage in abstract mathematical reasoning for the first time in their academic careers. Given that the ability to engage in such abstract reasoning is generally thought to emerge around age 12 and develop across the adolescent years (Susac et al., 2014), a one-year age difference would produce students with vastly different abilities to engage in the kind of abstract mathematical reasoning demanded by this coursework. This pattern is in-line with pattern of findings demonstrated in this study where retained (and thus older) students were more likely to enroll in advanced math coursework early, but this effect fades by high school when their younger, same grade peers have caught up developmentally.

It is also important to consider who is included in this study. Retained students were less likely to remain in the school system over time (see missing data section) and this pattern is frequently repeated in the literature (Stearns et al., 2007). Moreover, long term academic and social outcomes of retention are often negative (Bright, 2012; Xia & Kirby, 2009). This suggests that those who are scoring equivalent to non-retained students on standardized tests and obtaining similar GPAs are particularly resilient retained students. This is a particular group for whom other factors may be positively promoting resilience and in turn academic achievement at large. This combination of factors suggests that while retention is associated with an increase in the odds of early enrollment in advanced coursework, retention should not be pursued as an intervention to promote early access. The largely negative long-term outcomes of retention broadly (Bright, 2012; Xia & Kirby, 2009) and the negative relationship between retention and trajectories characterized by *persistence* in advanced math taking suggest that the short-term age benefit for advanced mathematics does not translate to long-term mathematics benefits for these students and risks an increased likelihood of dropping out and other negative academic and social consequences.

Suspension

While retention operated in some unexpected ways within this sample, middle and high school suspension had the hypothesized negative impact on advanced math course pathways. Essentially, students who were suspended in middle or high school were less likely to be in any pathway that included advanced course taking relative to the *Always Standard* class. Furthermore, middle or high school suspension also differentiated between the *Early Advanced* and *Late Honors Tryer* groups. Specifically, that those who were suspended in middle or high school were more likely to be *Late Honors Tryers* than *Early Advanced Tryers*. This is in line with our finding that teacher-perceived behavioral concerns at age 4 were negatively related to the odds of belonging to a math trajectory containing early advanced math taking.

Elementary school suspension was primarily unrelated to latent class assignment, however, much like with retention, there was a significant effect in the opposite direction hypothesized when predicting the likelihood of belong to the *Primarily Advanced with some CL* or the *Most/Earliest Advanced* classes. This may be reflect that once GPAs are high enough, previous suspensions are no longer a deterrent for advanced course taking.

Limitations/Future Directions

The primary limitation with this work was a lack of concurrent academic or social measures to relate to course selection. Specifically, without a measure of performance in each math course taken, we can't account for the role of concurrent success on persistence expectations. This is particularly important because current success in advanced math coursework likely heavily influences persistence in that advanced course trajectory. Furthermore, the larger social environment and an individual's peer relationships are likely also important factors which affect academic decision making for students, particularly for those who face social biases in advanced academic spaces. Future work should address these gaps and build on this dissertation's examination of early factors as they impact later advanced mathematics enrollment.

In addition, future work should more carefully examine the role of intersectional identities on advanced course taking. While we statistically control for variance attributable to race/ethnicity and gender, we don't employ moderation or subgroup analyses to statistically model how the relationship between child-level factors and advanced mathematics outcomes vary as a function of identity. This means that our results around ethnicity may be reflecting the experiences of *men* of color while our gender results may be reflecting the experiences of *White* women, leaving women of color's experiences unexamined. This is a recurrent problem in the literature (Hanson, 2009) and future research should be sure to specifically examine women and girls of color.

Moreover, without qualitative work to understand the lived experiences of kids of color and those in poverty, the story is only half-told. Qualitative work should examine questions of why students make course taking decisions and what promotes or impedes their academic journeys. Furthermore, qualitative work is also needed to understand the experiences of those while they are in these advanced math courses. Are their identities being affirmed in these spaces? Are students facing social isolation? Future work should address these gaps.

Finally, although the sample itself provided many advantages including its size and inclusion often understudied populations, generalizability should be considered carefully. This sample was recruited from a primarily Latinx community and includes only students from a large, award-winning school district. As such, comparisons to primarily White school districts or those with less policy regarding equity may result in different patterns of findings.

Conclusions/Implications

Overall this dissertation demonstrated that students are following a varied set of trajectories through math coursework across middle and high school. Examining these common math taking trajectories revealed that students who don't begin advanced math trajectories in middle school are unlikely to take advanced math courses in high school, and extremely unlikely to go on to take college-level math coursework. This finding is complicated by the results which revealed that access to early advanced math varies systematically. Specifically, some policies like gifted identification promote access to early advanced coursework, while other factors like teacher-perceived behavioral concerns reduced access to early advanced coursework. The included school district has attempted to reduce barriers to access by opening advanced courses to any students who wish to enroll by not requiring teacher permission. The high rates of enrollment in a trajectory which includes some advanced math coursework suggests that this policy, among other efforts by the district, is having a beneficial effect on enrollment among traditionally marginalized populations. Nevertheless, persistent bivariate associations between demographic factors like racial/ethnic identity and poverty status on math trajectory suggest that intervention is necessary earlier in the academic experience to target opportunity gaps that are preventing students of color and who are experiencing poverty from accessing the programs and indicators of achievement that result in advanced course enrollment (i.e. access to gifted programming).

Also notable was the pattern of course taking for *Late Honors Tryers,* which in conjunction with the other trajectories suggested that students who skip ADV, or middle school advanced, math coursework are unlikely to persist in advanced math taking. This suggests that the included school district's establishment of this preparation-level of advanced coursework is likely setting students up for the challenge of advanced math taking. This also aligns with the larger literature on frontloading which suggests that it is crucial to begin setting students up for rigorous coursework early if we want them to succeed and persist in these spaces. Given the generally positive results associated with exposing students to rigorous coursework (Wakelyn & the NGA, 2010), it seems like expanding access to this course could be a useful way to encourage higher-level math taking and persistence without harming those who chose not to pursue this option in the future. In addition, middle school appears to be an important time for students to have access to race-matched or interculturally competent teachers and guidance counselors to help promote this crucial early access.

As mentioned previously, access to math taking trajectories was not only determined by academic achievement, but also by the skills a student arrives to school with and even by their demographic and background characteristics. This suggests that in order to effectively close gaps in advanced math taking, interventions which support early skill development will be critical. One such intervention could be expanded access to high-quality childcare which is shown to boost school readiness skills (Yoshikawa et al., 2013). While we did not demonstrate preschool effects when comparing public-school and center-based preschool options, this study did not include those who were not enrolled in preschool at all. It is possible that those who don't attend preschool are arriving to school less ready and thus are less likely to take advanced courses down the line.

Finally, while race/ethnicity effects were largely non-significant when prior academic achievement had been controlled for, these effects persisted when differentiating who accessed the *Most/Earliest Advanced* trajectory relative to the *Primarily Advanced with some CL track.* In general, Latinx and Black students were more likely than White students (but less likely than Asian students) to belong to the *Most/Earliest Advanced* path when conditioning on prior academic achievement. This supports the notion that differences in early opportunity are driving overall enrollment disparities, rather than a lack of interest by students of color. Consequently, interventions which target social and economic disadvantage (like housing and zoning policies) will be necessary to address the existence of excellence gaps in education.

In sum, this dissertation presents an exploration of middle and high school math taking patterns among a predominately low-income, ethnically diverse sample. Roughly half the students studied followed a course taking trajectory which included some sort of advanced mathematics. Those who were achieving higher grades, higher standardized test scores, and who had been identified as gifted were more likely to belong to trajectories which included advanced course taking. Likewise, among trajectories which included advanced mathematics, higher elementary school achievement continued to predict course trajectories which included earlier and higher levels of math coursework. Although prior academic achievement exerted the largest effects on latent math trajectory, school readiness skills and select demographic factors also influenced path membership. This work highlights critical times for intervention (middle school, elementary school, and preschool) and emphasizes the importance of early access to rigorous coursework and programming for promoting advanced math taking among these students.

TABLES

Table 1

Percent Enrollment in Each Math Type by Grade for the Whole Sample

	G6		G7		G8		G9		G10		G11		G12	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Standard	10,640	61.2%	11,151	67.1%	9,856	58.5%	10,042	60.5%	11,189	70.5%	10,872	79.0%	10,295	81.8%
ADV	6,702	38.5%	4,392	26.4%	802	4.8%								
Honors	45	0.3%	1,068	6.4%	6,177	36.7%	6,527	39.3%	4,602	29.0%	2,315	16.8%	985	7.8%
AP							15	.1%	58	.4%	426	3.1%	1108	8.8%
DE							13	.1%	24	.2%	141	1.0%	200	1.6%
CL							28	0.2%	82	0.5%	567	4.1%	1,308	10.4%

Note. Those who were enrolled in an AP and a DE math simultaneously (136 incidences across all 4 high school years) are categorized as AP in this table. CL includes those who are enrolled in an AP, DE, or both in the relevant grade.

Table 2

Fit Indices for Latent Class Solutions

Classes	Free Parameters	Log-likelihood	AIC	BIC	SSABIC	Entropy	Adjusted LRT p-value
1	14	-77100.5	154228.9	154338.8	154294.3		
2	29	-65654.3	131366.7	131594.2	131502	0.815	0.000
3	44	-64795.9	129679.8	130024.9	129885.1	0.713	0.000
4	59	-64337.7	128793.4	129256.2	129068.7	0.707	0.000
5	74	-63909.4	127966.8	128547.2	128312.1	0.696	0.000
6	**89**	**-63713.8**	**127605.7**	**128303.8**	**128021**	**0.718**	**0.000**
7	104	-63600.3	127408.7	128224.4	127893.9	0.735	0.809
8	119	-63519.8	127277.6	128211	127832.8	0.735	1.000
9	134	-63456.5	127181	128232	127806.2	0.719	0.970

Note. The bolded row is the final class model.

Table 3
Classification Probability Table

	Latent Class Membership					
Latent Class	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
Class 1	**0.827**	0.048	0.001	0.033	0.089	0.001
Class 2	0.035	**0.751**	0.081	0.043	0.055	0.035
Class 3	0.005	0.033	**0.86**	0.095	0.004	0.003
Class 4	0.025	0.046	0.039	**0.832**	0.032	0.026
Class 5	0.125	0.079	0.003	0.023	**0.765**	0.005
Class 6	0.003	0.133	0.004	0.034	0.101	**0.725**

Note. Bolded terms on the diagonal represent the probability that an individual has been classified as a latent class and that they actually belong to that class.

Table 4

Probability of Course Enrollment by Latent Class Trajectory

		Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
G6							
	Standard	0.105	0.291	0.93	0.858	0.136	0.249
	Advanced	0.89	0.709	0.066	0.142	0.864	0.736
	Honors	0.005	0	0.004	0	0	0.015
G7							
	Standard	0.238	0.215	0.983	0.973	0.113	0.148
	Advanced	0.239	0.756	0.017	0.027	0.876	0.845
	Honors	0.522	0.028	0	0	0.011	0.006
G8							
	Standard	0.013	0.44	0.949	0.664	0.025	0.487
	Advanced	0.002	0.129	0.018	0.038	0.018	0.513
	Honors	0.985	0.432	0.033	0.298	0.957	0
G9							
	Standard	0.143	0.762	0.996	0.319	0.037	0.211
	Honors	0.856	0.237	0.001	0.681	0.962	0.786
	CL	0.001	0.001	0.003	0	0.001	0.003
G10							
	Standard	0.807	0.809	0.875	0.575	0.341	0.022
	Honors	0.177	0.191	0.121	0.42	0.655	0.97
	CL	0.016	0	0.004	0.005	0.004	0.008
G11							
	Standard	0.615	0.783	0.898	0.7	0.827	0.365
	Honors	0.111	0.216	0.098	0.29	0.146	0.618
	CL	0.274	0.001	0.004	0.01	0.027	0.017
G12							
	Standard	0.549	0.889	0.916	0.839	0.736	0.849
	Honors	0.042	0.093	0.08	0.105	0.055	0.151
	CL	0.409	0.019	0.004	0.057	0.209	0

Table 5

Actual Enrollment by Latent Class Trajectory

G6		Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
	Standard	8%	30%	92%	88%	13%	21%
	Advanced	92%	70%	8%	12%	87%	79%
	Honors	0%	0%	1%	0%	0%	0%
G7							
	Standard	30%	12%	100%	100%	7%	5%
	Advanced	8%	87%	0%	0%	93%	94%
	Honors	62%	1%	0%	0%	0%	1%
G8							
	Standard	1%	46%	95%	60%	0%	46%
	Advanced	0%	15%	2%	4%	0%	54%
	Honors	99%	40%	4%	35%	99%	0%
G9							
	Standard	14%	88%	100%	10%	1%	15%
	Honors	86%	12%	0%	90%	99%	85%
	CL	0%	0%	0%	0%	0%	0%
G10							
	Standard	85%	81%	86%	54%	37%	0%
	Honors	13%	19%	14%	46%	62%	99%
	CL	2%	0%	0%	0%	0%	1%
G11							
	Standard	59%	80%	89%	67%	82%	41%
	Honors	10%	20%	11%	32%	16%	57%
	CL	31%	0%	0%	1%	2%	2%
G12							
	Standard	57%	90%	91%	81%	72%	86%
	Honors	4%	9%	9%	10%	5%	14%
	CL	39%	1%	0%	9%	23%	0%

Table 6

Percent of Each Latent Class Relative to Sample Total

	Always Standard	Early Advanced Tryers	Late Honors Tryers	Consistently Mid-level Advanced	Primarily Advanced some CL	Most/ Earliest Advanced	Sample Total
Latinx	54.1	59.1	57.4	58	62.8	66.9	57.7
Black	42	33.6	37.6	31.4	24.7	20.6	35.6
White/ Other	3.7	7	4.6	9.7	11.4	9.7	6.1
Asian	0.2	0.4	0.3	1	1	2.6	0.6
None	11.7	16.5	16.7	23.4	29.4	32	18
Reduced	7.6	10.3	9.8	10.6	11	11.9	9.2
Free	80.7	73.2	73.5	65.9	59.6	54.8	72.9
Female	44.40	49.7	51.3	56.5	54.4	52.5	48.4
Male	55.6	50.3	48.7	43.5	45.6	47.5	51.6
Non-ELL	44.9	42.3	43.2	44	39.4	35.1	42.7
ELL	55.1	57.7	56.8	56	60.6	64.9	57.3
No Disability	74.3	94.7	88	97	97.2	97.5	84.7
Disability	25.7	5.3	12	3	2.8	2.5	15.3

Table 7

Multinomial Logistic Regression – Compared to the Always Standard Class

	Early Advanced Tryers	Late Honors Tryers	Consistently Mid-level Advanced	Primarily Advanced some CL	Most/ Earliest Advanced
Demographics	Odds Ratio	Odds Ratio	Odds Ratio	Odds Ratio	Odds Ratio
Male	1.39***	1.088	1.235*	1.631***	1.953***
Public School Pre-k	1.032	1.022	0.99	1.000	0.931
ELL	0.939	0.981	0.874	1.078	1.211*
Disability Status G6	0.271***	0.516***	0.195***	0.206***	0.218***
Black/Latinx	1.033	1.076	1.212	1.134	1.108
White/Latinx	1.253	0.941	1.517*	1.305*	0.958
Asian/Latinx	1.011	1.098	2.39	1.68	3.758***
Black/White	0.824	1.142	0.799	0.869	1.157
Full Lunch G6	0.825*	1.124	1.065	1.052	1.05
Reduced Lunch G6	1.02	1.133	1.048	1.021	1.086
School Readiness					
Cognitive	1.005***	1.003*	1.001	1.007***	1.008***
Language	0.998	0.999	0.994**	0.998	0.998
Fine Motor	1.003	1.004**	1.005*	1.007***	1.007***
Gross Motor	0.998	0.999	0.997	0.997**	0.996***
Teacher TPF	1.000	1.001	1.003	1.002	1.002
Teacher BC	0.997*	1.001	1.003	1.000	0.999
Parent TPF	0.999	1.000	1.001	0.999	1.001
Parent BC	1.001	0.999	1.000	0.998	1.000
Prior Academics					
Reading Score G5	1.616***	1.232***	1.946***	2.037***	2.209***
GPA G5	3.711***	1.973***	7.381***	11.855***	23.165***
Gifted	4.228***	1.397*	5.127***	6.527***	10.233***
Retained	1.261**	0.979	0.499**	0.793	1.969***
Suspended in K - G5	1.163	1.171	1.377	1.406**	1.652**
Suspended in G6 - G12	0.88*	0.626*	0.754**	0.445***	0.412***

Table 8

Multinomial Logistic Regression – Select Comparisons

	Late Honors Tryers vs Early Advanced Tryers		Consistently Mid-Level Advanced vs Early Advanced Tryers		Most/Earliest Advanced vs Primarily Advanced with some CL	
Demographics	Odds Ratio	*SE (B)*	Odds Ratio	*SE (B)*	Odds Ratio	*SE (B)*
Male	0.783***	0.069	0.889	0.109	1.198**	.065
Public School Pre-k	0.99	0.073	0.959	0.112	.931	.076
ELL	1.044	0.088	0.931	0.131	1.123	.081
Disability in G6	1.903***	0.131	0.719	0.285	1.057	.198
Black/Latinx	1.043	0.094	1.174	0.142	.977	.093
White/Latinx	0.751	0.153	1.211	0.204	.735**	.115
Asian/Latinx	1.086	0.549	2.363	0.587	2.236***	.237
Black/White	1.386	0.215	0.969	0.068	1.332*	.125
Full Lunch G6	1.326*	0.097	1.291	0.141	.999	.079
Reduced Lunch G6	1.111	0.112	1.027	0.17	1.063	.100
School Readiness						
Cognitive	0.998	0.002	0.996	0.003	1.000	.002
Language	1.001	0.002	0.996	0.003	1.000	.002
Fine Motor	1.001	0.002	1.003	0.003	1.000	.002
Gross Motor	1.001	0.001	0.999	0.002	.998	.001
Teacher TPF	1.001	0.002	1.002	0.002	1.000	.002
Teacher BC	1.004*	0.001	1.006**	0.002	.999	.001
Parent TPF	1.001	0.001	1.002	0.002	1.002	.001
Parent BC	0.998	0.001	0.999	0.002	1.001	.001
Prior Academics						
Reading Score G5	0.726***	0.039	1.204**	0.063	1.084	.044
GPA G5	0.532***	0.093	1.989***	0.161	1.954***	.120
Gifted	0.331***	0.127	1.213	0.132	1.568***	.070
Retained	0.776*	0.106	0.396***	0.261	2.485***	.180
Suspended in K – G5	1.007	0.121	1.184	0.213	1.175	.169
Suspended in G6 - G12	0.711*	0.07	0.857	0.112	.925	.080

FIGURES

Figure 1

Latent Class Pathways

1 **Always Standard** N = 9504 50.44%

G6	G7	G8	G9	G10	G11	G12
Standard (92%)	Standard (100%)	Standard (95%)	Standard (100%)	Standard (86%)	Standard (89%)	Standard (91%)
ADV	ADV	ADV	Honors	Honors	Honors	Honors
Honors	Honors	Honors	CL	CL	CL	CL

2 **Early Advanced Tryer** N = 1943 10.31%

G6	G7	G8	G9	G10	G11	G12
Standard (30%)	Standard	Standard (46%)	Standard (88%)	Standard (81%)	Standard (80%)	Standard (90%)
ADV (70%)	ADV (87%)	ADV	Honors	Honors	Honors (20%)	Honors
Honors	Honors	Honors (40%)	CL	CL	CL	CL

3 **Late Honors Tryer** N = 2074 11.01%

G6	G7	G8	G9	G10	G11	G12
Standard (88%)	Standard (100%)	Standard (60%)	Standard	Standard (54%)	Standard (67%)	Standard (81%)
ADV	ADV	ADV	Honors (90%)	Honors (46%)	Honors (32%)	Honors
Honors	Honors	Honors (35%)	CL	CL	CL	CL

4 **Consistently Mid-level Advanced** N = 527 2.80%

G6	G7	G8	G9	G10	G11	G12
Standard (21%)	Standard	Standard (46%)	Standard	Standard	Standard (41%)	Standard (86%)
ADV (79%)	ADV (94%)	ADV (54%)	Honors (85%)	Honors (99%)	Honors (57%)	Honors
Honors	Honors	Honors	CL	CL	CL	CL

5 **Primarily Advanced with some CL** N = 3080 16.35%

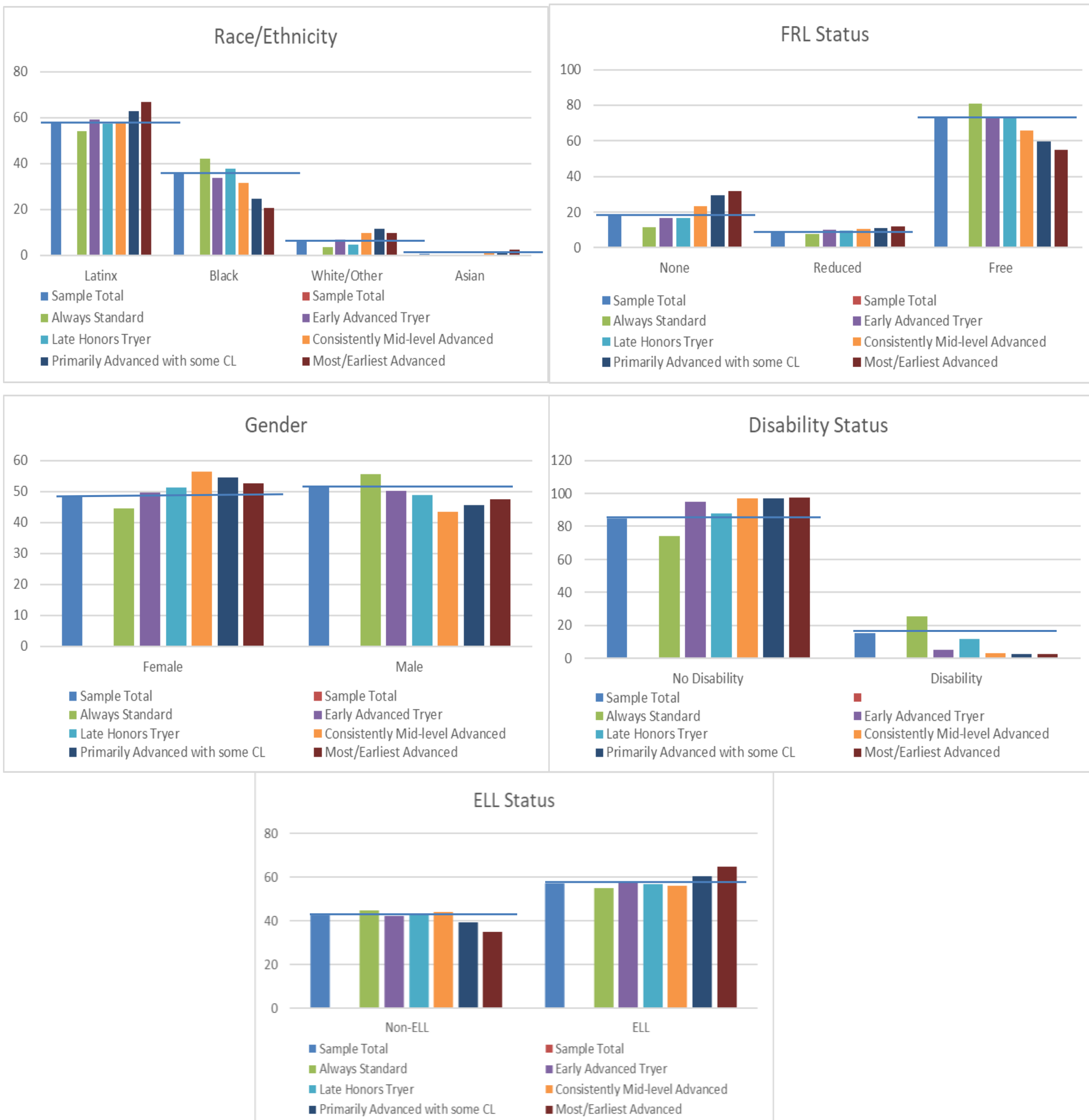
G6	G7	G8	G9	G10	G11	G12
Standard	Standard	Standard	Standard	Standard (37%)	Standard (82%)	Standard (72%)
ADV (87%)	ADV (93%)	ADV	Honors (99%)	Honors (82%)	Honors	Honors
Honors	Honors	Honors (99%)	CL	CL	CL	CL (23%)

6 **Most/Earliest Advanced** N = 1713 9.09%

G6	G7	G8	G9	G10	G11	G12
Standard	Standard (30%)	Standard	Standard	Standard (85%)	Standard (59%)	Standard (57%)
ADV (92%)	ADV	ADV	Honors (86%)	Honors	Honors	Honors
Honors	Honors (62%)	Honors (99%)	CL	CL	CL (31%)	CL (39%)

Figure 2

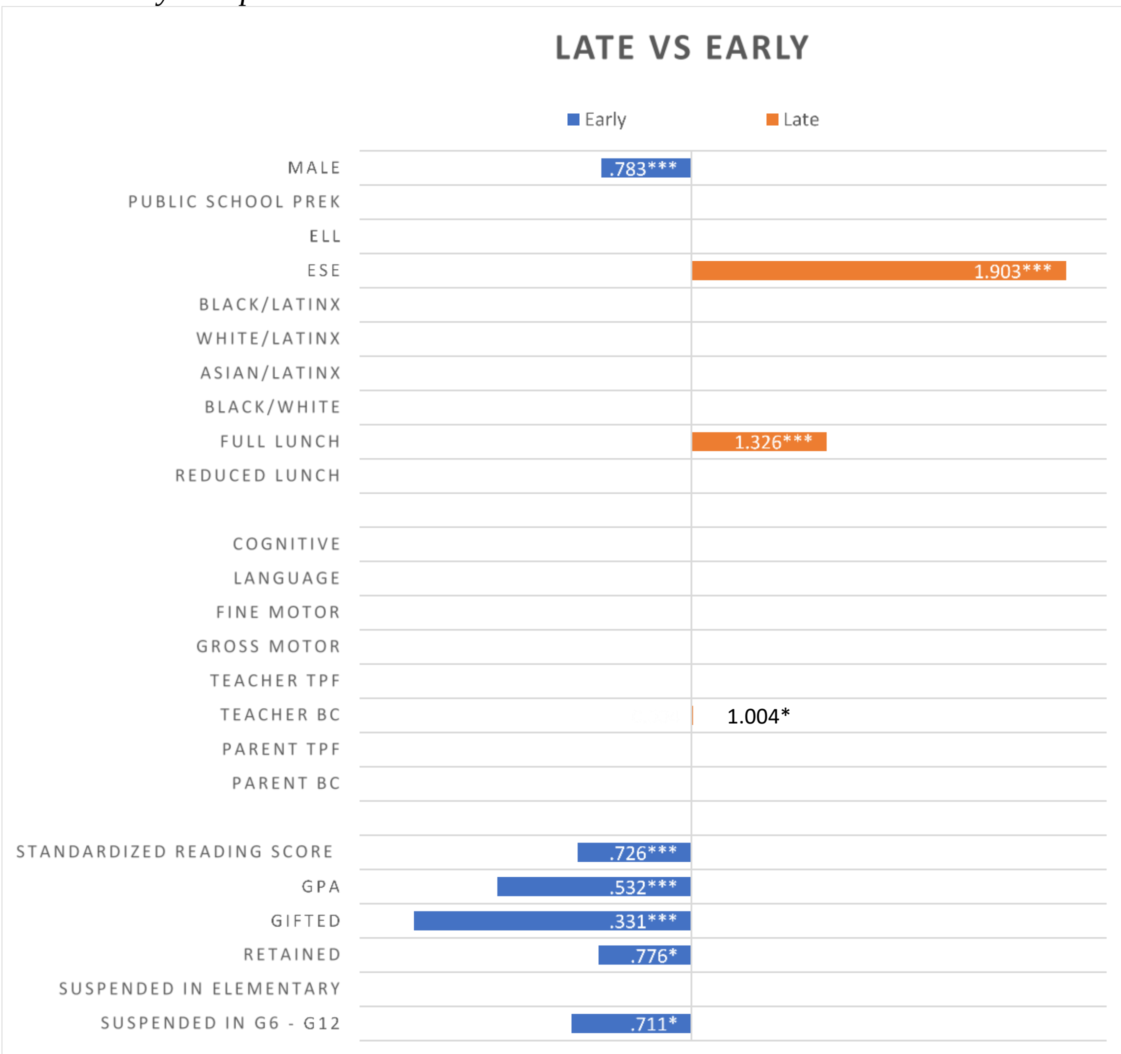
Class Membership Relative the Sample as Whole



Note. The bar on the far left of each set of data represents the proportion in the sample as whole. Bars taller than the corresponding sample total bar represent relative overrepresentation, while bars lower than the corresponding sample total bar represent relative underrepresentation.

Figure 3

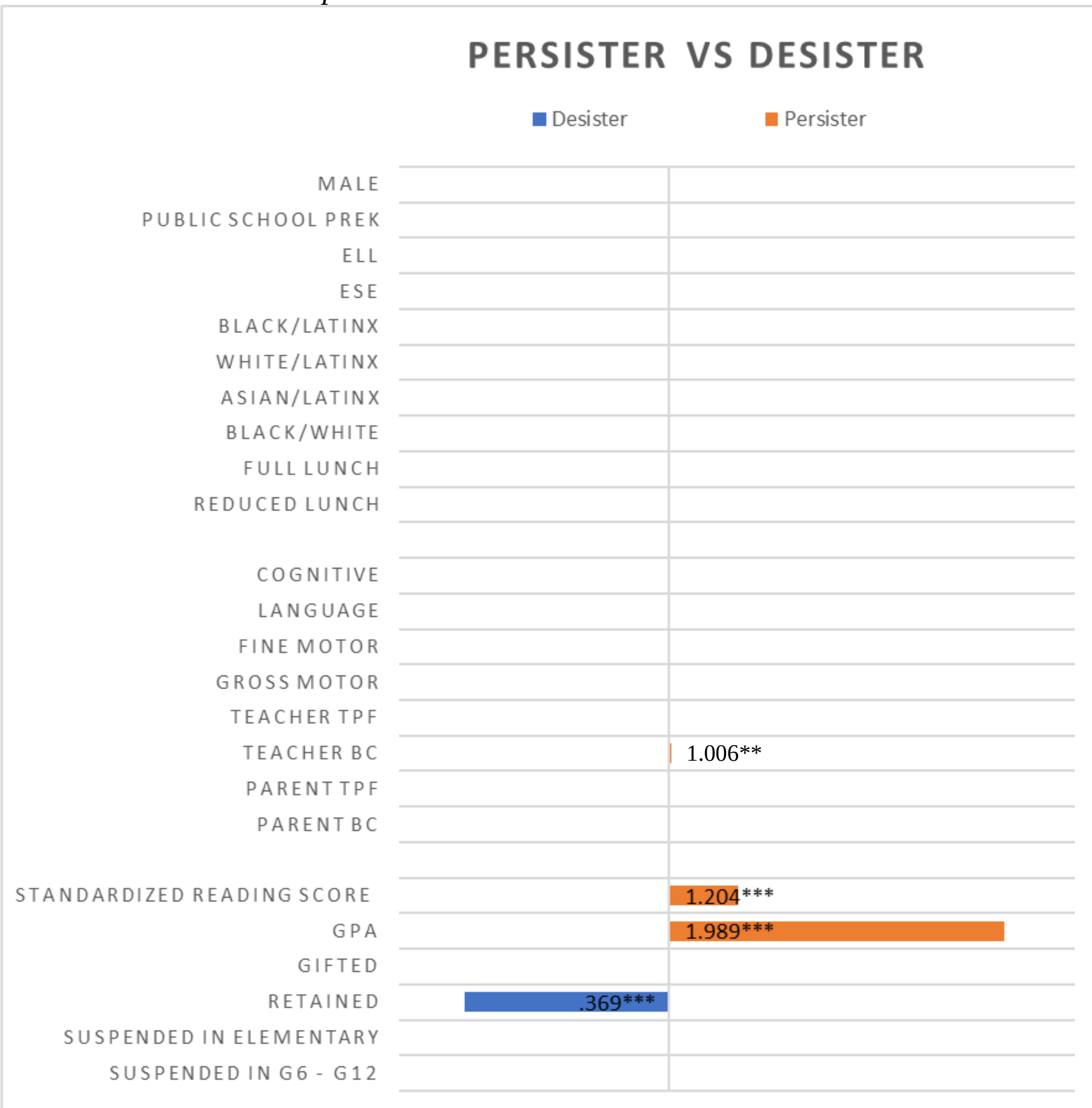
Late vs Early Comparison



Note. Blank rows represent non-significant findings. The center column represents an odds ratio of 1. Values of less than 1 represent a decrease in the odds of being a Later Honors Tryer, and thus are associated with higher odds of being an Early Advanced Tryer. Values higher than 1 indicate an increase in the odds of being a Late Honors Tryer.

Figure 4

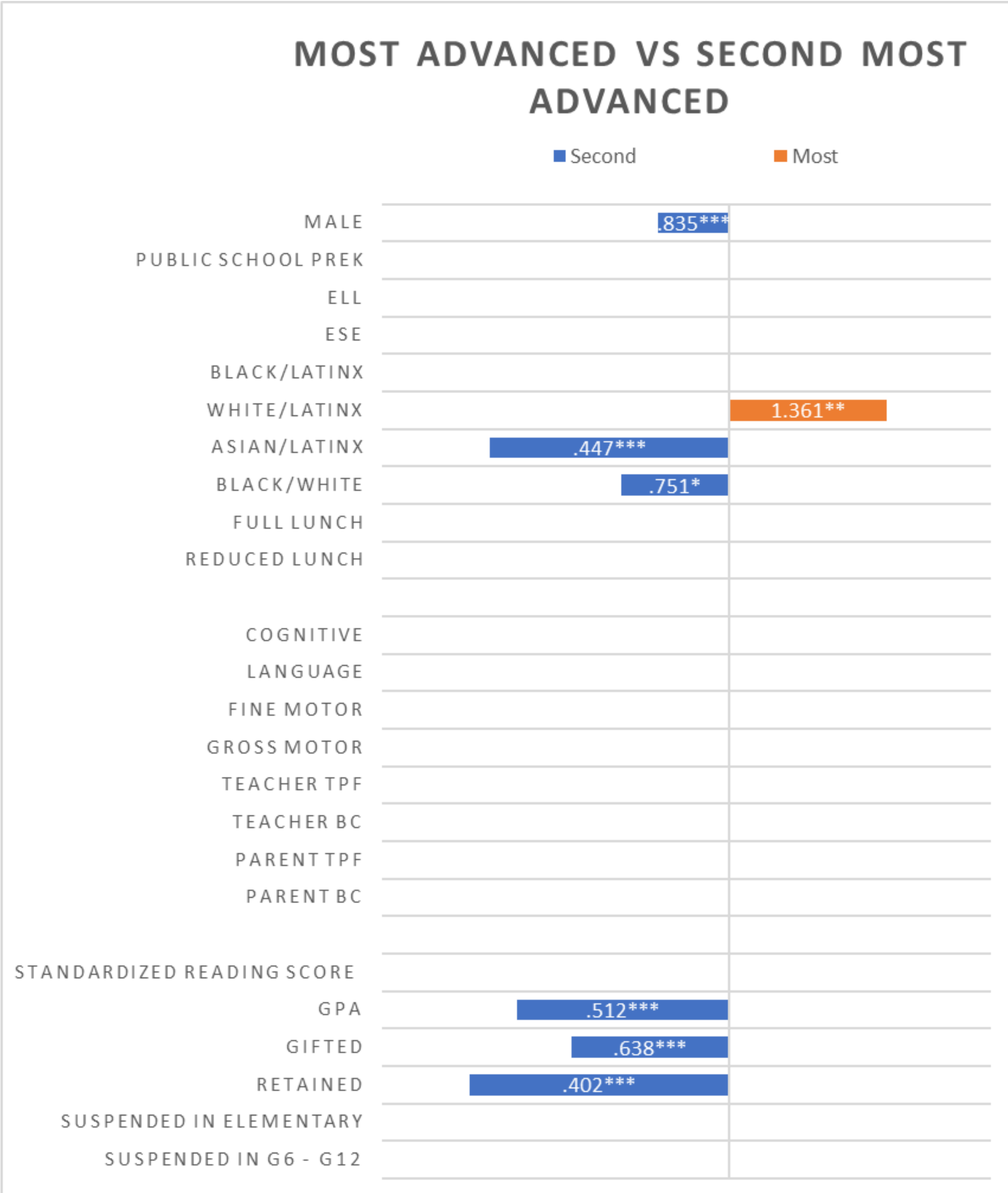
Persister vs Desister Comparison



Note. Blank rows represent non-significant findings. The center column represents an odds ratio of 1. Values of less than 1 represent a decrease in the odds of being a Consistently Mid-level Advanced taker, and thus are associated with higher odds of being an Early Advanced Tryer. Values higher than 1 indicate an increase in the odds of being a Consistently Mid-level Advanced Taker.

Figure 5

Most Advanced vs Second Most Advanced Contrast



Note. Blank rows represent non-significant findings. The center column represents an odds ratio of 1. Values of less than 1 represent a decrease in the odds of being a Most/Earliest Advanced taker, and thus are associated with higher odds of being an Primarily Advanced with some CL taker. Values higher than 1 indicate an increase in the odds of being a Most/Earliest Advanced Taker.

APPENDIX A

ADV Math Courses	Honors Math Courses	AP Math Courses	DE Math courses
M/J Grade 6 Math Adv	Geometry Hon	Adv Pl Calculus AB	DE: Discrete Math
M/J Grade 7 Math Adv	Algebra 1 Hon	Adv Pl Calculus BC	DE: Bus Calculus
M/J Grade 8 Math Adv	Algebra 2 Hon	AP Statistics	DE: Basic Bus Stats
M/J PreAlg Adv Gift	MATH ANALYSIS HON		DE: Bus Statsl
M/J Pre-Alg Adv Gift	Trigonometry Honors		DE: Calc & A Geom 3
			DE: Calc & Analyti 1
			DE: Calc & Analyti 2
			DE: Calculus 1
			DE: Calculus 2
			DE: College Algebra
			DE: Diff Equations
			DE: Elem Linear Alg
			DE: Finite Math
			DE: Intermediate Alg
			DE: Intg PCal Alg Tr
			DE: Math Liberal Art
			DE: Mth for Lib Arts
			DE: PCal Alg & Tr
			DE: Pre-Calc Algebra
			DE:Trigonometry
			DE: Multivariable Ca
			DE: Statistical Meth
			DE: Comb Alg/Pre-Cal
			DE: Inter. Algebra
			DE: Intro to Statis1
			DE: Statistics 1
			DE: Statistics 2

APPENDIX B

Table 1B

Multinomial Logistic Regression using 5th grade math – Compared to the Always Standard Class

		Early Advanced Tryers	Late Honors Tryers	Consistently Mid-level Advanced	Primarily Advanced with some CL	Most/Earliest Advanced
Demographics						
	Male	1.063	0.959	0.844	1.062	1.182*
	Public School Pre-K	1.074	1.035	1.058	1.084	1.028
	ELL	0.905	0.958	0.832	1.020	1.129
	Disability Status	0.260***	0.515***	0.182***	0.185***	0.188***
	Black/Latinx	1.045	1.086	1.240	1.169	1.157
	White/Latinx	1.190	0.915	1.424	1.217	0.883
	Asian/Latinx	0.975	1.076	2.218	1.523	3.308***
	Black/White	0.879	1.186	0.869	0.961	1.309
	Full Lunch	1.032	1.141	1.114	1.094	1.08
	Reduced Lunch	1.002	1.138	1.067	1.039	1.11
School Readiness						
	Cognitive	1.002	1.002	0.997	1.002	1.002
	Language	1.000	1.000	0.996	1.001	1.001
	Fine Motor	1.000	1.003	1.002	1.003*	1.002
	Gross Motor	0.998	0.999	0.998	0.998	0.997
	Teacher TPF	1.000	1.001	1.002	1.002	1.002
	Teacher BC	0.997*	1.001	1.003	1.000	0.999
	Parent TPF	0.999	1.000	1.001	0.999	1.001
	Parent BC	1.000	0.998	0.999	0.998*	0.999
Prior Academics						
	Standardized Math Score	2.192***	1.458***	3.107***	3.687***	4.905***
	GPA	2.981***	1.759***	5.215***	7.594***	12.846***
	Gifted	4.100***	1.363*	4.843***	5.969***	8.852***
	Retained	1.447***	1.058	0.615	1.046	2.827***
	Suspended in Elementary	1.181	1.188	1.407	1.437**	1.722***
	Suspended in G6 - G12	0.853**	0.618***	0.722**	0.423***	0.389***

Table 2B

Multinomial Logistic Regression using math scores – Select Comparisons

		Late Honors Tryers vs Early Advanced Tryers		Consistently Mid-level Advanced vs Early Advanced Tryers		Most/Earliest Advanced vs Primarily Advanced with some CL	
Demographics		OR	SE(B)	OR	SE(B)	OR	SE(B
	Male	0.902	0.071	0.793*	0.113	1.113	0.067
	Public School Prek	0.964	0.073	0.985	0.112	0.948	0.076
	ELL	1.059	0.088	0.92	0.131	1.108	0.081
	ESE	1.980***	0.132	0.699	0.284	1.012	0.201
	Black/Latinx	1.039	0.094	1.186	0.142	0.989	0.092
	White/Latinx	0.769	0.154	1.197	0.204	0.726**	0.114
	Asian/Latinx	1.104	0.538	2.275	0.591	2.172***	0.235
	Black/White	1.349	0.156	0.989	0.209	1.332*	0.125
	Full Lunch	1.333**	0.097	1.301	0.142	0.986	0.079
	Reduced Lunch	1.102	0.112	1.033	0.169	1.068	0.101
School Readiness							
	Cognitive	1.000	0.002	0.995	0.003	0.999	0.002
	Language	1.000	0.002	0.996	0.003	1.001	0.002
	Fine Motor	1.002	0.002	1.002	0.003	0.999	0.002
	Gross Motor	1.001	0.001	0.999	0.002	0.999	0.001
	Teacher TPF	1.001	0.002	1.003	0.002	1.000	0.002
	Teacher BC	1.004*	0.001	1.006*	0.002	0.999	0.001
	Parent TPF	1.001	0.001	1.002	0.002	1.002	0.001
	Parent BC	0.998	0.001	0.999	0.002	1.001	0.001
Prior Academics							
	Standardized Math Score	0.665***	0.042	1.417***	0.066	1.331***	0.051
	GPA	0.590***	0.093	1.750***	0.164	1.693***	0.120
	Gifted	0.333***	0.127	1.182	0.131	1.483***	0.069
	Retained	0.731**	0.106	0.424***	0.261	2.700***	0.181
	Suspended in Elementary	1.006	0.122	1.192	0.214	1.199	0.169
	Suspended in G6 - G12	0.724***	0.07	0.846	0.112	0.919	0.081

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