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Schedule-Driven Productivity: Evidence From Nontraditional School Calendars

Taylor J. Landon | Nolan G. Pope

University of Maryland, College Park, Maryland, USA

Correspondence: Nolan G. Pope (npope@umd.edu)

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ABSTRACT

Schools often overlook how structuring student and teacher schedules may impact educational outcomes. We analyze the impact of nontraditional school calendars on student and teacher productivity. These calendars differentially allocate mandated instructional time by choosing (1) the number of hours in the school day, (2) the number of school days each year, and (3) the distribution of school days throughout the year. To do this, we use administrative data on over 2 million students and exploit the staggered elimination of nontraditional school calendars that vary on these three dimensions. We find that while school schedules have little impact on younger children's learning, school schedules with longer and fewer school days have large negative effects on older students that are equivalent to decreasing teacher quality by nearly one standard deviation. Our results appear to be driven by changes in at-home study behavior and school start times rather than how school days are distributed throughout the year. In addition, school schedules with longer and fewer school days increase teacher turnover. Our results suggest an important role of daily schedules on school productivity.

1 | Introduction

The way schools allocate their fixed amount of instructional time may impact students' learning and teacher productivity. In the United States, the modal high school student is required to spend 1080 hours per year enrolled in school (see Figure A1 in the Supporting Information). School districts could meet these requirements through different combinations of school days and daily instructional hours. However, most school districts follow a standard structure: 180 six-hour days with a long summer break. This traditional allocation of school time is a holdout from the past when schools did not hold classes during the summer months due to a lack of air conditioning (de Melker and Weber 2014; Pedersen 2012). Despite the widespread use of the traditional calendar, a growing number of schools are adopting alternative calendar structures, with more than 2 million children attending schools on a nontraditional school schedule each year (von Hippel 2015). Yet, there remains limited empirical evidence on the optimal allocation of a school's daily schedule and yearly calendar.

In this paper, we estimate the effect of different school schedules on student achievement. While holding the total number of instructional hours in the school year fixed, the school schedules vary based on (1) the number of hours students spend in school each day, (2) the number of school days each year, and (3) the distribution of school days throughout the year. We estimate the impact of different school schedules using administrative data for over 2 million students from the Los Angeles Unified School District (LAUSD). To do this, we exploit the staggered elimination of two nontraditional school calendars that vary on these three dimensions.

By 2002, 20% of LAUSD schools were using one of two nontraditional, multitrack year-round calendars to combat overcrowding because of increased student population growth in the 1990s. The first calendar, the Concept 6 calendar, enrolled students for 163 days, lengthened the school day by 39 min by starting earlier, and divided the summer break into two shorter breaks. The second nontraditional school calendar, the 90-30 calendar, enrolled students for 180 days and retained the same daily schedule as the traditional school calendar but divided the 3-month-long summer break into two shorter breaks. However, decreasing student enrollment in the 2000s and a lawsuit against the state of California induced the LAUSD to transition all of its schools to a traditional school calendar by 2012. Using this setting, we estimate the impact of school calendars on student achievement and teacher turnover using a difference-in-differences framework that exploits variation from schools transitioning from a nontraditional calendar to a traditional calendar between 2002 and 2012. We also overcome potential endogenous selection into schools by leveraging within-student variation.

Our main estimates indicate that while school calendar structure has little to no impact on younger students' test scores; the calendar structure significantly impacts older students. We find those elementary and middle school students on a calendar with longer and fewer school days—the Concept 6 calendar—perform academically just as well as those with shorter and more school days. However, we find that having a school calendar with longer and fewer school days has a large negative impact on high school students. When high schools transitioned from the Concept 6 calendar to the traditional calendar, students' test scores increased by 0.08–0.15 standard deviations in math and 0.06–0.10 standard deviations in English. This is roughly equivalent to improving teacher quality by 1 standard deviation (Chetty et al. 2014; Petek and Pope 2023). While we see significant effects for high school students across the student-achievement distribution, our results suggest that high-achieving students have the largest benefits from a school calendar with shorter and more school days. These results suggest that even with a fixed amount of instructional time, how that time is allocated throughout the school day and the school year is an often-overlooked yet significant policy that influences student learning.

In addition to test scores, we estimate the effect of school calendar structure on student absences, grade repetition, and dropping out of high school. We find that transitioning to a traditional calendar decreases absences for elementary school students by 6%–11% while having little effect on the absences of older students. This suggests that families may not be willing or able to adjust their family schedules to match nontraditional school calendars relative to traditional school calendars, especially for younger children. We also find no meaningful effect of changing school calendars on the probability that a student repeats a grade or drops out of high school.

A school's academic calendar may also affect teachers. While teachers work the same number of hours, teachers on a nontraditional school calendar are usually required to share classrooms and have their summer break divided throughout the year. With Concept 6 calendars, teachers also have longer daily schedules. These additional schedule changes may result in more teacher turnover in schools that are on a nontraditional calendar. While we find no effect on teacher turnover for teachers transitioning from a 90-30 calendar, we find that transitioning from a Concept 6 to a traditional calendar decreases teacher turnover. Teachers who transition from a Concept 6 calendar are 3.3 percentage points, or 16%, less likely to leave the school. These results suggest that teachers dislike having longer and fewer school days.

The similarities and differences between the three school calendars suggest five potential mechanisms that could explain our results. These mechanisms include (1) school start times, (2) longer school days, (3) how school days are distributed throughout the year, (4) a reduction in school overcrowding, and (5) changes in at-home study time. While we cannot directly test all of the mechanisms with our data, we use estimates from previous research to provide suggestive evidence for the relative importance of each mechanism. First, estimates from Edwards (2012) and Kim (2022) suggest that the earlier school start times for schools on Concept 6 calendars could explain up to half of the overall effect found for high school students as the benefits for later school start times primarily coming from additional sleep time for adolescents (Carrell et al. 2011; Heissel and Norris 2018). Second, due to increased student or teacher fatigue, longer school days have been shown to negatively affect students' GPAs and test scores (Pope 2016). However, back-of-the-envelope calculations suggest that fatigue from longer school days explains less than 5% of our results. Third, since we find little to no effect of transitioning from a 90-30 to a traditional calendar for elementary students, how school days are distributed throughout the year is unlikely to explain the effect found for high school students. Fourth, changes in the overall student population at a school may explain our results. Using directly observable student population measures, we perform subgroup analyses for schools above and below the median student population percent change. We find little evidence that our results are explained by reductions in school overcrowding. Lastly, even if teachers assign the same amount of homework each day, because Concept 6 calendars have fewer school days, students would spend nearly 10% less time doing schoolwork at home. Teachers may also adjust to longer school days by assigning even less homework. While our data do not allow us to analyze students' at-home study behavior, work by Eren and Henderson (2011) suggests a 10% reduction in homework could explain approximately 30% of our results.

This paper contributes to two distinct literatures. Most broadly, the paper adds to a literature focusing on how the structure of work schedules affects workplace productivity. This research focuses on changes in productivity and safety between day and night shifts (Folkard and Tucker 2003) and the effect of longer and fewer work days for police officers or medical professionals (Amendola et al. 2011; B. J. Thompson 2019; Banakhar 2017). Amendola et al. (2011) find that police officers on 10-hour shifts performed no differently than those on 8-hour shifts but that those on 12-hour shifts experienced significantly higher levels of fatigue and lower levels of alertness. In their review, Banakhar (2017) finds that nurses experienced increased fatigue when on 12-hour shifts instead of 8-h shifts. Moreover, B. J. Thompson (2019) measures the reaction time, lapses of attention, and muscle function assessments in a lab setting after single 12-hour shifts and three consecutive 12-h shifts. They find increased fatigue impairments when working a single shift and additional impairments with consecutive work shifts. Recently, there has been renewed interest in the 4-day workweek, which increases the number of hours worked each day but eliminates one workday each week. Firms and governments in the United Kingdom, Japan, and Iceland are currently performing randomized controlled trials to study the impacts of a 4-day workweek on workplace productivity (Kalia 2022; BBC News 2021; Chappell 2019).

Second, we contribute to a growing literature examining how deviations from the traditional school calendar affect both student achievement and teacher retention. Much of this research has focused on later school start times (Carrell et al. 2011; Edwards 2012; Hinrichs 2011; Kim 2022), rearranging the daily class schedule (Pope 2016), and year-round school calendars (Graves 2010; Graves et al. 2018; McMullen and Rouse 2012). Most recently, researchers have focused on the effects of the 4-day school week on student and teacher outcomes (Anderson and Walker 2015; Morton 2021, 2023; P. N. Thompson et al. 2021; Thompson and Ward 2022; Morton and Dewil 2024). Similar to the Concept 6 calendar, the 4-day school week has fewer but longer school days. Thompson et al. (2021) indicate that adoption of the 4-day school week also leads to less time in school overall compared to the national average for 5-day schools. Although the total number of instructional hours is lower under a 4-day school week than a 5-day school week, our results are broadly consistent with this literature. In particular, papers using student-level data find that test scores decrease after a school adopts a 4-day school week for elementary, middle, and high school students (P. N. Thompson et al. 2021; Thompson and Ward 2022; Morton and Dewil 2024). While the negative achievement effects for younger children on 4-day school calendars are inconsistent with our results, they may be attributed, in part, to the fewer yearly educational hours associated with the 4-day school week. Contrary to policymakers' expectations, this literature primarily finds that the shortened school week may increase teacher turnover (Manion et al. 2021; Nowak et al. 2023; Ainsworth et al. 2024; Morton and Dewil 2024; Camp 2024), consistent with our findings.

The setting in our paper is most similar to work done by Graves (2010) and McMullen and Rouse (2012) who study the effect of year-round calendars on student achievement. Graves (2010) provides some of the first estimates of the effect of a year-round calendar on student achievement. Using school-level data in California, she finds that the test scores of students on a year-round calendar are 1–2 percentile points lower than those of students on traditional calendars. In subsequent work, Graves (2011) finds larger negative effects of year-round calendars for low-income and minority students. This literature has also considered the impact of year-round school calendars on teacher employment (Graves et al. 2018; Gilpin 2020) and maternal employment (Graves 2013).

Later work by McMullen and Rouse (2012) overcomes student selection by using student-level data and relying on within-student variation in calendar type. They exploit a 2007 North Carolina school policy change where 22 elementary and middle schools transitioned from a traditional calendar to a year-round calendar that still had 180 days but split the summer break into four small breaks. They find little evidence that this year-round calendar impacts student test scores, suggesting that how days are distributed throughout the year has little impact on student learning. In later work, McMullen et al. (2015) consider possible distributional effects of the year-round calendar using a quantile approach and find a small positive effect for the lowest-performing students in North Carolina after schools transitioned to this year-round school calendar.

Our paper benefits from the LAUSD's use of two types of nontraditional calendars. This allows us to better distinguish between the effect of how school days are distributed throughout the year and also the impact of longer and fewer school days. Our paper finds that changes to the daily school schedule appear to be more important than changes in the yearly school calendar. These results potentially reconcile the limited effect of year-round calendars found by McMullen and Rouse (2012) with the negative effect found by Graves (2010). Like McMullen and Rouse (2012), we exploit policy variation and find that transitioning from a year-round calendar with 180 days and more breaks to the traditional calendar has little effect on student achievement. However, we also find that transitioning from a year-round calendar with longer and fewer school days to a traditional calendar significantly improves student achievement. These effects are even larger than those found by Graves (2010), who combines both of these types of multitrack year-round calendars and estimates an average effect across all multitrack year-round calendar types. Our paper helps better understand the literature on year-round calendars by distinguishing between calendars that do or do not change the daily school schedule and estimating their differential impact on student and teacher productivity.

2 | LAUSD and Nontraditional School Calendars

During the 1990s, the LAUSD suffered from overcrowded schools because of a large increase in its student population (see Figure A2 in the Supporting Information). In response, schools in the LAUSD adopted nontraditional school calendars, which allowed schools to simultaneously meet building-capacity constraints and accommodate the increased number of students. By 2002, more than 20% of schools in the LAUSD had adopted a nontraditional calendar.

In the early 2000s, concerns that California schools did not provide adequate access to teachers, instructional materials, or school buildings resulted in a class-action lawsuit against the State of California (CA Dept of Education 2004). In response to this lawsuit and declining student enrollment, the LAUSD decided to eliminate nontraditional calendars from its schools by 2012. Between 2004 and 2012, the LAUSD transitioned all but one of its schools back to a traditional school calendar. Our empirical method exploits this policy decision by the LAUSD to eliminate nontraditional school calendars.

When nontraditional school calendars were initially implemented in the 1990s, schools adopted one of two types of nontraditional calendars: the 90-30 or Concept 6 calendar. Figure 1 compares the traditional calendar to these two nontraditional school calendars. These three calendars varied based on (1) the number of hours students spent in school each day, (2) the number of school days each year, and (3) the distribution of school days throughout the year. As in most of the country, LAUSD schools on a traditional calendar started the school year in early September and continued through June of the following year with a 2-week winter break. Students then had a long summer break between June and September. Schools on a traditional school calendar provided instruction to students for 180 six-hour days.

In contrast, schools using either the 90-30 or the Concept 6 calendar ran on a track system. Schools on the track system divided the student body into multiple groups called tracks. Each

FIGURE 1 | Nontraditional school calendars and the track system. (a) Traditional calendar—180 days; 6 h each day. (b) 90-30 calendar—180 days; 6 h each day. (c) Concept 6 calendar—163 days; 6 h, 39 min each day. We use the LAUSD 2005 school year calendar to construct this figure. Panel A shows the yearly calendar for students in a traditional calendar school. Panels B and C present the track system for schools using 90-30 and Concept 6 calendars. Schools using the 90-30 calendar had four tracks (Labeled A–D) while Concept 6 schools had three tracks. While 90-30 and Concept 6 calendar schools both used the track system, Concept 6 schools enrolled students for 163 days while 90-30 schools enrolled students for 180. Traditional calendars would also enroll students for 180 days.

track would begin the school year and have breaks at different times than other tracks. Under this system, breaks between tracks were staggered, ensuring that at least one track of students was on break at any given time. The 90-30 calendar grouped students into four tracks, while the Concept 6 calendar used three tracks. Panels B and C of Figure 1 illustrate the multitrack nature of each of the nontraditional calendars. On the 90-30 calendar, students on Tracks B, C, and D began the new school year in July. In mid-August, Track A would begin school, and Track C would begin their first break. Track C would resume roughly 30 days later, at which time Track B would begin its first break. Following this structure, each track would follow a schedule of instruction times and breaks for the remainder of the school year. Students on the Concept 6 calendar followed a similar system with three tracks instead of four. Schools that adopted either track system were able to accommodate more students.

While both nontraditional calendars use the multitrack system, major differences exist between the two. Similar to the traditional calendar, schools on the 90-30 calendar enrolled students for 180 days and had 6-hour school days. However, the 90-30 calendar eliminated the traditional summer break in lieu of two smaller breaks. In contrast, the Concept 6 calendar enrolled students for only 163 days and lengthened the school day by 39 minutes to ensure equivalent instruction time. In order to not interfere with after-school activities, Concept 6 schools typically started the school day 30 minutes earlier than either the 90-30 or the traditional calendar. Like the 90-30 calendar, the Concept 6 calendar converted the summer break into two smaller breaks throughout the year.

During the 1990s, schools predominantly adopted Concept 6 calendars. We observe 112 elementary schools, 19 middle schools, and 19 high schools using Concept 6 calendars. This is in contrast to the 41 elementary schools and 1 middle school that adopted the 90-30 calendar. Figure 2 shows the the number of schools each year that transitioned to the traditional calendar between 2003 and 2012.

3 | Data Description

Our analysis relies on student-level administrative data from the LAUSD. These data include all students from kindergarten to Grade 12 from the 2002–03 to 2012–13 school years. The district enrolled over 600,000 students yearly; employed over 24,000 teachers; and operated over 750 elementary, middle, and high schools during this period. The LAUSD student composition was roughly 73% Latino, 8% Black, and 11% White. For convenience, we will reference school years by the year's class start (e.g., the 2002–03 school year is denoted as 2002).

These data contain information on our student outcomes of interest: standardized math and English test scores, the fraction of days absent, whether a student repeats a grade, and whether a student drops out of high school. These test score data come from the math and English California State Tests and are normalized to be mean 0 and standard deviation 1 at the grade-year level within the school district. The California State Test is taken in the spring of each year by all students in Grades 2–11. The fraction of days absent is constructed by dividing the number of days

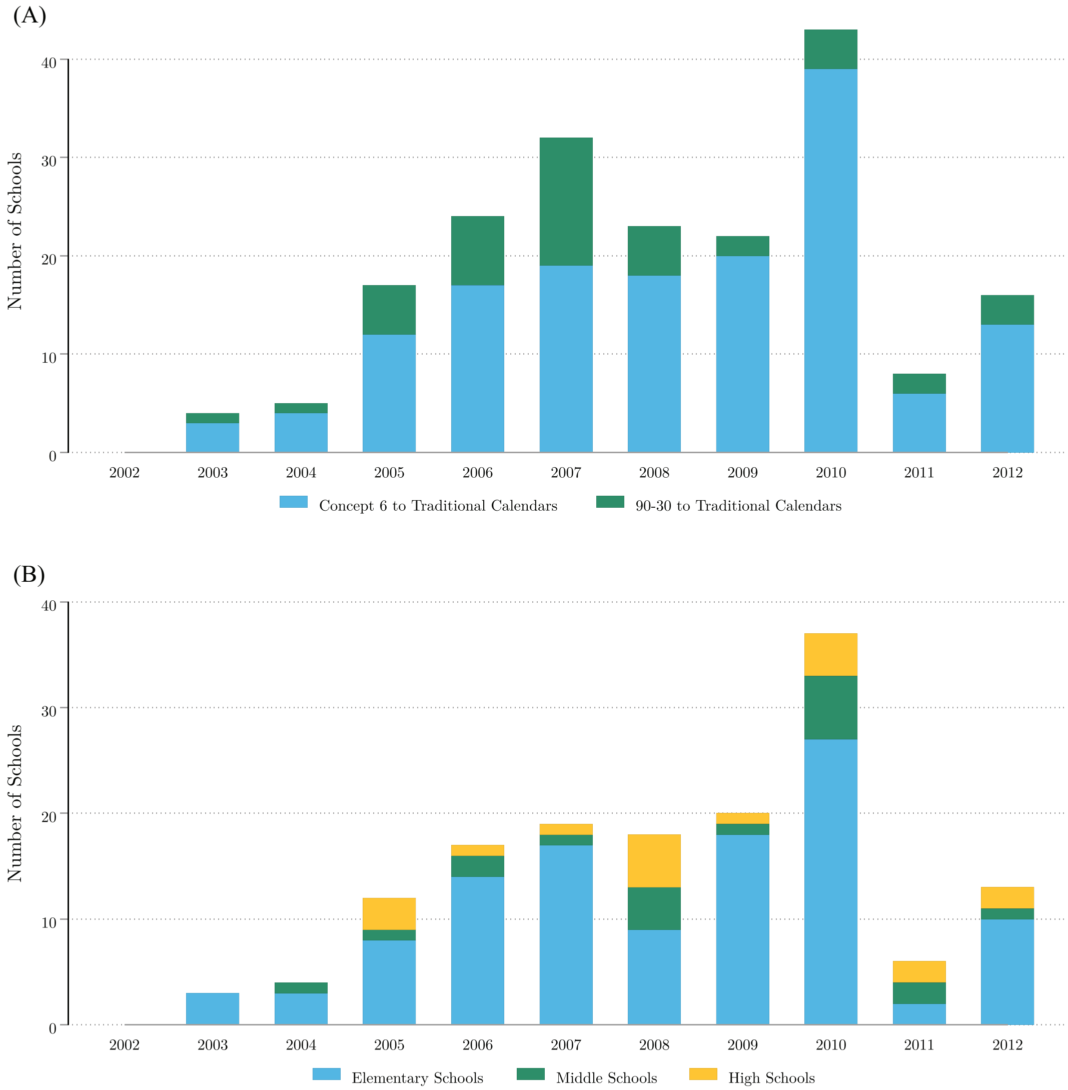

FIGURE 2 | Schools transitioned to the traditional calendar between 2003 and 2012. (a) Both 90-30 and Concept 6 schools transitioned to traditional calendars. (b) Elementary, middle, and high schools transitioned from Concept 6 to a traditional calendar. Panel A depicts the number of 90-30 and Concept 6 schools that transitioned each year. The majority of 90-30 schools were elementary schools. In contrast, Concept 6 schools included elementary, middle, and high schools. Panel B displays the number of elementary, middle, and high schools that transitioned from a Concept 6 to a traditional calendar each year.

absent by the total number of days enrolled in the school year. Therefore, the fraction of days absent for students at Concept 6 schools is the total number of days absent divided by 163, and the fraction of days absent for students on 90-30 and traditional calendars is divided by 180 days. Consequently, each day absent is weighted differently across calendar types and the fraction of days absent is equivalent to the fraction of instructional hours missed due to absences. We determine that a student repeats a grade if the student is enrolled in the same grade in two subsequent years. A student is considered a dropout if they enroll in ninth grade and does not graduate high school within 5 years. These data also include whether a student is an English-language learner but do not include student demographic data such as gender and race. Due to the lack of individual student characteristics, we add school-level demographic characteristics obtained from the Common Core of Data to the student-level data. These data include the number of students enrolled; the student-to-teacher ratio; the percentage of students who are Asian, Hispanic, Black, and White; and the percentage of students eligible for free or reduced-price lunch. These data do not include track-level information.

In addition to the student-level data, we use data on teachers in the school district. For each teacher, we can identify the school where they taught and the number of years of previous teaching experience. We measure teacher turnover using an indicator for whether a teacher stops teaching at a school. We observe whether a teacher moves to another LAUSD school, but we are unable to follow a teacher outside of the LAUSD.

We combine these student- and teacher-level data with school calendar data from the California Basic Educational Data System from 2002 to 2012. These data are used to determine the school calendar for each school throughout the sample period. They also allow us to determine the year that schools transitioned from a nontraditional to a traditional calendar.

TABLE 1 | Summary statistics.

	Transition from 90-30 Calendar	Transition from Concept 6 Calendar	Always Traditional
A. Student-level measures			
Standardized English score	−0.156	−0.222	0.149
Standardized math score	−0.121	−0.182	0.126
Fraction of days absent	0.044	0.066	0.060
Repeat a grade	0.016	0.049	0.045
Dropout	0.111	0.166	0.125
English language learner	0.497	0.429	0.214
Number of student-years	351,083	2,381,118	3,980,851
Number of students	123,140	706,650	1,082,912
B. School-level measures			
Elementary schools	42	112	272
Middle schools	0	19	73
High schools	0	19	142
Number of students enrolled	789	1,396	784
Student–teacher ratio	21	21	22
Fraction Asian	0.05	0.04	0.07
Fraction Hispanic	0.82	0.85	0.63
Fraction Black	0.08	0.08	0.14
Fraction White	0.03	0.02	0.14
Fraction free lunch eligible	0.78	0.78	0.58
Fraction reduced-price lunch	0.07	0.06	0.07

Note: Schools are divided into three, mutually exclusive groups: schools that transitioned from a 90-30 calendar, schools that transitioned from Concept 6, and schools that always remained on the traditional calendar.

Student and school summary statistics are presented in Panels A and Panel B of Table 1, respectively. We separate schools into three mutually exclusive groups: schools that transitioned from a 90-30 calendar, schools that transitioned from a Concept 6 calendar, and schools that always remained on a traditional calendar. Panel A provides student-level measures for each of these three groups, while Panel B provides school-level measures. Student and school summary statistics provided separately for elementary, middle, and high schools by calendar type can be found in Tables A1–A3 in the Supporting Information.

When compared to students in 90-30 schools, students in Concept 6 schools perform worse across all student outcomes. They perform worse on standardized math and English tests, are absent more, are more likely to repeat a grade, and are more likely to drop out of high school. However, students at always traditional schools have higher test scores than those at 90-30 or Concept 6 schools, with minor differences in other measures of student achievement. English language learners are more likely to be at a school with a nontraditional calendar. We also see differences in school-level measures between schools with nontraditional and traditional calendars. Compared to 90-30 and Concept 6 schools, always-traditional schools have a higher percentage of Asians, Blacks, and Whites in their student body but have fewer Hispanic students and fewer students on free lunch. We also see that 90-30 schools were primarily elementary schools.

4 | Empirical Strategy

Our main objective is to estimate the causal effect on student outcomes of the 90–30 and Concept 6 calendars relative to the traditional calendar. However, whether a school is on either of these calendars is endogenously chosen by the school. We overcome this endogeneity issue by exploiting the staggered elimination of nontraditional calendars in the LAUSD between 2002 and 2012. We estimate the effect of each of these school calendars on student achievement measures using the following difference-in-differences framework.

Our main model is as follows:

$$Y_{igst} = \beta \text{Traditional}_{st} + \delta X_{igst-1} + \lambda S_{st} + \mu L_{igst} + \phi_s + \psi_{gt} + \epsilon_{igst}, \tag{1}$$

where Y_{igst} is the outcome of interest for student i in grade g at school s in year t. These student outcomes are standardized math and English test scores, the fraction of days absent, whether a student repeats a grade, and whether a student drops out of high school. Traditional_{st} is an indicator for whether school s is

TABLE 2 | Estimates of transitioning from a 90-30 school calendar.

	Elementary schools		
	(1)	**(2)**	**(3)**
A. Standardized math scores			
Transition to traditional calendar	−0.005	0.003	−0.024
	(0.022)	(0.024)	(0.055)
N	347,847	347,847	347,847
R^2	0.632	0.638	0.862
B. Standardized English scores			
Transition to traditional calendar	0.015	0.021	−0.001
	(0.013)	(0.015)	(0.029)
N	347,915	347,915	347,915
R^2	0.710	0.715	0.898
C. Fraction of days absent			
Transition to traditional calendar	−0.004*	−0.003*	−0.004***
	(0.002)	(0.002)	(0.001)
N	438,387	438,387	438,387
R^2	0.046	0.275	0.703
D. Grade is repeated			
Transition to traditional calendar	−0.001	−0.001	−0.004
	(0.002)	(0.002)	(0.003)
N	450,466	450,466	450,466
R^2	0.480	0.480	0.763
E. Drop out of high school			
Transition to traditional calendar	0.005	0.008	
	(0.012)	(0.011)	
N	46,204	46,204	
R^2	0.044	0.045	
Grade × year FE	X	X	X
School FE	X	X	X
Lagged test scores	X	X	
Lagged non-test score controls		X	
Peer controls		X	
Time-varying school controls		X	X
Student FE			X

Note: We present the estimates of β from Equation (1) for five outcomes-standardized math scores, standardized English scores, the fraction of days absent, a dummy variable if the grade is repeated, and a dummy variable if a student drops out. To account for differences in both of the nontraditional calendars, we separately estimate this model for schools transitioning from a Concept 6 or a 90-30 calendar. This table provides the estimates for schools that transitioned from the 90-30 calendar, which were all elementary schools. **Lagged test scores** include lagged English and math test scores. **Lagged non-test score controls** include a lagged indicator of suspensions, lagged fraction of days absent, and an indicator for being an English language learner. **Peer controls** is a measure of the average lagged math and English test scores of all students in the same school and grade in year t, excluding student i. **Time-varying school controls** include the fraction of students that are Hispanic, Black, White, Asian, the student–teacher ratio, and the fraction of students eligible for free or reduced-price lunch. In all specifications, we include a school fixed effect and a grade-by-year fixed effect. We cluster our standard errors at the school level. $* \; p < 0.10$, $** \; p < 0.05$, $*** \; p < 0.01$.

on a traditional calendar in year t. In the fully specified model, we control for a vector of lagged student characteristics, X_{igst-1}, that contains lagged student test scores, a lagged indicator of suspensions, the lagged fraction of days absent, and an indicator for being an English language learner. We also control for a vector of time-variant school characteristics, S_{st}, including the fraction of students that are Hispanic, Black, White, and Asian, the student–teacher ratio, and the fraction of students eligible for free or reduced-price lunch. In addition, we include controls for peer effects, L_{isgt}, which is a measure of the average lagged math and

TABLE 3 | Estimates of transitioning from Concept 6.

	Elementary schools			Middle schools			High schools		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. Standardized math scores									
Transition to traditional calendar	0.003	0.000	0.010	−0.018	−0.021	0.057	0.080***	0.090***	0.154***
	(0.014)	(0.017)	(0.024)	(0.017)	(0.022)	(0.071)	(0.021)	(0.024)	(0.052)
N	518,077	518,077	518,077	546,761	546,761	546,761	403,472	403,472	403,472
R^2	0.634	0.638	0.863	0.681	0.683	0.866	0.528	0.530	0.814
B. Standardized English scores									
Transition to traditional calendar	0.006	−0.001	0.003	−0.022*	−0.014	0.010	0.060***	0.062***	0.096***
	(0.008)	(0.010)	(0.015)	(0.012)	(0.018)	(0.019)	(0.014)	(0.013)	(0.026)
N	518,092	518,092	518,092	548,221	548,221	548,221	446,034	446,034	446,034
R^2	0.708	0.714	0.896	0.751	0.755	0.911	0.692	0.697	0.887
C. Fraction of days absent									
Transition to traditional calendar	−0.002***	−0.002***	−0.002***	−0.001	−0.001	−0.004	−0.005**	−0.001	0.001
	(0.001)	(0.000)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)
N	638,481	638,481	638,481	668,453	668,453	668,453	771,688	771,688	771,688
R^2	0.051	0.292	0.711	0.087	0.396	0.781	0.110	0.428	0.729
D. Grade is repeated									
Transition to traditional calendar	−0.001	−0.001	−0.002	−0.001	−0.001**	0.000	−0.009	0.013	−0.004
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.000)	(0.015)	(0.017)	(0.021)
N	658,289	658,289	658,289	672,483	672,483	672,483	790,480	790,480	790,480
R^2	0.512	0.512	0.766	0.091	0.092	0.747	0.148	0.193	0.727
E. Drop out of high school									
Transition to traditional calendar	−0.004	−0.006		−0.011	−0.007		−0.008	0.002	
	(0.007)	(0.007)		(0.007)	(0.007)		(0.013)	(0.009)	
N	72,410	72,410		248,945	248,945		499,495	499,495	
R^2	0.043	0.045		0.077	0.087		0.103	0.128	
Grade × year FE	X	X	X	X	X	X	X	X	X
School FE	X	X	X	X	X	X	X	X	X
Lagged test scores	X	X		X	X		X	X	
Lagged non-test score controls		X			X			X	
Peer Controls		X			X			X	
Time-varying school controls		X	X		X	X		X	X
Student FE			X			X			X

Note: We present the estimates of β from Equation (1), estimated separately for elementary, middle, and high school that transitioned from a Concept 6 to a traditional calendar. **Lagged test scores** include lagged English and math test scores. **Lagged non-test score controls** include a lagged indicator of suspensions, lagged fraction of days absent, and an indicator for being an English language learner. **Peer controls** is a measure of the average lagged math and English test scores of all students in the same school and grade in year t, excluding student i. **Time-varying school controls** include the fraction of students that are Hispanic, Black, White, Asian, the student–teacher ratio, and the fraction of students eligible for free or reduced-price lunch. In all specifications, we include a school fixed effect and a grade-by-year fixed effect. We cluster our standard errors at the school level. $*\ p < 0.10$, $**\ p < 0.05$, $***\ p < 0.01$.

English test scores of all students in the same school and grade in year t, excluding student i. In all specifications, we include a school fixed effect, ϕ_s, and a grade-by-year fixed effect, ψ_{gt}. We cluster our standard errors at the school level.

The main coefficient of interest, β, represents the impact of transitioning from a nontraditional calendar to a traditional calendar on student achievement. Including lagged math and English test scores allows us to measure the change in test scores from year to year instead of test score levels. This allows us to measure the yearly value added by a nontraditional school calendar to student achievement. To account for differences in both of the nontraditional calendars, we separately estimate this model for schools transitioning from a Concept 6 or a 90–30 calendar. For example,

TABLE 4 | Accounting for heterogeneous treatment effects in fully lagged test score specification.

	90-30 calendar Elementary schools (1)	Concept 6 calendar Elementary schools (2)	Middle schools (3)	High schools (4)
A. Standardized math scores				
Transition to traditional calendar	−0.035	−0.000	−0.019	0.077***
	(0.023)	(0.017)	(0.023)	(0.020)
N	337,940	511,954	545,844	403,472
B. Standardized English scores				
Transition to traditional calendar	0.003	−0.007	0.004	0.072***
	(0.013)	(0.010)	(0.013)	(0.012)
N	338,011	511,960	547,324	446,034
C. Fraction of days absent				
Transition to traditional calendar	−0.005**	−0.001***	−0.002	0.000
	(0.002)	(0.001)	(0.002)	(0.002)
N	416,069	630,580	667,444	771,688
D. Grade is repeated				
Transition to traditional calendar	0.001	−0.001	−0.003	0.012
	(0.002)	(0.001)	(0.002)	(0.009)
N	427,807	650,162	671,452	790,480

Note: The reported estimates account for potential heterogeneous treatment effects using the estimator suggested by Borusyak et al. (2024). As seen by comparing Table 4 to Tables 2 and 3, adjusting for heterogeneous treatment effects provides nearly identical results. We cluster our standard errors at the school level. $*$ $p < 0.10$, $**$ $p < 0.05$, $***$ $p < 0.01$.

when limiting the sample to both schools that transitioned from a Concept 6 calendar and schools always on a traditional calendar, the coefficient of β measures the difference in the change in test scores before and after transitioning between students whose schools transitioned and always-traditional schools. In some specifications, we exclude lagged test scores and include a student fixed effect, α_i, instead. These specifications estimate the within-student effect of schools transitioning from a nontraditional calendar to a traditional calendar.

The main identifying assumption for this model is that the achievement of students at schools with nontraditional and traditional calendars would have parallel trends in the absence of a calendar change. While the counterfactual parallel trends assumption cannot be observed, we can test for parallel trends before nontraditional schools transitioned to traditional calendars. In Figures 3–6, the pretrends can be separately seen for 90-30 and Concept 6 calendar schools. We also explicitly test for parallel pretrends in Table A4 of the Supporting Information following Borusyak et al. (2024). We discuss these in detail in Section 5.5 of the results and find little evidence of pretrends, except in the case of students repeating a grade. For robustness, we adjust for potential pretrends using the method suggested by Freyaldenhoven et al. (2021) in Figures A7–A10 of the Supporting Information and find similar results to those in our main tables.

Additionally, for the parallel trends assumption to hold, no other policy that impacts student achievement should be occurring in conjunction with schools transitioning calendars. There were some district-wide reforms during this period, such as maintaining clean and safe schools, providing an adequate number of textbooks, and hiring qualified teachers, but these reforms were implemented in all schools and did not align with the timing of most nontraditional schools transitioning calendars. While we are unaware of any simultaneous changes to school-level policy, students may sort across schools after their school transitions to a traditional calendar, thereby potentially changing the student composition within a school. While this would be problematic for a school-level analysis, our student-level data allow us to control for student characteristics through either lagged test scores or a student fixed effect. In particular, using a student fixed effect allows us to measure the impact of transitioning calendars within a student. Our results are similar whether we control for endogenous choice using lagged test scores or a student fixed effect.

A potential concern with our design is that the treatment and control groups do not start with the same treatment status—schools on nontraditional calendars are transitioning to the traditional calendar, rather than a conventional setup where one group gains treatment while another remains untreated. However, our pretrend analysis suggests that before the elimination of nontraditional calendars, students in schools on nontraditional calendars were evolving similarly to students in always-traditional schools. This is likely because both groups of students were subject to the same district-wide policies, with school calendar structure being the primary difference. To further validate the robustness of our findings, we perform an alternative analysis using students in schools that transitioned to a traditional calendar in later years

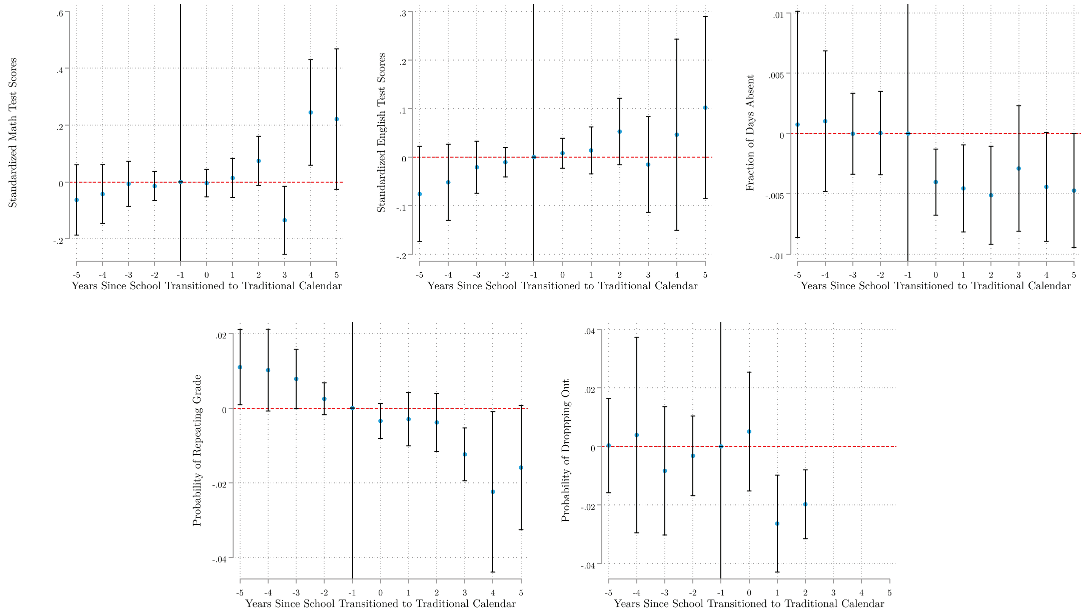

FIGURE 3 | Dynamic treatment effects for schools that transitioned from a 90-30 to a traditional calendar. We display the point estimates and 95% confidence intervals using the method described by Sun and Abraham (2021), which accounts for heterogeneous treatment effects across treatment cohorts. We use the student fixed effect specification for all outcomes except dropping out. We use the full lagged test scores specification for dropping out. Standard errors are clustered at the school level.

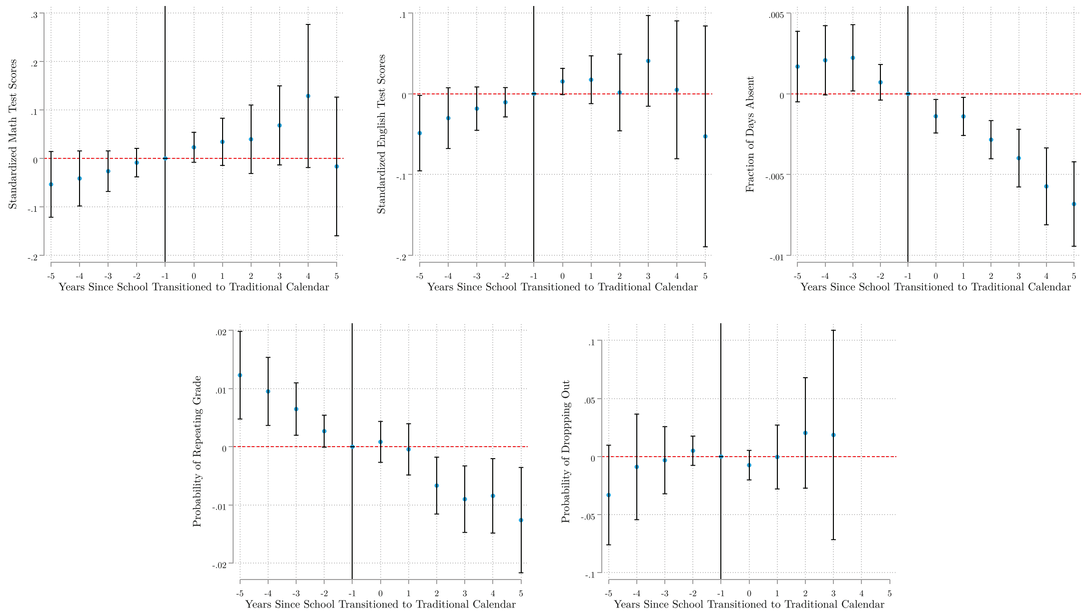

FIGURE 4 | Dynamic treatment effects for elementary schools that transitioned from a Concept 6 to a traditional calendar. We display the point estimates and 95% confidence intervals using the method described by Sun and Abraham (2021), which accounts for heterogeneous treatment effects across treatment cohorts. We use the student fixed effect specification for all outcomes except dropping out. We use the full lagged test scores specification for dropping out. Standard errors are clustered at the school level.

as the control group. The results using the alternative control are reported in Tables A14 and A15 of the Supporting Information and show that our results remain nearly identical to our main results, reinforcing the validity of our identification strategy.

In addition to the parallel trends assumption, recent literature has examined how two-way fixed effects regressions can be biased in the presence of heterogeneous treatment effects between groups or over time (Goodman-Bacon 2021; Callaway and Sant'Anna 2021; de Chaisemartin and D'Haultfœuille 2020; Borusyak et al. 2024). We take into account the potential heterogeneous treatment effects by using the estimators suggested by Borusyak et al. (2024) and Sun and Abraham (2021). When using both of these new approaches, we find that our results differ little from the traditional two-way fixed effect estimates. Our estimates using the estimators in Borusyak et al. (2024) are found in Table 4. Our dynamic effect results using those of Sun and Abraham (2021) are shown in Figures 3–6.

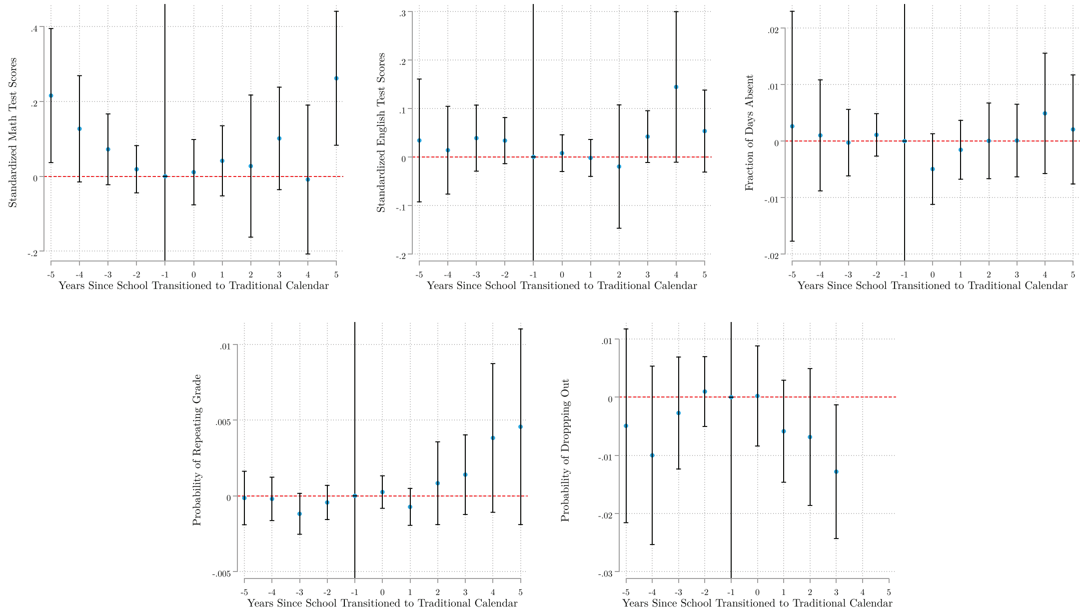

FIGURE 5 | Dynamic treatment effects for middle schools that transitioned from a Concept 6 to a traditional calendar. We display the point estimates and 95% confidence intervals using the method described by Sun and Abraham (2021), which accounts for heterogeneous treatment effects across treatment cohorts. We use the student fixed effect specification for all outcomes except dropping out. We use the full lagged test scores specification for dropping out. Standard errors are clustered at the school level.

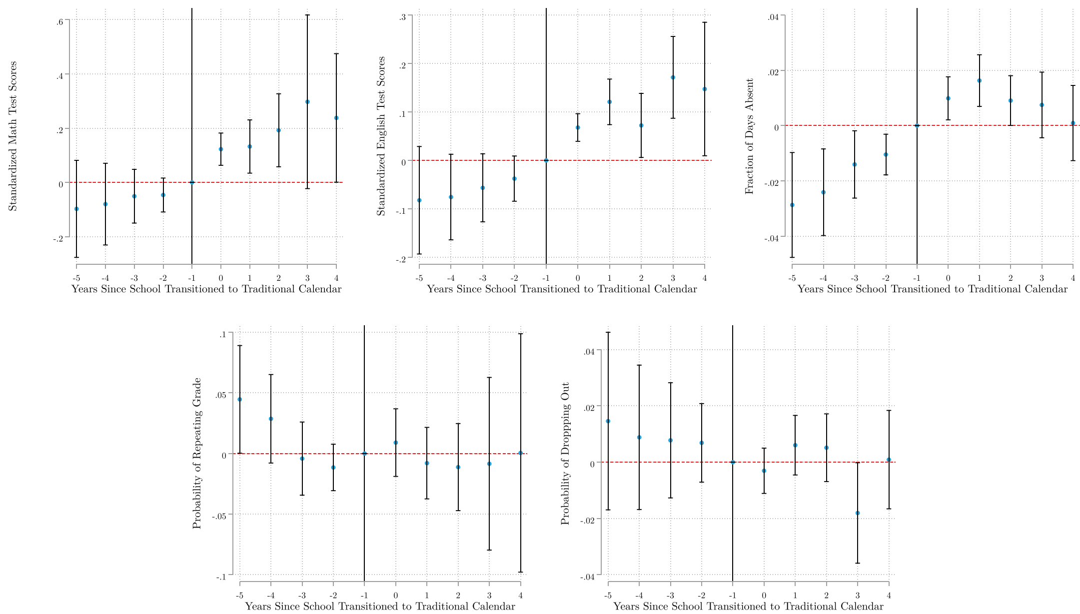

FIGURE 6 | Dynamic treatment effects for high schools that transitioned from a Concept 6 to a traditional calendar. We display the point estimates and 95% confidence intervals using the method described by Sun and Abraham (2021), which accounts for heterogeneous treatment effects across treatment cohorts. We use the student fixed effect specification for all outcomes except dropping out. We use the full lagged test scores specification for dropping out. Standard errors are clustered at the school level.

5 | Results

We present our results in seven subsections. Section 5.1 presents the effect on student outcomes of transitioning from a 90-30 calendar to a traditional calendar. Analogously, Section 5.2 presents the effect of transitioning from a Concept 6 calendar. The student outcomes of interest throughout the results section are standardized math scores, standardized English scores, the fraction of days absent, the probability of repeating a grade, and the probability of dropping out of high school. In Section 5.3, we show that the results are robust to the potential presence of heterogeneous treatment effects. Section 5.4 provides our estimates for the dynamic effect of transitioning from either the 90-30 or the Concept 6 calendar. Section 5.5 reports estimates that adjust for pretrends. In Section 5.6, we investigate student achievement heterogeneity. Lastly, Section 5.7 reports the estimates for how transitioning to the traditional calendar impacts teacher turnover by experience.

5.1 | Transitioning From 90-30 Calendars

In this section, we estimate the impact on students of transitioning from a 90-30 calendar—with the same daily schedule as traditional schools but a more dispersed summer break—to a traditional calendar. Our sample contains only students in elementary schools. We report difference-in-differences estimates from Equation (1) using students in schools always operating on traditional calendar as the control group.

5.1.1 | Standardized Math and English Test Scores

The impact of transitioning to a traditional calendar on standardized math and English test scores is found in Panels A and B of Table 2. The specification in Column 1 includes grade-by-year and school fixed effects and lagged test scores. Including lagged test scores accounts for potential changes in student composition at the school. The resulting estimates are statistically indistinguishable from zero. The estimates remain indistinguishable from zero after including lagged nontest score controls, peer controls, and time-varying school controls as seen in Column 2. In Column 3, we alternatively control for student composition changes by including student fixed effects. Again, we find little evidence that transitioning to a traditional calendar impacts student test scores. Our preferred specification, found in Column 3, suggests that transitioning from a 90-30 to a traditional calendar has little to no impact on test scores for students in elementary school.

5.1.2 | Fraction of Days Absent, Repeating Grades, and Dropping Out of High School

Panel C of Table 2 provides estimates for the fraction of days a student is absent. The estimates indicate that students have fewer absences after transitioning to the traditional calendar from the 90-30 calendar, and the effect remains consistent across the different specifications. The estimate in Column 3 implies that moving to a traditional calendar decreases elementary school student absences by 0.4 percentage points (10.9%) or by 0.72 days per year. This suggests that families may not be as willing or able to adjust their family schedules to match nontraditional school calendars relative to traditional school calendars. This result may be attributed to the increased number of school days during the summer on nontraditional calendars. Families report that they are most likely to travel during the summer months (Minnaert 2017), suggesting that families would no longer need to pull students out of school during the summer months after a school adopted the traditional calendar.

In Panels D and E, our results imply that moving from a 90-30 to a traditional calendar plays a minimal role in whether a grade is repeated or on whether a student drops out of high school. Overall, it appears that moving from a 90-30 calendar to a traditional calendar has little impact on elementary students' educational outcomes except for student absences. This suggests that how vacation days are distributed throughout the year has little impact on younger students.

5.2 | Transitioning From Concept 6 Calendars

5.2.1 | Standardized Math and English Test Scores

Analogous to Section 5.1, we estimate the impact on students of transitioning from a Concept 6 calendar—with longer and fewer days—to a traditional calendar. In the first three columns of Table 3, the estimates for elementary schools transitioning from a Concept 6 calendar mirror the results for elementary schools transitioning from 90-30 calendars with little to no impact on student test scores. Our results also show that moving from a Concept 6 calendar has little impact on middle school students.

In contrast to the estimates for elementary and middle schools, we find that transitioning calendars have a large and meaningful impact on high school students. The estimates reported in Columns 7–9 show that moving from a Concept 6 to a traditional calendar improves high school students' standardized math test scores by 0.080–0.154 standard deviations. Although somewhat smaller, the results for English are similar, with effect sizes between 0.060 and 0.096 standard deviations. The impacts of school calendar on math and English test scores are statistically significant and large—roughly equivalent to improving teacher quality by 1 standard deviation (Chetty et al. 2014; Petek and Pope 2023).

5.2.2 | Fraction of Days Absent, Repeating Grades, and Dropping Out of High School

As seen in Table 3, transitioning from a Concept 6 calendar reduces the number of absences for students in elementary school. This effect on absences is about half the size of the effect found on 90-30 calendars and suggests that transitioning from a Concept 6 to a traditional calendar reduced absences for elementary school students by 0.2 percentage points (6%), or about 0.36 days. While there are modest negative effects on elementary school students, we find little evidence that moving from a Concept 6 calendar impacted older students' absences. The estimates for grade repetition and dropping out of high school (Panels D and E) are typically negative, and we find little to no evidence that moving from a Concept 6 to a traditional calendar impacts either outcome, with estimates generally statistically indistinguishable from zero.

Overall, our results suggest that moving from a Concept 6 calendar to a traditional calendar notably improves high school students' test scores while having little impact on younger students. As we further explore in the section on potential mechanisms, these results may suggest that the daily schedule changes tied to having longer and fewer school days on the Concept 6 calendar may explain our results.

5.3 | Robustness to Heterogeneous Treatment Effects

Following the recent difference-in-differences literature, we estimate the impact of transitioning to a traditional calendar from a nontraditional calendar accounting for the potential presence of heterogeneous treatment effects (Goodman-Bacon 2021; Callaway and Sant'Anna 2021; de Chaisemartin and D'Haultfœuille 2020; Borusyak et al. 2024). Using the specification from Column 2 of Table 2, we adjust for potential heterogeneous treatment effects by using the estimator suggested by Borusyak et al. (2024) and report our results in Table 4. As seen by comparing Table 4 to Tables 2 and 3, adjusting for heterogeneous treatment effects provides nearly identical results.

5.4 | Estimates of Dynamic Effects

In addition to the estimates from Equation (1), we estimate dynamic treatment effects using the estimator proposed by Sun and Abraham (2021), which accounts for heterogeneous treatment effects across treatment cohorts. These results are shown in Figures 3–6. For comparison, standard difference-in-differences dynamic effects, in which we estimate Equation (1) while interacting $Traditional_{st}$ with dummy variables for the number of years before or after a school transitions to a traditional calendar, are shown in Figures A3–A6 of the Supporting Information. Each figure displays the point estimate and the 95% confidence interval. While some of the figures appear to exhibit pretrends (e.g., English test scores for high school students or repeating a grade in elementary school), we test for and address pretrend concerns in Section 5.5. These tests suggest that the parallel trends assumption holds for most outcomes. To further assess robustness, we explicitly adjust for potential pretrends using the method proposed by Freyaldenhoven et al. (2021). This adjustment introduces additional noise but yields consistent results, reinforcing the validity of our main findings described below.

The dynamic effect estimates also illustrate how the effect of transitioning to a traditional calendar evolves over time. We include the same controls as in Column 3 of Tables 2 and 3 except for the probability of dropping out of high school, which uses the specification in Column 2. Because of the heterogeneous treatment effects we find between younger and older children transitioning from a Concept 6 calendar, we present these dynamic effects separately for elementary, middle, and high school students. All estimates are relative to $t = -1$, indicated by a vertical line. The first year in which a school operates on a traditional calendar is indicated by $t = 0$.

Figure 3 shows the dynamic effect of transitioning from a 90-30 to a traditional calendar, estimated using only elementary schools. With the exception of repeating a grade, we find limited evidence of nonparallel pretrends for 90-30 calendars. Consistent with the 90-30 calendar results in Table 2, we find little evidence that transitioning to a traditional calendar impacts student achievement except for absences which decline by 0.3–0.5 percentage points, or a reduction in absences of 8%–14%, after transition. Moreover, there appears to be no dynamic treatment effect for absences or any other outcome. While there are some statistically significant effects for repeating a grade post-transition, we are reluctant to interpret these effects because they appear to be following the pretrend.

Figure 4 reports the dynamic results for elementary schools transitioning from Concept 6. Similar to the 90-30 calendar results, we find little evidence of nonparallel pretrends except for repeating a grade and potentially days absent, supported by the results in Table A4 of the Supporting Information with *p*-values above 0.15 for each of the five outcomes. Comparable to the 90-30 calendar results, we find little evidence that transitioning from a Concept 6 calendar affects student outcomes other than absences. Unlike the 90-30 calendar estimates for absences, we find a negative effect on absences that increases over time after transitioning from a Concept 6 calendar. In the first 2 years after transitioning, we see absences decrease by 0.1 percentage points, or 3%. This effect on absences grows and is more than 0.5 percentage points, or 14%, 5 years after transitioning. Figure 5 presents the dynamic estimates for middle schools transitioning from Concept 6, showing parallel pretrends for each outcome and no evidence of overall or dynamic effects.

Figure 6 reports the dynamic effects for high school students transitioning from a Concept 6 to a traditional calendar. Although there appears to be a nonparallel pretrend for absences and potentially repeating a grade (see Table A4 in the Supporting Information), we see little evidence of nonparallel pretrends for the other outcomes. Similar to our results in Table 3, we find positive effects of transitioning from a Concept 6 calendar on standardized math and English test scores. While the effects on test scores may appear to be growing over time, the difference in the effect sizes is not statistically significant because of the large standard errors in later years. In the post-transition years, we find a positive effect on math test scores of between 0.1 and 0.3 standard deviations. Similarly, for English, we find a positive effect of between 0.07 and 0.18 standard deviations. There is little evidence that transitioning from a Concept 6 calendar impacts other student outcomes for high school students. Overall, the dynamic effects are consistent with the difference-in-differences estimates and typically appear to be relatively constant post-treatment with few effects changing dynamically over time.

5.5 | Adjusting for Pretrends

Our identification strategy relies on the parallel trends assumption. To assess the validity of this assumption, we first apply the test proposed by Borusyak et al. (2024), which examines whether treatment and control groups exhibit similar trends in the pre-treatment. As shown in Table A4 of the Supporting Information, we find little evidence of pretrends in most of the outcomes. At $\alpha = 0.10$, we fail to reject the null hypothesis for all outcomes except for two: (1) dropping out of high school in Concept 6 middle schools and (2) grade is repeated in Concept 6 high schools.

While the results of the previous test provide supporting evidence for parallel trends in most of our outcomes, potential concerns about subtle pretrends may remain. To address this, we implement the approach suggested by Freyaldenhoven et al. (2021), which explicitly adjusts for pretrends to account for any differential trends in the preperiods. This method allows us to estimate the cumulative effect of the calendar change adjusting for a pretrend that starts in the three time periods before the calendar change and formally test for pretrends. Their statistical test suggests little evidence of pretrends for most outcomes, reinforcing the validity of our main identification strategy. While adjusting for pretrends potentially reduces bias, it also introduces additional noise into the point estimate, increasing the size of the 95% confidence intervals.

The pretrend adjusted cumulative effect of the calendar change using the specification from Column 2 of Table 2 are presented in Figures A7–A10 of the Supporting Information. In contrast to our previous results, we find that moving from a Concept 6 calendar has little effect on the fraction of days absent for Concept 6 elementary schools. Additionally, we find some evidence that moving from a Concept 6 calendar increases the probability of dropping out for high school students. Overall, we find similar, though less precise, results to those previously reported for the majority of outcomes.

5.6 | Student Achievement-Level Heterogeneity

In this section, we estimate the heterogeneous effects of school calendars by student achievement level. In Table A5 of the Supporting Information, we find little evidence that transitioning from a 90-30 calendar impacts elementary school students differently based on their prior achievement across any educational outcomes. Analogously, the estimates for Concept 6 elementary schools are reported in Table 5 and show little heterogeneity across achievement groups except for the fraction of days absent and dropouts from high school. Transitioning to a traditional calendar reduces the fraction of days absent by 0.2–0.3 percentage points among the low- and middle-achieving groups with smaller and statistically insignificant effects for the high-achieving group. Additionally, we find that the probability of dropping out of high school decreases by 1.5 percentage points for high-achieving elementary school students after transitioning to a traditional school calendar, while we find no analogous effect for low- and middle-achieving students.

The results for high school students by achievement group reported in Table 6 show a differential effect between achievement groups for math test scores. We find that moving to a traditional calendar increases standardized math scores from between 0.03 and 0.07 standard deviations for low-achieving students up to 0.11–0.24 standard deviations for high-achieving students. In contrast to the math test scores, we find that transitioning from a Concept 6 calendar increases standardized English test scores by 0.06–0.11 standard deviations for all achievement groups. We find no differential effect by achievement group for the remaining student outcomes. As we discuss further in our section on potential mechanisms, a change in at-home study time may partially explain the differential impact we find across achievement groups for older students. While these estimates do not adjust for heterogeneous treatment timing, the results from specifications that do—reported in Tables A7–A10 of the Supporting Information—are nearly identical.

5.7 | Teacher Turnover

Nontraditional school calendars may also play an important role in teachers' well-being. For example, on multitrack calendars, teachers frequently have to share classrooms and have a shorter summer break that may limit them from obtaining a summer job or vacationing at their preferred time. In addition, the Concept 6 calendar required more instructional hours each day. Teachers' preferences for school calendar type may result in different levels of teacher turnover for each calendar type. This may partially explain why teacher turnover rates were 23.9% and 22.1% for 90-30 and Concept 6 schools, respectively, but only 20.7% for traditional schools. Using school-level data linked to teachers, we estimate the effect of school calendar type using our difference-in-differences design on an indicator for whether a teacher leaves their school between years t and $t+1$.

Table 7 presents our estimates of teacher turnover for teachers who transitioned from either a 90-30 calendar (Columns 1–3) or a Concept 6 calendar (Columns 4–6) to a traditional calendar. The estimates in Columns 1–3 suggest that transitioning from a 90-30 to a traditional calendar has little effect on teacher turnover rates, including novice and experienced teachers. Our estimates are consistent with the results of Graves et al. (2018), who find that transitioning from a traditional calendar to a year-round calendar (with no change to the daily schedule) did not affect teacher turnover.

Alternatively, transitioning from a Concept 6 calendar to a traditional calendar decreases teacher turnover. In Columns 4–6, the estimated effect on teacher turnover of transitioning from a Concept 6 calendar is roughly 3.3 percentage points. With a base turnover rate of 20.6%, this is equivalent to a 16% decline in teacher turnover. Clotfelter et al. (2008) estimate that a $1800 annual bonus payment reduces teacher turnover by 17%. These results suggest that teachers value being at a school with a traditional calendar compared to the Concept 6 calendar for 1 year by approximately $1500. These findings are also consistent with recent evidence on the 4-day school week that finds that 4-day school week schedules increase teacher turnover (Nowak et al. 2023; Ainsworth et al. 2024; Morton and Dewil 2024). Together, these results suggest that teachers may more highly value changes to the daily schedule structure than to the yearly calendar.

When we estimate the effect on teacher turnover by school type in Table 8, we find that the effect sizes for elementary schools are nearly identical to those found in Table 7. Similarly, for high school teachers, the effect sizes are slightly larger (4.3–5.5 percentage points, or 22%–28%). In contrast, we find no effect on middle school teacher turnover. However, due to the large standard errors, we are unable to reject the differences between the effects across the three different school types. We also find no clear differences by teacher experience. Overall, our results suggest that based on their decision to stay at or leave a school, teachers prefer traditional calendars over Concept 6 calendars. In particular, our results suggest that a teacher's decision to stay may be more influenced by daily schedule changes in the Concept 6 calendar rather than by yearly calendar changes as seen in both nontraditional calendars.

6 | Mechanisms

In this section, we discuss potential mechanisms for our results. Our main results demonstrate that moving from a Concept 6 to a traditional calendar improves the test scores of high school students. For younger students, we find that moving to a traditional calendar has little impact on student outcomes

TABLE 5 | Elementary school estimates of transitioning from Concept 6 by student achievement groups.

	Low-achieving			Middle-achieving			High-Achieving		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. Standardized math scores									
Transition to traditional calendar	−0.012	−0.013	−0.005	0.006	0.003	0.005	0.021	0.015	0.020
	(0.014)	(0.017)	(0.021)	(0.016)	(0.019)	(0.028)	(0.020)	(0.024)	(0.038)
N	155,386	155,386	155,386	172,383	172,383	172,383	184,299	184,299	184,299
R^2	0.354	0.360	0.747	0.316	0.324	0.739	0.403	0.412	0.769
B. Standardized English scores									
Transition to traditional calendar	−0.010	−0.014	−0.015	0.008	0.007	0.002	0.028**	0.001	0.015
	(0.010)	(0.011)	(0.017)	(0.010)	(0.012)	(0.018)	(0.012)	(0.014)	(0.020)
N	155,344	155,344	155,344	172,395	172,395	172,395	184,335	184,335	184,335
R^2	0.359	0.362	0.745	0.387	0.396	0.778	0.523	0.533	0.833
C. Fraction of days absent									
Transition to traditional calendar	−0.003***	−0.002***	−0.002***	−0.003***	−0.002***	−0.002**	−0.001**	−0.001**	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
N	189,485	189,485	189,485	214,550	214,550	214,550	227,471	227,471	227,471
R^2	0.049	0.320	0.718	0.041	0.265	0.699	0.043	0.265	0.705
D. Grade is repeated									
Transition to traditional calendar	0.002	0.000	0.001	−0.000	−0.001	−0.002	0.000*	0.001*	0.001*
	(0.002)	(0.002)	(0.004)	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)
N	198,969	198,969	198,969	220,095	220,095	220,095	231,859	231,859	231,859
R^2	0.552	0.553	0.784	0.343	0.344	0.694	0.158	0.159	0.673
E. Drops out of high school									
Transition to traditional calendar	0.019	0.014		−0.005	−0.003		−0.017**	−0.018**	
	(0.017)	(0.016)		(0.008)	(0.009)		(0.008)	(0.008)	
N	17,707	17,707		25,570	25,570		28,300	28,300	
R^2	0.076	0.077		0.053	0.056		0.046	0.048	
Grade × year FE	X	X	X	X	X	X	X	X	X
School FE	X	X	X	X	X	X	X	X	X
Lagged test scores	X	X		X	X		X	X	
Lagged non-test score controls		X			X			X	
Peer controls		X			X			X	
Time-varying school controls		X	X		X	X		X	X
Student FE			X			X			X

Note: We present the estimates of β from Equation (1) by achievement groups for elementary schools that transitioned from a Concept 6 to a traditional calendar. We divide students into terciles representing low-achieving, middle-achieving, and high-achieving students. To allow for a student fixed effect specification, we construct a measure of academic achievement that keeps students in the same tercile over time. We construct these terciles within grade and year using the average of a student's first observed standardized math and English test scores. Standard errors are clustered at the school level. $*\ p < 0.10$, $**\ p < 0.05$, $***\ p < 0.01$.

other than reducing absences. We also find that for high school students, moving to a traditional school calendar affects high-achieving students more than low- or middle-achieving students. We propose and investigate five potential mechanisms for our results that may meaningfully explain the pattern of results we observe: (1) school start times, (2) the length of school days, (3) how school days are distributed throughout the year, (4) a reduction in school overcrowding, and (5) changes in at-home study time. Although we do not directly observe these potential mechanisms, we rely on estimates in similar settings from prior research to provide back-of-the envelope calculations on the possible size of each mechanism.

First, we investigate the impact of later school start times. After transitioning from a Concept 6 to a traditional calendar, the typical school shifted its start times by roughly 30 minutes from 7:30 a.m. to 8:00 a.m. Previous literature has found that school start times have a meaningful impact on student achievement.

TABLE 6 | High school estimates of transitioning from Concept 6 by student achievement groups.

	Low-achieving			Middle-achieving			High-achieving		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. Standardized math scores									
Transition to traditional calendar	0.041*	0.034	0.074	0.087***	0.084***	0.139***	0.110***	0.157***	0.240***
	(0.024)	(0.020)	(0.048)	(0.026)	(0.026)	(0.046)	(0.028)	(0.032)	(0.080)
N	111,974	111,974	111,974	134,538	134,538	134,538	146,985	146,985	146,985
R^2	0.139	0.144	0.582	0.249	0.253	0.670	0.504	0.509	0.817
B. Standardized English scores									
Transition to traditional calendar	0.063***	0.056***	0.078***	0.059***	0.058***	0.089***	0.053***	0.070***	0.115***
	(0.015)	(0.014)	(0.028)	(0.016)	(0.014)	(0.029)	(0.014)	(0.015)	(0.029)
N	127,543	127,543	127,543	149,499	149,499	149,499	157,416	157,416	157,416
R^2	0.297	0.308	0.720	0.400	0.409	0.771	0.579	0.582	0.841
C. Fraction of days absent									
Transition to traditional calendar	−0.004	0.000	0.004	−0.003	−0.001	0.001	−0.004	−0.001	−0.001
	(0.003)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)
N	223,372	223,372	223,372	256,041	256,041	256,041	267,167	267,167	267,167
R^2	0.078	0.411	0.718	0.084	0.409	0.719	0.082	0.397	0.716
D. Grade is repeated									
Transition to traditional calendar	−0.007	0.015	−0.007	−0.010	0.008	−0.006	−0.004	0.012*	0.006
	(0.025)	(0.028)	(0.034)	(0.014)	(0.016)	(0.024)	(0.005)	(0.006)	(0.008)
N	230,774	230,774	230,774	262,311	262,311	262,311	271,456	271,456	271,456
R^2	0.154	0.200	0.715	0.135	0.181	0.734	0.091	0.131	0.751
E. Drops out of high school									
Transition to traditional calendar	−0.008	−0.001		−0.001	0.006		0.002	0.001	
	(0.021)	(0.017)		(0.011)	(0.008)		(0.008)	(0.006)	
N	117,108	117,108		166,048	166,048		201,309	201,309	
R^2	0.113	0.128		0.043	0.063		0.022	0.037	
Grade × year FE	X	X	X	X	X	X	X	X	X
School FE	X	X	X	X	X	X	X	X	X
Lagged test scores	X	X		X	X		X	X	
Lagged non-test score controls		X			X			X	
Peer controls		X			X			X	
Time-varying school controls		X	X		X	X		X	X
Student FE			X			X			X

Note: We present the estimates of β from Equation (1) by achievement groups for high schools that transitioned from a Concept 6 to a traditional calendar. We divide students into terciles representing low-achieving, middle-achieving, and high-achieving students. To allow for a student fixed effect specification, we construct a measure of academic achievement that keeps students in the same tercile over time. We construct these terciles within grade and year using the average of a student's first observed standardized math and English test scores. Standard errors are clustered at the school level. $* \ p < 0.10$, $** \ p < 0.05$, $*** \ p < 0.01$.

Using random assignment of college classes, Carrell et al. (2011) find that starting the school day 50 minutes earlier decreases the average freshman's GPA by 0.031–0.076 standard deviations. Other studies also find that later school start times are associated with increases in student achievement, with the largest effects for older children (Dills and Hernández-Julián 2008; Heissel and Norris 2018). Work by Edwards (2012) estimates that a 1-hour later school start time due to busing increases test scores by 1.5–2.1 percentiles, or approximately 0.05 standard deviations. Similarly, Kim (2022) finds in South Korea that a 1-hour-later school start time increases math test scores by 0.069–0.104 standard deviations, with little effect on other subjects. This literature suggests two implications for our findings. First, later start times could explain why we find that the traditional school calendar affects the test scores of high school students but not the test scores of elementary and middle school students. Second, using the estimates for later start times from Edwards (2012) and Kim (2022), back-of-the-envelope calculations suggest that later

TABLE 7 | Estimates of transitioning from a nontraditional calendar on teacher turnover.

	Transition from 90-30 calendars			Transition from Concept 6 calendars		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Teacher turnover						
Transition to traditional calendar	−0.00751	−0.0058	−0.0129	−0.0332***	−0.031***	−0.0332***
	(0.0165)	(0.0162)	(0.0165)	(0.012)	(0.012)	(0.012)
N	21,779	21,779	21,779	77,290	77,290	77,290
R^2	0.036	0.0362	0.0368	0.03	0.0302	0.03
B. Teachers with 0–2 years of experience						
Transition to traditional calendar	0.0114	0.0109	−0.0225	0.0211	0.0206	0.0211
	(0.0399)	(0.0395)	(0.0457)	(0.0209)	(0.021)	(0.0209)
N	3992	3992	3992	14,867	14,867	14,867
R^2	0.222	0.223	0.226	0.148	0.148	0.148
C. Teachers with 3+ years of experience						
Transition to traditional calendar	0.0201	0.0199	0.00496	−0.0172*	−0.0163*	−0.0172*
	(0.0136)	(0.0134)	(0.014)	(0.00929)	(0.00922)	(0.00929)
N	17,781	17,781	17,781	62,420	62,420	62,420
R^2	0.0335	0.0335	0.0355	0.0296	0.0296	0.0296
Grade × year FE	X	X	X	X	X	X
School FE	X	X	X	X	X	X
Lagged average grade test scores		X	X		X	X
Time-varying school controls			X			X

Note: We report teacher turnover estimates separately for schools transitioning from a Concept 6 or a 90-30 calendar. Teacher turnover is a dummy variable that is equal to on if the teacher teaches in 1 year but does not return to that school in the subsequent year (i.e., the teacher leaves a given school). If teachers teach multiple grades, we use the grade for which the teacher teaches the most number of students to assign a grade-by-year fixed effect. Standard errors are clustered at the school level. $* \ p < 0.10$, $** \ p < 0.05$, $*** \ p < 0.01$.

start times could explain one-quarter to one-half of the overall effect found for high school students. While later school start times appear to explain a meaningful part of the results, other mechanisms may explain the remaining fraction.

A second potential mechanism is student or teacher fatigue because of a longer school day. Students on a Concept 6 calendar attended school for an additional 39 minutes each school day, or 6.5 extra minutes each class period for students in middle or high school. Pope (2016) finds that students in middle and high school who have math or English classes earlier in the school day receive higher GPAs and perform better on their standardized math and English tests. The average student with math in the first two periods sees an increase in math test scores of 0.021 standard deviations and an increase of 0.072 GPA points in their math GPA. These effects are a result of students' and teachers' increased fatigue throughout the day. Similarly, other work shows that having multiple college courses in a row results in poorer performance in later courses (Haggag et al. 2021; Williams and Shapiro 2018). Using the estimates from Pope (2016), increased fatigue from longer school days would explain less than 5% of our results. Alternatively, teacher fatigue or turnover may be impacting student learning. We estimate similar teacher turnover across school levels, and teachers experienced comparable schedule changes across school levels. If teacher fatigue or turnover were the primary channel, we would likely expect similar effects on test scores across school levels. We do not observe this pattern in our results, suggesting that teacher turnover or fatigue may play a minimal role. Overall, this suggests that additional student and teacher fatigue from a longer school day may play only a minor role in explaining our results.

How school days are distributed throughout the year may also explain part of our results. Work by McMullen and Rouse (2012) finds that elementary and middle school students on a year-round calendar—similar to the 90-30 calendar—performed just as well as those on a traditional calendar. They conclude that the amount of time a student spends learning appears to be more important than when the learning takes place during the year. Similarly, we find when elementary school students transition from a 90-30 calendar to a traditional calendar, there is little to no effect on their test scores. Although prior work by Cooper et al. (1996) and Borman and Boulay (2004) suggests that students suffer from learning loss over breaks, our results and those from McMullen and Rouse (2012) suggest that such learning loss appears to not differ whether there is one long summer break or the summer break is spread throughout the year. However, both our paper and McMullen and Rouse (2012) focus on elementary and middle school students when estimating the effect of how school days are distributed throughout the year, and we do not observe high school students on the 90-30 calendar in our setting. As such, the distribution of school days during the year may potentially have

TABLE 8 | Estimates of transitioning from Concept 6 on teacher turnover by school-level.

	Elementary school			Middle school			High School		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. Teacher turnover									
Transition to traditional calendar	−0.0355***	−0.0341***	−0.0306**	−0.00468	−0.00117	−0.00969	−0.044**	−0.0432**	−.0556
	(0.0124)	(0.0124)	(0.0136)	(0.0326)	(0.0317)	(0.0372)	(0.0208)	(0.0201)	(.0351)
N	31,456	31,456	31,456	26,036	26,036	26,036	18,571	18,571	18,571
R^2	0.0348	0.0348	0.0356	0.0296	0.0302	0.0312	0.0299	0.03	.0307
B. Teachers with 0-2 years of experience									
Transition to traditional calendar	0.00953	0.00907	−0.00613	0.0704	0.0713	0.0127	0.0161	0.0124	−.0708
	(0.0292)	(0.0292)	(0.0343)	(0.0505)	(0.0496)	(0.0517)	(0.0347)	(0.0346)	(.0598)
N	5888	5888	5888	5359	5359	5359	3310	3310	3,310
R^2	0.201	0.202	0.204	0.112	0.112	0.118	0.145	0.146	.15
C. Teachers with 3+ years of experience									
Transition to traditional calendar	−0.012	−0.0125	−0.0304***	0.00382	0.00569	−0.0137	−0.0373**	−0.0345**	−.0476*
	(0.0104)	(0.0105)	(0.0113)	(0.0236)	(0.023)	(0.0335)	(0.0156)	(0.0148)	(.0282)
N	25,564	25,564	25,564	20,677	20,677	20,677	15,255	15,255	15,255
R^2	0.0329	0.0329	0.0343	0.0262	0.0265	0.0287	0.0346	0.035	.0367
Grade × year FE	X	X	X	X	X	X	X	X	X
School FE	X	X	X	X	X	X	X	X	X
Lagged average grade test scores		X	X		X	X		X	X
Time-varying school controls			X			X			X

Note: For schools that transitioned from a Concept 6 calendar, we report teacher turnover estimates by school-level. Teacher turnover is a dummy variable that is equal to 1 if the teacher teaches in 1 year but does not return to that school in the subsequent year (i.e., the teacher leaves a given school). If teachers teach multiple grades, we use the grade for which the teacher teaches the most number of students to assign a grade-by-year fixed effect. Standard errors are clustered at the school level.

a meaningful impact on older students that we do not observe. It remains possible that the timing of breaks has a different effect on high school students. While we suspect that the daily structure of school time plays a larger role, we cannot rule out the possibility that the distribution of school days during the year also contributes to the effects we observe for high school students.

Fourth, decreases in school overcrowding may explain our results. Transitioning to a traditional calendar may coincide with reductions in student enrollment, potentially improving student achievement by alleviating overcrowding or easing pressure on school infrastructure. Our data allow us to observe the student population throughout our sample period. We observe that the median percent decrease in student population after a school transitions to a traditional calendar is 6% at elementary schools, 15% at middle schools, and 24% at high schools. If school overcrowding is a possible explanation for the effects we see for high school math and English test scores, we would expect our results to be driven by schools with the largest decrease in overcrowding. Tables A12 and A13 in the Supporting Information provide the estimates for schools above and below the median percent decrease in student population, respectively. In contrast to what we would expect if overcrowding explained our results, we find that our main results are driven more by schools with the *smallest* decrease in overcrowding. One possible concern is that daily enrollment in the school building matters, not the overall school enrollment. After a school transitions to a traditional calendar, all students are combined onto one track, which may result in a higher daily enrollment even if overall enrollment decreases. This would attenuate the overall effect for test scores toward zero. However, most of these schools were already at building capacity—a primary reason to adopt a nontraditional calendar. Consequently, a reduction in overall school enrollment would result in either a similar level or a reduction in daily enrollment. We would expect combining tracks to negatively affect students *more* from schools with the smallest decrease in student population through this channel, suggesting overcrowding is unlikely to explain our results for high school students.

Relatedly, reduced overcrowding after a transition to a traditional calendar may lead to less wear and tear on school facilities, as transitioning from a year-round calendar reduces building use during the summer months. This reduction in usage could, over time, slow the depreciation of the school's physical infrastructure, potentially preserving facility quality. However, any potential benefits from slower depreciation are likely to accumulate gradually, suggesting slow gains in student achievement over time. In contrast, we observe relatively sharp changes in student outcomes after a calendar change. The immediate nature of our effects suggests that capital stock quality is unlikely to be a primary mechanism, although this channel may be relevant for long-term outcomes.

Lastly, changes in school calendars may impact the amount of time students spend studying at home. For example, if teachers assigned the same amount of homework each day regardless of calendar type, because Concept 6 calendars have 17 fewer school days per year, students would spend nearly 10% less time doing schoolwork at home. While teachers may increase their amount of daily homework to compensate for the reduced number of school days, it is also possible that teachers may reduce the amount of daily homework due to the longer school days and increased fatigue. Students may also shirk homework and spend less time at home studying, even conditional on the amount of homework assigned because of longer school days. While our data limit us from measuring changes in at-home study behavior, Eren and Henderson (2011) find that a 60% increase in the amount of assigned homework increases students' test scores by 0.17 standard deviations. Additionally, a larger literature in education and psychology shows that students in courses with homework perform better than those in courses without homework (Roschelle et al. 2016; Grodner and Rupp 2013). Using the results from Eren and Henderson (2011), if students received 10% less homework in Concept 6 schools, this could explain approximately 30% of our results for high school students. In addition, evidence from this literature shows large effects for older students with mixed results for elementary school students (Cooper et al. 2006). As such, the changes in the amount of homework may also partially explain the differential effect between younger and older students. Moreover, with longer school days, high- and low-achieving students may differentially manage their at-home study time, resulting in the heterogeneous results we find across achievement groups (Del Boca et al. 2017).

While these mechanisms are unlikely to fully explain the effects we are finding, the change in school start time and potential changes in at-home study behavior may explain up to 80% of the results. Both of these mechanisms also help explain the differential effect between younger and older students. In addition, changes in at-home study behavior may also potentially explain the differential effects between achievement groups. The potentially large role that school start time and changes in at-home study behavior play may suggest that changes to the daily school schedule may be more important than changes in the yearly school schedule. However, since no high schools transition to a traditional school calendar from the 90-30 calendar, we are unable to determine whether there are any effects between these two calendar types in high school. Consequently, we are unable to fully parse the differential role of the daily school schedules from yearly calendars.

7 | Conclusion

In this paper, we estimate the differential impact of two different nontraditional school calendars that vary based on (1) the number of hours students spend in school each day, (2) the number of school days each year, and (3) the distribution of school days throughout the year. We exploit the staggered elimination of these two nontraditional school calendars and find that while school calendar structure has little to no impact on the test scores of younger students, the calendar structure significantly impacts older students. We find those elementary and middle school students on a calendar with longer and fewer school days—the Concept 6 calendar—perform academically just as well as those with shorter and more school days. However, we find that leaving a school calendar with longer and fewer school days increases the test scores of high school students by 0.08–0.15 standard deviations in math and 0.06–0.10 standard deviations in English. In addition, transitioning from a Concept 6 calendar decreases teacher turnover by 16%, suggesting teachers prefer traditional calendars over school calendars with longer and fewer school days.

Our finding that having a school calendar with longer and fewer school days negatively impacts older students appears to be likely driven by changes in school start times and at-home study behavior. By having longer school days—but a fixed number of instructional hours each school year—students may be induced to substitute away from daily out-of-school activities, such as sleep and homework, which may negatively impact their learning. Our paper focuses on a low-SES urban setting with many English language learners. This may reduce the generalizability of our results to other student populations. However, the mechanisms are not unique to LAUSD, and the effects we document may generalize to other settings where similar shifts in daily structure occur. In particular, any district considering calendar changes that compress instructional time into longer days may negatively affect student achievement, especially for older students. Our results show that teachers also reveal a preference against calendars with longer and fewer school days by being less likely to leave when on a traditional calendar. These results suggest that even with a fixed amount of instructional time, how that time is allocated throughout the school day and the school year is an often-overlooked yet significant policy decision that influences students and teachers.

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Data Availability Statement

The dataset used in this paper is student administrative data from the Los Angeles Unified School District (LAUSD) and is proprietary. Thus, we are unable to release these data on a public website. Researchers interested in acquiring these data can get additional information to apply for these data at the following website: https://orpe.lausd.org/apps/pages/index.jsp?uREC_ID=4433814&type=d&pREC_ID=2657178

Endnotes

[1] States mandate the minimum number of educational hours students are required to receive in each grade. Using the 2018 state educational

mandates and student-grade populations in each state, we find that 28% of elementary students are enrolled for at least 900 educational hours and 19% for at least 1,080 hours. For middle school students, 32% are enrolled for at least 900 hours, 16% for at least 990 hours, and 21% for at least 1,080 hours. For high school students, 11% are enrolled for at least 900 hours, 22% are enrolled for at least 990 hours, and 35% for at least 1,080 hours. See State Education Practices, Table 5.14 for state educational mandates.

[2] These results for the 90-30 calendar are similar to those of McMullen and Rouse (2012), who analyze a similar school calendar in North Carolina.

[3] One type of nontraditional school calendar—the multitrack, year-round calendars—helps alleviate overcrowding by allowing more students to enroll during the school year than could be accommodated by traditional calendars. To illustrate, suppose 150 students enroll at their neighborhood school, but the school only has a capacity of 100 students at any given time. By dividing the students into three groups of 50 students each and staggering student breaks throughout the year so that only two groups of students are in school at any time, the school can accommodate 150 students even with the 100-student building constraint.

[4] See Aspen Environmental Group (2004) for a detailed plan that outlines the LAUSD's goals to improve the district and how it intended to meet those goals.

[5] All three school calendars continued the typical 5-day school week.

[6] The multitrack system is often considered a potentially cost-effective use of fixed capital resources. Under this multitrack calendar structure, schools can accommodate 20–33% more students than a traditional school calendar (Graves et al. 2013). The multitrack system is more cost-effective when the school's population exceeds 115% of the school's capacity (Cooper et al. 2003). Estimates from the California Department of Education suggest that annual per-pupil costs in a school with a 500-student building constraint are $25 lower on a multitrack calendar than a traditional calendar when the student population reaches 635 students, with the gap widening as the student population increases (see https://www.cde.ca.gov/ls/fa/yr/guide.asp). Such cost savings amount to more than $15,000 per school with a 635 student enrollment (Graves et al. 2013).

[7] The 90-30 calendar gets its name because of the general structure of the system: 90 days in school followed by a 30-day break.

[8] Regardless of the school calendar, California educational guidelines required that students in the same grade level receive the same number of minutes of instruction.

[9] Statistics from https://achieve.lausd.net/facts using the Wayback Machine for earlier statistics.

[10] With our definition of dropout, this includes students who drop out of high school or students who leave the school district.

[11] Unfortunately, the California Basic Educational Data System no longer publicly maintains these data for years before 2008. Graciously, Jennifer Graves provided these data for the years 2002–2007.

[12] Some schools do not fit the typical model of an elementary, middle, or high school (e.g., elementary schools are usually defined as schools housing students in kindergarten to Grade 5). In LAUSD, some schools are span schools which are "schools that 'span' or cover more grades than traditional elementary, middle, or high schools such as K to 8, 7 to 12, or K to 12" (Aspen Environmental Group 2004). These span schools make up only four of the schools on a nontraditional calendar and have been removed from our data.

[13] Note that since there is no within-student variation for dropping out, we are unable to provide estimates from the student fixed effect specification.

[14] To create achievement-level groups, we divide students into terciles representing low-achieving, middle-achieving, and high-achieving students. To allow for a student fixed effect specification, we construct a measure of academic achievement that keeps students in the same tercile over time. We construct these terciles within each grade and year using the average of a student's first observed standardized math and English test scores. We then estimate Equation (1) separately for each of these three groups.

[15] Results for Concept 6 middle schools in Table A6 of the Supporting Information suggest there are few differing effects by student achievement groups for middle school students.

[16] While we find highly statistically significant effects on teacher turnover for the full sample of teachers, we find statistically insignificant or marginally significant effects for novice and experienced teachers in Panels B and C. The estimates are noisier in these subgroups, and we do not detect clear differences across experience levels.

[17] When we account for heterogeneous treatment effects in Table A11 of the Supporting Information, we find generally consistent results compared to those reported above. One notable difference emerges for high school teachers with 0–2 years of experience, where the heterogeneous treatment effects adjustment suggests a 14 percentage point decline in turnover.

[18] The LAUSD is located in a warm climate with long, sunny days. Our conclusions may not extend to school districts that are more prone to winter weather and days with less sunlight.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Online Appendix