Time in School: A Conceptual Framework, Synthesis of the Causal Research, and Empirical Exploration

Matthew A. Kraft
Brown University

Sarah Novicoff
Stanford University

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Abstract

We examine the fundamental and complex role that time plays in the learning process. We begin by developing a conceptual framework to elucidate the multiple obstacles schools face in converting total time in school into active learning time. We then synthesize the causal research and document a clear positive effect of additional time on student achievement typically of small to medium magnitude depending on dosage, use, and context. Further descriptive analyses reveal how large differences in the length of the school day and year across public schools are an underappreciated dimension of educational inequality in the United States. Finally, our case study of time loss in one urban district demonstrates the potential to substantially increase instructional time within existing constraints.

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1. Introduction

For decades, policymakers have argued that the American education system fails to provide the necessary instructional time for U.S. students to remain competitive in an increasingly globalized economy. In 1983, the landmark report *A Nation at Risk* warned that the "mediocre educational performance" of American students threatened the very safety and economic security of the country. The report attributed this competitive decline, in part, to the comparatively fewer hours Americans spent in school and the ineffective use of instructional time (Gardner et al., 1983). Ten years later, the National Education Commission on Time and Learning characterized the American school system as "a prisoner of time" (C. Kane, 1994). President Obama echoed these sentiments in 2009, arguing that the American school calendar "puts us at a competitive disadvantage" and that "the challenges of a new century demand more time in the classroom" (Martin, 2009).

Most recently, policymakers have advocated for major increases to time in school as a response to the loss of in-person instructional time caused by the COVID-19 pandemic (T. Kane & Reardon, 2023; Perez, 2021). Some states and districts have moved in this direction with the support of federal dollars from the Elementary and Secondary School Emergency Relief (ESSER) Fund and the American Rescue Plan Act (ARPA). In Texas, 46 elementary and middle schools in the Dallas Independent School District opted to extend the school year by five weeks (Little, 2022). District and union leaders in the Los Angeles Unified School District agreed to the addition of four optional instructional days after contentious negotiations (Sequeira, 2022). Most recently, New Mexico passed legislation to raise the minimum amount of mandatory instructional time by over 1,000 hours per year (Mahnken, 2023). At the same time, hundreds of districts across the U.S. have reduced instructional time by adopting four-day weeks as a response to teacher staffing challenges and budget constraints (Thompson, Gunter, et al., 2021).

In this paper, we aim to inform the ongoing national dialogue about expanding instructional time in U.S. public schools in three primary ways. First, we propose a conceptual framework of time in school that illustrates how a multitude of challenges prevents schools from converting total time in school to active learning time. Second, we conduct a systematic review of research employing methods capable of supporting causal inferences to answer the question: What is the effect of time in school on student achievement? Third, we draw on a range of international, national, and district datasets to produce a novel set of empirical facts about time allocation and use in U.S. public schools. Our descriptive analyses are aimed at answering three interrelated research questions:

- How does total time in U.S. schools compare to that in other countries?
- How much does total time in school vary in the U.S.?
- How much instructional time is lost within the school day?

Together, our conceptual model, literature synthesis, and descriptive analyses illuminate key insights and policy tradeoffs that would not be evident if each were considered in isolation.

Scholars have long studied the relationship between total time in school and student achievement, relying primarily on case studies and correlational evidence to conclude there is a weak positive relationship (Aronson et al., 1998; Berliner, 1990; Cotton, 1989; Fraser et al., 1987; Huyvaert, 1998; Karweit, 1985). The most influential and highly cited review of the modern literature synthesizes 15 studies published prior to 2010, many of which employed weak research designs unable to support causal inferences (Patall et al., 2010). As Karweit (1982) wrote in her review over 40 years ago, we should be cautious about ascribing causal interpretations to correlational studies because "other factors, which covary with time but which are not measured, may be responsible for the observed effects." However, the increasing use of experimental and quasi-experimental methods in the social sciences over the last decade has resulted in a growing body of more rigorous empirical evidence on the causal relationship between time and achievement.

We identify and synthesize the findings from 74 studies that apply credible causal research designs to estimate the effect of total time on students' academic achievement. We organize our review around four specific education policies that influence the amount and structure of total time in school: extending the school year, extending the school day, adopting a four-day school week, and setting school start times. The research provides a compelling body of evidence that increasing total time leads to gains in academic achievement, the magnitude of which depends critically on the existing amount of time, how time is increased, and how time is used. While academic gains from increased total time are primarily small or medium in magnitude, studies of whole-school reforms (e.g., urban charter and turnaround schools) demonstrate that extending the school day and year can produce large effects when combined with efforts to maximize student engagement and instructional quality. Research also consistently shows that student achievement declines when districts reduce time in school by adopting four-day school weeks.

Given that time is an important input for learning, we aim to provide policymakers and administrators with a better understanding of the landscape of total time in U.S. public schools. We estimate that the typical K-12 public school in the U.S. is in session for 6.90 hours per day and 178.59 days per school year, on average, for a total of 1,231 hours per year. Despite claims of being left far behind, the U.S. ranks eighth in terms of average instructional time compared to other high-income countries, with a relatively longer school day but shorter school year. We then show that the decentralized education system in the U.S. has resulted in large differences in total time across K-12 public schools. For example, schools at the 90th percentile of the distribution of total time are in session almost 200 hours more than schools at the 10th percentile. This is equivalent to over five and a half weeks per year, or two full school years, over the course of a K-12 education. Large differences in total time are also evident across states. Over the course of a K-12 education, students living in the five states with the highest median number of school hours will have access to 1.4 more years of effective schooling compared to students living in the five states with the lowest median hours.

We conclude with a case study of the Providence Public School District (PPSD) to illustrate the importance of lost instructional time within the school day. Making conservative assumptions about time loss, we estimate that students in PPSD lose between 16 and 25 percent of the time during the school day specifically allocated to instruction. Aggregate instructional time loss is likely even higher given that our estimates do not incorporate additional challenges such as off-task student behavior that prevents schools from converting instructional time into active learning time.

Our study makes several important contributions to the academic literature and policy debate. Our conceptual model helps to highlight how underappreciated daily obstacles in school erode instructional time, pointing to productive areas for further research. We extend the findings of prior literature reviews on time in school (Dağlı, 2019; Gromada & Shewbridge, 2016; Holland et al., 2015; Patall et al., 2010; Redd et al., 2012; Scheerens et al., 2013; Silva, 2007) by presenting the first synthesis focused exclusively on causal research. Our descriptive analyses illuminate how differential access to time in school is an underappreciated dimension of educational inequality in the United States. Finally, our case study illustrates the key educational challenge of converting instructional time into learning time, as highlighted in our conceptual framework.

2. Conceptual Framework

The connection between time and learning is an age-old idea. The philosopher and educator William James made these points in several speeches to teachers around the turn of the 19th century (Berliner, 1990). Equally intuitive for anyone who has participated in school is the insight that not all time in school is spent learning. Carroll (1963) formalized this intuition in his seminal model of learning, providing a foundation for future empirical studies of time in school. He theorized that learning was a function of two primary factors: the time each student requires to learn and the time they spend learning. In the Carroll model, time in school is simply an "opportunity" or "empty vessel" – necessary for learning but not sufficient.

Scholars have since extended the Carroll model in several ways that help refine how time relates to student learning. Bloom (1968) posited that with the appropriate amount of time – an amount that would vary based on individual student aptitude – and individualized instruction, all children could develop mastery of core academic subjects. Wiley and Harnischfeger (1974) further extended the Carroll model, defining learning as not only a function of the amount of total time allocated for learning, but also the proportion of that time that is usable and actively used. Total time, for example, was not usable when students were absent or teachers did not properly align their instruction to the learning goals. Karweit (1982) further quantified additional factors preventing total time from becoming learning time including teacher strikes, school closings, non-academic events, and poor classroom management.

In the 1980s, Levin published a collection of studies that drew upon economic theory to illustrate key potential limitations to policies aimed at raising student achievement via extended learning time. Building on the Carroll model, he outlined learning as a function of 1) student capacity, 2) student effort, 3) total time allocated to learning, and 4) the quality of learning resources (Levin, 1984). Because student effort itself is a function of the amount of total time in school, he posited that extending learning time may not raise achievement because students may not be able (or choose) to sustain the same level of effort over longer periods of time. In this way, extended learning time could even be counterproductive if there were few intrinsic or extrinsic rewards for students to maintain their attention.

The eminent sociology James Coleman framed time as key input into what he characterized as the “intensity” of schooling. He viewed intensity as a conceptual index measure of the total time dedicated to schooling, the amount of resources available, and the quality of these resources (Coleman, 1968). From a sociological perspective, more intensive schooling can serve to reduce inequalities by compensating to a greater degree for the unequal learning environments students experience outside of school. Thus, time in school matters not only for supporting students’ ability to learn but may play a role in reducing inequality.

We build on prior conceptual models (see Berliner, 1990 for a review) to propose a framework centered on three broad concepts, each denoted by color in Figure 1:

Total time – The amount of time in an academic calendar

Instructional time – The amount of time dedicated to instruction

Learning time – The amount of time students spend learning

That figure presents a cascading model of time to illustrate how incremental challenges collectively erode the amount of *active learning time* that individual students experience in school. We begin by defining *allocated total time* (which we abbreviate to *total time* and use synonymously with *time in school*) to mean the number of planned days per year multiplied by the number of planned hours per day in line with previously established definitions (e.g. Abadzi, 2009; Gromada & Shewbridge, 2016; Patall et al., 2010; Phelps et al., 2012; Wiley & Harnischfeger, 1974). Next, we subtract scheduled non-instructional hours like recess, lunch, and passing periods to form *allocated instructional time* (which we abbreviate to *instructional time*). *Instructional time* is the most optimistic definition of time that students could be learning and is typically uniform across a school or district.

A variety of organizational challenges can reduce the amount of time available for instruction at a school. Most basically, schools can be unexpectedly closed due to weather, teacher strikes, or other unplanned occurrences. We subtract these closures to define *available instructional time*. Although these days are sometimes made up at the end of the academic year, we expect that additional instructional time after testing during anticipated summer breaks is far from a perfect substitute.

Time varies within a school by classroom as well; our conceptual figure shifts the color of these segments to indicate when the level changes. Teacher absences, which occur by classroom, further limit instructional time to an amount we call *staffed instructional time*. Evidence suggests learning suffers during teacher absences even when absences are covered by a substitute teacher (Herrmann & Rockoff, 2012). Next, teachers have to proactively use instructional time for academic activities, but some of this time is invariably lost to non-academic routines such as taking attendance, transitions between activities, and waiting time. We label this time *planned instructional time*. Classroom interruptions, like use of the intercom or calls to classroom phones, further subtract time to create a quantity we denote as *usable* *instructional time* (Kraft & Monti-Nussbaum, 2021). *Usable instructional time* can be thought of as the amount of time inside a classroom that is free from external interruptions, which again can vary at the individual classroom level, even within a school. *Undisrupted instructional time* is then a subset of *usable instructional time* minus the time taken up by student disruptions that occur in the classroom.

Undisrupted instructional time is still at arm's length from becoming *active learning time*. For one, students must be present in the classroom to benefit from the instruction being delivered by their teacher(s). We characterize the time in which an individual student is present in their classroom, accounting for absences (excused and unexcused), suspensions (in-school and out-of-school), and tardies, as their *potential learning time*. This is the first level of our conceptual framework that varies by individual students, rather than at the classroom or school level. Finally, students can convert *potential learning time* into *active learning time* by engaging in the learning activities. In this way, the amount of *active learning time* for an individual student is a product of multiple factors including their own effort and internal motivation, the ability of their teachers and schools to motivate, the curriculum, and their peers' behavior.

3. What is the effect of time in school on student achievement?

The conceptual framework presented above suggests that the effect of time on student achievement is attenuated as it moves further up the causal cascade away from active learning time towards total time. While we are conceptually interested in the direct effects of active learning time, causal research on this more fine-grained measure of time use is largely unavailable. This is because policymakers and administrators can manipulate how much total time – and in some instances, instructional time – exists, but they have little control over the individual classroom-level and student-level factors that diminish its potential. Thus, empirical education research typically cannot directly measure the effect of active learning time. Instead, research literature can help us understand the more distal effects of total time and instructional time. Here, we synthesize the evidence on time in school by conducting a systematic review of the empirical literature.

3.1 Search Procedures and Inclusion Criteria

We began by defining our focus to be on studies that examine time during the traditional school day and exclude literature on after-school and summer programs which have been surveyed extensively in other reviews (Durlak et al., 2010; Kidron & Lindsay, 2014; McCombs et al., 2019).[1] Our systematic review involved a three-part process. First, we identified articles using five search engines (Google Scholar, JSTOR, ERIC, NBER, and EconLit) and an iteratively developed set of search terms including "length of school day [year]," "extended school day [year]," "extended learning time," and "increasing time in school." Second, we reviewed references in prior reviews of time identified above and from the studies that met our inclusion criteria to cross-check our search process. Third, we contacted many authors of the articles included in this analysis to solicit their help in identifying additional studies.

We limited our search to papers written and published in English and focused on students in kindergarten through 12th grade. We also required studies to employ methods that were capable of supporting plausibly causal inferences about the effect of time. Studies were eligible if they used the following research designs: randomized control trials (RCT), instrumental variables (IV), regression discontinuity (RD) designs, difference-in-differences (DiD)/event-study designs, and panel methods with high-dimensional fixed effects. While causal

[1] We recognize that the line between an afterschool program and an extended day program can be subjective, as can be the line between a summer program and an extended year program. We focus on traditional extended day and extended year programs whenever possible.

identification is not a simple binary characteristic of a research design, these methods are generally viewed as being credible causal designs when important identifying assumptions are met and robustness tests rule out other plausible alternative explanations (Angrist & Pischke, 2009). Although it was not our original intention, we ultimately chose to more narrowly focus on studies that estimated effects on student academic achievement given that the preponderance of research examines effects on standardized test scores. We emphasize, however, that time in school can have important consequences for a whole range of outcomes including social-emotional skills, contact with the juvenile justice system, parental employment, teacher labor markets, and property values (e.g., Clauretie & Neill, 2000; Graves et al., 2018; Ward, 2019).

Our search and review process resulted in 74 papers that meet our inclusion criteria. We provide a comprehensive list of all papers, the policies they evaluate, the magnitude of time changed, location, methods, outcomes, and effect sizes in Online Appendix A. We then group studies into five broad categories of policy changes that affect time in school on distinct margins. Finally, we wrote thematic memos and looked for cross-cutting themes and common insights related to implementation and costs. Throughout our synthesis, we characterize effect sizes on student achievement relative to benchmarks based on the empirical distributions found in the broader literature (Evans & Yuan, 2022; Kraft, 2020).

3.2 Increased Total Time as Part of a Package of Inputs

Studies of charter public school operators such as KIPP, Promise Academy, and urban charter schools in Massachusetts that operate schools with extended days (and sometimes years) show positive and often moderate to large effect sizes on academic achievement as measured by test scores (Abdulkadiroglu et al., 2011; Angrist et al., 2012, 2013; Dobbie & Fryer, 2011; Hoxby & Murarka, 2009). Leveraging randomized lottery admission processes, these studies find effects as large as 0.42 standard deviations ("σ" hereafter) in middle school math per year and 0.25σ in middle school English (Abdulkadiroglu et al., 2011). However, determining the degree to which additional total time in these schools is responsible for driving these effects is a difficult empirical task given the inability to isolate time from other elements of the schools such as tutoring, lower student-to-teacher ratios, data-driven instruction, frequent teacher observations and feedback, and health interventions. Several studies attempt to disentangle the component parts of these package reforms through more exploratory regression analyses and find, to varying degrees, that additional total time is a predictor of schools with larger causal effects on achievement (Angrist et al., 2013; Dobbie & Fryer, 2013; Hoxby & Murarka, 2009).

There is also evidence of traditional school districts implementing similar bundled interventions and seeing positive results. Twenty public schools in Houston that implemented a set of best practices used in high-performing charter schools, including additional total time, experienced gains in math of over 0.10σ, with small gains in reading (Fryer, 2014). These reforms included extending the school day and year, increasing instructional time by 21 percent, and incorporating high-dosage tutoring throughout the extended school day. In Lawrence, Massachusetts, the state took over the traditional public school district and instituted a series of changes, including increasing school-level expenditures, replacing underperforming staff, and adding extra time for underperforming students. In year two of the takeover, the district also added 200 hours to the school year for all first through eighth graders. Using a DiD approach, researchers show math scores increased by 0.30σ and English language arts (ELA) scores increased by 0.10σ (Schueler et al., 2017).

We provide a visual overview of the effects of bundled education reforms that increase the amount to time in school in Figure 2 Panel A. We plot the effect size distribution from the studies described above to illustrate the magnitude and variation in effects on standardized achievement in math and reading. In this panel, as in the others of this figure, we exclude research on non-standardized test scores though we report the full results of our literature review on other achievement outcomes (e.g., college entrance exams or grade repetition) in Online Appendix A. The research on time as part of a package of inputs, which is entirely U.S.-based, suggests additional total time in school can have moderate to large effects when it is part of a broader reform effort to improve instructional quality.

3.3 Extending the School Year

Causal evidence on the effect of additional school days often leverages plausibly exogenous differences in the number of days that students are in school before taking standardized tests. These studies often find a small positive increase in achievement in math and ELA from the addition of 10 or more extra days (Aguero & Beleche, 2013; Aucejo & Romano, 2016; Fitzpatrick et al., 2011), while others find small positive effects in math but not ELA (Hansen, 2011; Sims, 2008). Optional extended school-year programs may also raise student achievement, but not all students will participate when they are voluntary. One study found that weeklong math-focused vacation academies in Massachusetts resulted in imprecisely estimated effects of 0.07σ in math but no effect in ELA (Schueler, 2020).

Leveraging snowfall, strikes, and other plausibly exogenous events, research finds corresponding decreases in the overall academic performance of students who experience an unscheduled loss of total time. Several studies using weather-related school cancellations as an instrument find small negative effects of lost total time on math but not ELA (Hansen, 2011; Marcotte, 2007), while others find small declines in both math and ELA (Marcotte & Hemelt, 2008) and one finds no effect on either subject (Goodman, 2014). A recent study using DiD to examine the effects of an unexpected, regulatory change in Spain that reduced the school calendar documents moderate negative effects in Spanish and English (Sanz & Tena, 2021).

Several international studies examine policy changes that induced large increases in total time due to extended school calendars and find consistent patterns: increases in time improve student outcomes, while decreases in time harm them. Leuven et al. (2010) uses an IV approach to study an increase of one month to the school year for four-year-olds in the Netherlands and finds small positive effects on language and math, though only the language score increase is statistically significant. Parinduri (2014) uses a RD to show that an additional six months of learning in Indonesia increased educational attainment by almost a full year. Pischke (2007) studies a decrease of 13 weeks of school in West Germany using a DiD design and finds it increased the likelihood of grade repetition by almost 30%.

As shown in Figure 2 Panel B, the literature demonstrates that additional days of instruction lead to improved academic outcomes for students of generally small magnitude in both the U.S and international context. More substantial expansions of the school year do appear to produce larger effects, but these are often measured in terms of on-time educational progress and attainment and do not show in the figure. Reductions in the length of the school year often have the opposite effect, harming student achievement.

3.4 Extending the School Day

The causal literature on extending the school day consists primarily of international studies of policy changes using DiD, RD, and panel data methods. Importantly, the amount of additional total time added varies meaningfully across contexts, and thus, so does the scale of the impact. In Colombia, when the school day went from 3.5 to 7 hours per day, it increased achievement by between 0.04σ to 0.14σ across grades and subjects (Hincapie, 2016). In Mexico, a new program that extended the school day from 4.5 to 8 hours led to large positive effects in math and language test scores with effects growing over time (Cabrera-Hernandez, 2020; Padilla-Romo, 2022). Researchers saw similarly large positive effects in math and language test scores in a Brazilian state that expanded the length of the school day from 4.5 to 8 hours (Rosa et al., 2022). In Chile, reforms increased the length of the school day from about 5.3 to 6.75 hours per day with more mixed evidence of its impact on student achievement. Across studies, one finds moderate effects in math and language (Bellei, 2009), while another finds no effect on math and a small effect on language (Barrios Fernández & Bovini, 2017), and a third study shows a moderate effect on reading (Berthelon et al., 2016). A fourth study shows positive effects on educational attainment (Dominguez & Ruffini, 2021). In Peru, scholars find that a two-hour increase in the length of the day increased math test scores by 0.24σ and reading test scores by 0.14σ using an RD approach (Aguero et al., 2021). In Ethiopia, an increase of 1-2 hours per day led to large increases in numeracy and writing achievement, though not in literacy (Orkin, 2013).

Smaller increases in the length of the school day – 90 minutes or less – also lead to positive results, albeit with smaller effect sizes. In Germany and Israel, when schools added 1-2 more hours per week, DiD and IV approaches showed small increases in achievement across multiple subjects (Huebener et al., 2017; Lavy, 2019). Work in Italy and Denmark though, where total time increased by less than an hour per day, showed medium positive effects in math but no other subjects (Battistin & Meroni, 2016; Jensen, 2013; Meroni & Abbiati, 2016). Finally, two studies with smaller samples conducted in Germany and the Netherlands find medium positive, but not statistically significant, effects on academic achievement from increasing the school day by 45-60 minutes (Dahmann, 2017; Meyer & Van Klaveren, 2013).

Three studies evaluate schools that adopted extended days in the U.S. context with more mixed results. Using a comparative interrupted time series design, Checkoway et al. (2013) find that the Expanded Learning Time Initiative in Massachusetts in which 26 schools added at least 300 instructional hours to the school year had no effect on achievement in math, ELA, or science. A study leveraging admissions lotteries as IVs within a DiD framework found that extending the school day by two hours for high-dosage tutoring at one Boston area charter school increased achievement in ELA by as much as 0.25σ with no effect in math (Kraft, 2015). Figlio, Holden, and Ozek (2018) use a RD design to analyze a Florida policy that required the 100 lowest-performing elementary schools to add an additional hour of reading instruction each day and find it increased reading test scores by 0.05σ in the first year.

Three related studies leverage data collected by the Programme for International Student Assessment (PISA) to examine the effect of subject-specific instructional time (Cattaneo et al., 2017; Lavy, 2015; Rivkin & Schiman, 2015). These studies isolate within-student or within-school variation in instructional time across subjects and find small to medium effects; a single hour of additional instruction per week in a subject increases achievement by between 0.02σ and 0.07σ. A similar study uses data from the Trends in International Mathematics and Science Study (TIMSS) and finds a 0.02σ increase in academic achievement for every additional hour in the school day (Wu, 2020). In the U.S., some districts have also begun expanding instructional time in specific subjects without changing total instructional time. Using RD and DiD designs, studies show small or medium positive effects of double-dose math classes on math achievement and larger effects on high school graduation and college enrollment (Cortes et al., 2015; Cortes & Goodman, 2014; Taylor, 2014a).

Full-day kindergarten offers the best example of a widescale expansion in the length of the school day in the U.S. Estimated effects of full-day kindergarten on end-of-year achievement are almost uniformly positive and of medium or large magnitude across studies using fixed effects (Lee et al., 2006; Zvoch et al., 2008), IVs (Cannon et al., 2006; Gibbs, 2014b; Warburton et al., 2012), DiDs (Cannon et al., 2011), and RCTs (Amsden et al., 2005).[2] However, studies that examine longer-run outcomes find that these positive effects tend to fade out over time (Friesen et al., 2022; Gibbs, 2014a; Gottfried et al., 2019).

Overall, the literature on extending the length of the school day suggests a consistent positive effect of adding more total time on student achievement as shown in Figure 2 Panel 3. International studies indicate consistent positive effect sizes of small to often medium magnitude on student achievement. The much smaller research base focused on the U.S. is more divided, showing positive effects in some students and no effects in others. The overall pattern of findings across these studies is also broadly consistent with a theory of positive but marginally decreasing returns to additional time during the school day; larger increases in time in education systems with fewer total hours demonstrate larger overall effects.

3.5 The Structure of School Time

In addition to lengthening the school day or school year, districts can also change the way that they structure their existing time. The structure of school time can have important consequences for the amount of active learning time students experience even when total time and learning time are held constant. This is because the length of the school day and year, as well as start and ending times have direct effects on many of the school, classroom, and student level

[2] Gibbs (2013) offers an exception to this, showing a positive effect using an instrumental variables approach but no significant effect using a regression discontinuity. Cannon et al. (2011) show positive, moderate, and statistically significant effects in kindergarten and negative (though statistically insignificant and small) effects by 2nd grade.

factors that can prevent schools from converting total time into active learning. For example, the structure of time in school can impact teacher and student attendance as well as students' ability to focus and stay on task.

Important dimensions of how time is structured in school include academic calendars, class schedules, the number of school days in a week, and school start times. We point readers to prior reviews of the limited causal literature on year-round calendars (Graves et al., 2013; N. Pope & Landon, 2023; P. von Hippel, 2016), which suggests staggering school breaks has very minimal effects. We found scant causal evidence on block schedules.[3] Thus, we focus our discussion below on four-day weeks and school start times. We find that four-day weeks rarely improve student academic outcomes and often lead to decreases in performance, while altering start times can improve outcomes but do not always.

Four-Day School Weeks

Four-day weeks, with the potential to decrease HVAC and busing costs, are an increasingly popular tool to restructure time. These schedules are currently being used in over 850 districts in at least 24 states (Morton et al., 2023). When four-day weeks maintain the same total time in a school year by lengthening the day but shortening the number of days, research shows mixed effects. In Colorado, researchers find that the switch to a four-day week in small rural districts led to a small increase in the percent of students scoring proficient on math and reading tests for upper elementary students (Anderson & Walker, 2015). In Oklahoma, a DiD study shows no effect on achievement but does find that the shortened school week saves districts money and decreases bullying and fights among the student body (Morton, 2020, 2022).

[3] A recent RCT of block scheduling in Croatia found null effects, though there were positive effects for some grades (Labak et al., 2020, 2021). See Zepeda & Mayers (2006) for a review of the correlational evidence.

Studies of districts that have both shifted to a four-day school week and reduced the total number of hours in a school year show more consistently negative effects. This is more common, with the average student in a four-day week school experiencing 85 fewer total instructional hours per school year (Thompson, Gunter, et al., 2021). Results of those programs (examined via DiD designs) are more uniformly negative, with studies showing a corresponding small to moderate decrease in math and reading test scores (Kilburn et al., 2021; Thompson, 2019, 2021; Thompson & Ward, 2022). Two recent studies that examine effects across multiple districts, some of which changed total time and some of which did not, find decreases in achievement levels and achievement growth between 0.03σ and 0.09σ (Morton et al., 2023; Thompson, Tomayko, et al., 2021).

The overall pattern of results from research on four-day school weeks in the U.S., summarized in Figure 2 Panel D, suggests that four-day school weeks typically have a small negative effect on student achievement.

School Start Times

In addition to expanding or restructuring time, schools can also shift their start and end times to address concerns about students coming to school well rested and ready to learn. Later school start times have been shown to increase sleep, mood, and attention while decreasing car accidents given adolescents later sleep schedules (e.g., Gariépy et al., 2017; Bostwick, 2018). A study using DiD methods in North Carolina shows that a one hour delay in middle school start times caused a small increase in math and reading achievement (Edwards, 2012), while another study using IV in Florida finds medium-sized increases in math and reading achievement across 3rd through 10th grade (Heissel & Norris, 2019). In South Korea, research using DiD finds that a policy to move start times in secondary schools back by one hour to 9 a.m. led to a medium increase in math scores, but had no significant effects on test scores in Korean and English (Kim, 2022). Studies on a later high school start in Minnesota show no effects on ACT scores but a positive effect on GPA (Hinrichs, 2011; James et al., 2023). When a county in North Carolina moved high school start times earlier, research using DiD methods showed ACT scores were not affected (Lenard et al., 2020). A school fixed effects model in North Carolina showed a similar null result on ACT scores, but a medium negative result on math test scores (Bastian & Fuller, 2018). A student fixed effects model, also in North Carolina but with middle school students who may be differently affected by the time shift, showed small positive results on math and reading (Bastian & Fuller, 2023).

As summarized in Figure 2 Panel E, research on the effects of delaying school start times in middle and high school shows small to moderate positive effects on state standardized tests.

4. Empirical Facts about Time in U.S. Schools

The existing body of research demonstrates clearly that total time has direct positive benefits to student achievement. Here, we explore the implications of these findings by examining how the U.S. compares to its international peers as well as the degree to which time in school varies within the U.S. Data on cross-country and cross-state comparisons of time capture the macro parameters that policymakers can influence and researchers can measure: total time and instructional time.

We first describe the key international and state-specific differences in these coarse measures. These analyses serve to highlight the inequity in access to time in school both across countries on average and within the U.S. across states and schools. We then explore the scale and scope of time lost to specific school-level, classroom-level, and student-level factors that erode instructional time using detailed data from a district case study. Our case study serves as a concrete example of the specific ways in which instructional time is lost along the causal cascade shown in Figure 1 as schools try to convert instructional time into active learning time.

4.1 How does instructional time in U.S. schools compare to other countries?

We draw on data collected in 2021 by the Organization for Economic Cooperation and Development (OECD) which captures instructional time in lower secondary schools across OECD member countries and partners. National ministries and departments of education provide data to the OECD on the average intended instruction hours per year and the average number of instruction days per year (OECD, 2021).[4] Lower secondary schools in the U.S. are, on average, providing 1,022 hours of instructional time across 180 days per year. Dividing instructional time by the average number of days provides an estimate of 5.7 hours per day.

As shown in Figure 3, the U.S. ranks near the top of the distribution of instructional time: eighth among the 37 countries. Overlaid "isoquant" curves highlight how countries achieve similar instructional time per year through different combinations of the length of the school day and year. We achieve this ranking through the combination of a relatively long school day (ranked eighth) and short school year (tied for 24th). Fifteen countries have school calendars that are at least two weeks longer than the average 180 days in the United States. We also draw on estimates of total regular instructional hours per week in lower secondary schools constructed from student responses on the 2018 PISA as a robustness check for the relative ranking of the U.S. Similar to our estimates of the length of the school day based on data reported by governments, the PISA data shows the U.S. ranked eighth among 77 countries using this alternative measure (OECD, 2020).[5]

4.2 How much does total time in school vary within the U.S.?

[4] For complete data see Tables D1.1 and D1.2 in OECD (2021).

[5] Estimates based on survey responses from 15-year-olds about the number of academic periods in a school day and the length of a typical period. For complete data see Table V.B1.6.1 in OECD (2020).

State Laws on Minimum Time in School

Unlike most countries, where a central governing body sets national education policies, the U.S. system of government delegates authority over education to individual states. States set the minimum length of the school year, the minimum number of total hours in school, and/or the minimum number of hours in a school day. A database maintained by the Education Commission of the States shows that, in February 2023, 16 states mandated both the length of the school year and the amount of total hours, while 10 states gave districts the freedom to meet either a minimum number of days or total hours requirement (Silva-Padron & McCann, 2023). Eleven states required only a minimum number of days, and 13 states only set a minimum requirement for the number of total hours.[6]

This patchwork system results in markedly different minimum school time requirements for U.S. students depending on where they live. Among the 37 states that identify a minimum number of days per year, the majority (28) set the minimum at 180 days, with a range between a low of 160 in Colorado to a high of 186 in Kansas. Thirty-nine states specify a minimum number of hours per year, with high school hours ranging between 720 hours in Arizona to 1,260 hours in Texas. Even setting these two outliers aside, there exist large differences across states. High school students in Alaska, Florida, and Connecticut are only required to have 900 hours of school per year, while public high school students in Maryland are required to have 1,170 hours (Silva-Padron & McCann, 2023). Graduating seniors in Maryland will have been required to attend high school for 30 percent longer – approximately 160 more days – than students in Alaska, Florida, and Connecticut.

[6] Further inconsistencies arise from a lack of clarity about whether state laws on minimum hours refer to total time or instructional time in school (i.e., whether the minimums include lunch or other purposefully non-instructional uses of time).

Total Time in School

While there exist stark differences in the minimum number of hours and days across states, districts maintain the autonomy to increase time requirements so long as their budgets can cover the expansion. We draw upon the 2017-18 National Teacher and Principal Survey (NTPS) to quantify the actual amount of total time students spend in U.S. public schools. The NTPS is a nationally representative survey of K-12 public schools, including both traditional and charter schools.[7]

We estimate that the typical K-12 public school in the U.S. is in session for 6.90 hours per day and 178.59 days per school year, on average, for a total of 1,231 hours per year. In Table 1, we describe the wide variation in the number of school hours per day, days per year, and hours per year. Students attending schools at the 90th percentile of the distribution of the number of hours per day are in school more than an hour longer each day than those at the 10th percentile (7.50 vs. 6.33 hours). Similarly, schools at the 90th percentile of the distribution of the number of days per year are in session two weeks more than schools at the 10th percentile (183 vs. 173 days). Cumulatively, the total number of school hours per year differs by almost 200 hours between schools at the 90th and 10th percentiles (1,332 vs. 1,136 hours). This gap equates to a difference of approximately five and half weeks of schooling, or more than two full school years over the course of a K-12 education.[8]

[7] We exclude from our sample a small fraction of schools that provide alternative or nontraditional education (6.0 percent), specialized schools with a targeted emphasis in a given subject such as STEM or performing arts (3.7 percent), special education schools (1.4 percent), and career/technical/vocational schools (1.4 percent) and apply appropriate population weights.

[8] A difference of 196.17 hours per year translates to 2.06 additional years over a student's 13 years in the U.S. school system. The math is as follows: (196.17 hours per year * 13 years) / 6.9 hours per day / 179 days per year = 2.06 years.

Figure 4 illustrates the variation in the time schools are open in the U.S. and how this differs across elementary, middle, and high schools. As shown in Table 1, schools are in session a similar number of days per year across schooling levels but are in session for more hours a day, on average, as students become older (elementary 6.80 hours; middle 6.97 hours; high 7.03 hours). The 90^{th}-10^{th} percentile difference in total hours per year remains quite large even when restricting comparisons within schooling levels (elementary 187.50 hours; middle 190.83 hours; high 165.00 hours).

We further explore the variation in the total number of hours in a school year by plotting the full population-weighted sample of schools in Figure 5. This scatterplot illustrates the wide variation in the total number of hours per school year. The outlying cluster in the upper left quadrant represents schools that are in session only four days a week (~150 days a year) for upwards of eight total hours a day. Although these schools achieve a similar number of hours as many schools that are in session the standard five days a week, research described above suggests number of days per week and hours per day are not perfect substitutes in the extremes.

We next explore the degree to which systematic differences across states account for the variation in total time across individual U.S. public schools described above. We estimate that 23 percent of the variation in total school hours is accounted for by differences across states. Thirty-one percent of the variation in hours per day is explained by states compared to only 20 percent of the variation in the number of days per year. We depict the substantial variation in the number of hours per year across states in Figure 6 and report average and median estimates by state in Online Appendix B. The five states where students attend schools the longest (Texas, Nebraska, Arkansas, Mississippi, and Alabama) are in session at least 133 hours more, at the median, than the five states where schools are open the fewest hours (Hawaii, Nevada, Maine, Oregon, and

Rhode Island). Over the course of a K-12 education, students living in the states that ranked in the top five for total hours will have access to 1.4 more years of effective schooling, at the median, compared to students living in the states ranked in the bottom five for total hours.[9]

We next examine heterogeneity in school hours by school type and location using the NTPS data. We find that, on average, charter public schools are in session for 65 more total hours than traditional public schools (1,291 vs. 1,226) and rank at the 82nd percentile among non-charters. The distribution of charter schools has a thick upper tail consisting of predominantly urban charter schools that have notably extended the length of the school day and/or year. The total number of hours per school year also varies by schools' locations. Suburban schools are in session the least (1,212 hours on average), whereas schools in rural areas (1,241 hours) and towns (1,240 hours) have the longest average time in school. There is considerably more variation in the total hours among schools in cities (1,239 hours), with schools in the upper range of the distribution being much more likely to be in cities than elsewhere.

The composition of students attending schools with more total hours differs from schools with fewer hours. In Table 2, we present average student characteristics among schools grouped by quintiles of total hours per year. We find that African-American students disproportionately attend schools with more total hours. African-Americans represent 21 percent of students at schools in the top quintile of time, but just 10 percent in the bottom quintile. This is partially due to the fact that, nationally, African-American students are twice as likely to attend a charter school as a traditional public school (28 vs. 14 percent) and the longer school days and years in many southern states. Similar to African-American students, students eligible for free- or reduced-price lunch disproportionately attend schools in the top quintile of time. Students from

[9] A difference of 133 hours per year translates to 1.4 additional years over a student's 13 years in the U.S. school system. The math is as follows: (133 hours per year * 13 years) / 6.9 hours per day / 179 days per year = 1.4 years.

low-income families comprise 68 percent of the student body in top quintile schools, but only 58 percent in bottom quintile schools. Asian and Hawaiian/Pacific Islander students follow an opposite trend, disproportionately attending schools in the bottom quintile. This is not surprising given Hawaii, Oregon, California, and Washington State all rank in the bottom 11 states in terms of total hours per school year. Hispanic students show a bimodal distribution, clustering at the bottom and top quintiles, while white students cluster in the middle of the distribution.

4.3 How much instructional time is lost within the school day?

A large body of research that examines teaching and learning within classrooms documents how instructional time is lost to organizational disruptions, off-task behavior, and mundane activities like transitions. Reviews of the Process-Product literature from the 1970s and 1980s conclude that optimizing instructional time is among the most important factors for improving student achievement (Brophy & Good, 1984; Hawley et al., 1984). Phelps et al., (2012) collect instructional logs from thousands of classrooms and estimate that, on average, students miss instruction in math and ELA about 40 days per year due to a range of factors including student and teacher absences, special events, and testing. We examine the amount of instructional time lost in Providence Public School District (PPSD) in 2016-17 due to a range of student, teacher, and organizational factors highlighted in Figure 1 to better understand the magnitude of time loss in U.S. schools. Specifically, we calculate the instructional hours that remain after accounting for student absences, suspensions, and tardies as well as teacher absences and outside interruptions to estimate the potential gains from better utilizing currently allotted time. (See Online Appendix C for a detailed description of our methods.) This exercise helps to demonstrate how translating instructional time into active learning time can be an elusive goal that remains at arm's length for schools and teachers.

Setting

PPSD is a midsize urban school district in Rhode Island. PPSD operated 41 schools serving over 24,000 students in 2016-17. The district predominantly serves students of color from low-income families. Sixty-four percent of PPSD students are Hispanic, 17 percent are African-American, and nine percent are white. Over 85 percent of students receive free- or reduced-price lunch. One in four students is an English Language Learner, and 15 percent receive special education services.

The state of Rhode Island requires public schools to be in session at least 6 hours a day for 180 days a year, a total of 1,080 hours. PPSD exceeds these minimum requirements by lengthening the school day to 6.52 hours in elementary schools and 6.75 hours in secondary schools. Multiplying by 180 days in the PPSD academic year produces a total of 1,174 hours for elementary schools and 1,215 hours for secondary schools. This places PPSD at the 35th percentile of the national distribution for elementary schools, the 35th percentile for middle schools, and the 27th percentile for high schools.

While PPSD is not unusual in terms of total time, it was a pre-pandemic outlier in the degree to which students are absent or suspended. In 2015-16, 45 percent of PPSD high school students missed more than 18 days of school, the equivalent of 10 percent of the school year (Rhode Island Kids Count Factbook, 2017). This compares to 26 percent of students statewide who missed more than 18 days and less than 14 percent nationally. PPSD also suspends students at relatively high rates, issuing 21 in-school or out-of-school suspensions per every 100 students in the district compared to 17 statewide (Rhode Island Kids Count Factbook, 2017). However, chronic absenteeism has increased substantially after the COVID-19 pandemic such that many districts and even states now have rates of chronic absenteeism approaching levels found in Providence prior to the pandemic (Chang et al., 2022).

The Rhode Island Department of Education took over PPSD for a five-year term starting in 2019 after the release of an independent district review documenting major concerns over low student achievement and chronic absenteeism, deteriorating buildings, unsafe learning conditions, a demoralized teaching staff, and families who felt marginalized and without a voice (Borg, 2019; *Providence Public School District: A Review*, 2019). Thus, PPSD serves as a case study of a district facing considerable challenges in supporting students' success – and an example of a district where students might greatly benefit from more effective use of existing instructional time. Although the specific results of our case study likely have limited generalizability, we believe the general lessons can be broadly informative given that the COVID-19 pandemic increased attendance challenges nationwide.

Case Study Findings

In Figure 7, we illustrate how instructional time loss affects students in elementary, middle, and high schools across the district. As shown in Panel A, we estimate that the average elementary school student in PPSD loses 16 percent of instructional time, while the typical middle school student loses 21 percent. High school students lose a total of 25 percent, a full fourth of their instructional time. Assuming that additional time would suffer from the same rate of loss, we estimate that Providence would need to add an extra 1.85 hours of total time to every school day to achieve the 5.76 hours of instructional time that the district intends for its high school students.

Disaggregating our time loss estimates reveals that three factors account for the majority of lost instructional time. As shown in Figure 7 Panel B, unexcused student absences account for the largest portion, particularly in high school. Outside interruptions and teacher absences, the second and third largest contributors to lost instructional time, respectively, limit student learning in the classroom and are arguably more directly under the control of school districts. These outside interruptions to instruction include intercom announcements, calls to classroom phones, and the subsequent disruptions these interruptions cause. Notably, middle school teachers report more frequent outside interruptions than those in elementary and high schools.

Teacher absences constitute the third largest source of lost instructional time. Although it is possible that students do learn from substitute teachers, our classroom observations in PPSD suggest that substitutes are rarely successful at delivering sustained instruction and that requests for substitutes frequently go unfilled. Together, interruptions and teacher absences cost the average PPSD high school student 97.3 hours per year. Excused absences, suspensions, and tardies account for the remainder of the lost time, bringing the total amount of instructional time lost in high schools to 258 hours per year – approximately 45 days of school.

Our analyses provide a lower bound estimate of the instructional time lost in PPSD. Our estimates do not capture how usable instructional hours are further eroded by disruptions within the classroom and non-academic activities in class as illustrated in our conceptual framework (Figure 1). Estimates of off-task behavior, transitions, and wait-time suggest these activities occupy between 17 and 29 percent of instructional time (Fisher, 2009; Godwin et al., 2016; Rosenshine, 2015; Schwartz et al., 2018).

5. Discussion

5.1 Interpreting the Evidence

Synthesizing the causal research on time in school presents a challenge because time is measured, organized, and implemented in different ways across very diverse contexts.

Conceptually, many researchers and policymakers are implicitly interested in drawing conclusions about the causal effect of undisrupted learning time – the amount of instructional time schools provide when teachers and students are present and the learning environment is free of impediments to active learning. As our case study illustrates, this construct is extremely challenging to measure at the scale required by well-powered causal research designs. Instead, researchers must rely on two proxies – total time and instructional time. This is both because of the measurement challenges and because causal research on time in school relies overwhelmingly on quasi-experimental methods that exploit shifts in school and district calendars (i.e., total time). Although some studies leverage shifts in instructional time from changes in school schedules and initiatives like double-dose algebra, even this measure is still at arm's length from capturing undisrupted learning time.

Overall, the empirical evidence we review establishes a clear positive causal effect of increasing total time and instructional time on student achievement. Estimates are overwhelmingly positive and significant. Quantifying the magnitude of these effects is more challenging because studies differ considerably in the amount of time added and the baseline levels of time. In our review, estimates reflect the effect of increasing total time by as little as one day per year or 20 minutes per day to as much as 6 months per year or 3 hours per day. Even efforts to convert these estimates onto a common unit scale would not create an apples-to-apples comparison. As Levin (1984) theorized over 40 years ago, the causal effect of time on student academic outcomes is likely a non-linear relationship with diminishing marginal returns that could even become negative in the extreme. Extending an already long school day from seven to eight hours is unlikely to have the same benefit as increasing a short school day from five to six hours. Consistent with prior reviews (Dağlı, 2019; Gromada & Shewbridge, 2016), we find evidence of diminishing marginal returns to increased schooling in the pattern of results across studies as well as within individual analyses (Aguero & Beleche, 2013; Rivkin & Schiman, 2015; Taylor, 2014b; Wu, 2020).

Our read of the literature suggests that non-trivial expansions of total time in school (e.g., a 10% increase or more) are most likely to produce small increases in student achievement in the U.S. context (less than 0.05σ), but more often produce medium size effects (between 0.05σ and 0.20σ) in international settings. Large effects (greater than 0.20σ) are the exception and are found almost exclusively in bundled treatment effects of urban charter school and turnaround schools in the U.S. (Abdulkadiroglu et al., 2011; Angrist et al., 2013) and strikingly large changes in learning time in the international context (Parinduri, 2014; Pischke, 2007). The largely positive but variable effects of time in school suggest two things are true: 1) most school systems that substantially increase total time are able to convert this additional time into at least small gains in academic achievement, and 2) how time is used matters.

The small to moderate effect sizes we find also suggest that the direct effect of active learning time is likely quite substantial, but our conceptual framework illustrates why this concept may be elusive. Schools dedicate time to lunch, recess, and non-academic activities for good reason. Schools are complex social organizations where unpredictable things happen. There are substantial challenges to delivering undisrupted instructional time and, even when successful, students have to take the final step to convert it into active learning time.

Important questions remain about whether extended learning time is a reform that is equity enhancing or might widen existing opportunity gaps. From an educational achievement perspective, work by Carroll (1963) and Levin (1984) suggest that increasing total time in schools could exacerbate inequality if students with higher aptitude are better able to take advantage of this time or because more advantaged students attend schools that are more successful, on average, at converting total time into undisrupted instructional time. On the other hand, Coleman's (1968) concept of the intensity of schooling frames longer school hours as an equity enhancing reform because it reduces the amount of time students spend outside of schools where there exist wide differences in access to enriching learning environments. Research on summer learning loss suggests that differences in student achievement arise largely before students enter schools and grow over the summer months (P. T. von Hippel et al., 2018). Longer school days and years may even be a compensatory policy that reduces educational inequity. From an economic standpoint, more time in school is equity enhancing because it provides free childcare and decreases barriers to labor force participation, which benefits families from lower socio-economic backgrounds the most. From a long-term outcome perspective, research suggests that longer school days can reduce teen pregnancy and incarceration (Dobbie & Fryer, 2015) and increase future wages (Parinduri, 2014).

Our review of the literature suggests there is no consistent pattern of heterogeneous effects of time along dimensions of student prior achievement, socio-economic status, race, or gender. There exists evidence of equity enchaining effects of additional time (Aucejo & Romano, 2016; Cannon et al., 2011; Cattaneo et al., 2017; Cortes et al., 2015; Hincapie, 2016; Marcotte & Hemelt, 2008; Wu, 2020), evidence that it benefits more advantaged students (Aguero & Beleche, 2013; Figlio et al., 2018; Orkin, 2013), and evidence of no heterogenous treatment effects (Bellei, 2009; Cannon et al., 2006; Dominguez & Ruffini, 2021; Rosa et al., 2022). These results suggest that how time affects educational equity has more to do with who has access to its benefits rather than how it benefits students differentially.

5.2 U.S. Policy Considerations

While the U.S. education system provides a comparable amount of instructional time to most other high-income countries, on average, many students are being left behind. Over 19% of public schools are in session at least a full week less than the national median (180 days), while another 14% of public schools have school days that are shorter than the national median (6.9 hours) by 30 minutes or more. These differences represent substantial inequities in the amount of total time students are provided by schools that add up to stunning differences across a K-12 education. Millions of public school students in the United States will have access to what amounts to two years of additional time in school during their K-12 educational career compared to millions of their peers simply because of where they live.

Raising minimum school time requirements across states to be closer to the national average would be one promising policy response to the COVID-19 pandemic. Minimum time requirements are blunt instruments, but they offer a feasible top-down policy reform that is within the control of policymakers. Given that research suggests time in school has diminishing marginal returns, focusing on those schools that offer the least amount of time might also produce the largest returns. As a thought experiment, imagine if the five states where schools are open the fewest hours raised state minimum time requirements to seven hours a day (e.g., 8:30 a.m. to 3:30 p.m.) for 180 days a year. The 94 percent of schools in Hawaii, Nevada, Maine, Oregon, and Rhode Island that do not meet these minimums would gain an average of 125 hours of schooling per year, an increase of 1,625 hours over 13 years. This would effectively add 1.3 years to the schooling trajectories of over 368,000 students. A parallel nationwide effort to adopt 7-hour, 180-day minimums would increase total time in 71 percent of U.S. public schools. The effect would be to add more than 4.6 million hours of additional time per year across U.S. public schools, potentially benefitting more than 32 million students.

However, increasing time in school is a financially costly policy that may not make sense for all states and districts. Federal relief funds in response to COVID-19 provided districts with the opportunity to cover the costs of expanding time in the short run. Even flushed with federal dollars, most districts were hesitant to make changes to school schedules given the considerable uncertainty about sustaining these costs after one-time federal funds are spent down. Extending time in school is an expensive policy that may not be as cost-effective as other alternative policies (Levin & Tsang, 1987) and does not always succeed (Checkaway et al., 2013).

Our research synthesis and case study point to several lower-cost, complementary approaches to maximizing time in schools. At a minimum, districts should fiercely avoid reducing time in school. There is a compelling body of evidence across multiple states documenting the negative effects of four-day school weeks that decrease total time. There are also low-cost opportunities to adjust school calendars in ways that keep total time constant but might reduce the challenges of converting total time into active learning time. One such example is shifting school start times to be later for older students. Evidence shows that later start times produce achievement gains as well as other health benefits for students. Designing schedules so that students take core academic classes earlier in the day when their attention is highest would also maximize available time (N. G. Pope, 2016).

Our case study suggests that many U.S. public schools would also benefit from concentrated efforts to utilize instructional time more effectively. Schools have the potential to recover substantial amounts of lost instructional time without changing their schedules at all. This approach to increasing instructional time is far less malleable from a top-down policy perspective, but we expect it offers greater potential returns for many more schools. Behavioral interventions to increase student attendance, school-wide systems to reduce disciplinary incidents that remove students from class, policies that limit school intercom and phone use, and incentives to curb teacher absenteeism could all play roles in maximizing instructional time.

5.3 Implementation Challenges

Building teacher and parent buy-in is also crucial to any efforts to expand time in school. Teachers can be hesitant to agree to extended day and year initiatives even when they are compensated for their time. This may be particularly true for teachers who were attracted to the profession because it allows them to care for their own children after school and during the summer. Teaching is also a physically and mentally exhausting job. Districts that expand time in school will have to take additional steps to attract and retain effective teachers given the rising rates of teacher turnover and burnout in the wake of the pandemic (Barnum, 2023; Steiner et al., 2022). Parent buy-in also presents a substantial obstacle to expanding school time. Support for more time in school is decidedly mixed among parents (Barnum, 2022). Many districts have navigated this challenge by making additional time voluntary for families or allowing individual schools to opt-in, but this could widen achievement disparities if only the most motivated students or well-organized schools participate in these new programs.

Schools and districts also have to choose *how* to expand time. Extending the school day can be an attractive approach because it is marginally less expensive than adding days to the school year as it does not require additional food or transportation costs. However, it is likely more challenging for both schools and students to convert time added to the end of the school day into active learning time than it is to make additional school days productive. Longer school days often require teachers to adopt new instructional approaches and students to maintain their focus longer. Adding days to the start or end of the school year requires few organizational changes, and thus, may be the easier approach to adding time. The length of the school year is also the dimension of time where the U.S. lags behind other nations the most.

6. Conclusion

Stagnating test scores and increasing economic competition have led to repeated calls for expanding time in U.S. public schools over the last several decades. The COVID-19 pandemic and resulting learning loss experienced by students have sparked renewed interest. Deriving a single conclusion from the causal research literature on time in school is nearly impossible because of the multiple ways in which learning time is operationalized in schools (e.g., via the length of the school day, week, and year). Time operates similarly to another key resource in education: money. Time, like money, is necessary for supporting student academic success. Evidence demonstrates that schools can leverage additional time to improve students' academic success. But when time is used ineffectively or in ways unaligned with academic goals, it will produce little benefits for students.

Time use is always about tradeoffs. Some families simply value the flexibility that shorter school days and years provide. Additional time in school might even be counterproductive if it crowds out enriching life experiences for students outside of school or if schools are unable to convert added time into active learning. After-school and summer activities can have positive benefits for student achievement, social-emotional development, and mental well-being (Durlak et al., 2010; Kidron & Lindsay, 2014; McCombs et al., 2019). More instructional time alone will not ameliorate the deep harms caused by the COVID-19 pandemic. But the clear inequities in access to time and new urgency to support students' academic recovery in the wake of the pandemic suggest that targeted efforts to expand time in school and ensure that this time is used effectively would be a wise investment.

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Table 1. *Allocated Total Time in U.S. Public Schools Across Schooling Levels in 2017-18*

	Hours in Day				Days in Year				Hours in a Year			
Percentile	Overall	Primary	Middle	High	Overall	Primary	Middle	High	Overall	Primary	Middle	High
1	6.00	6.00	6.00	6.07	147	154	159	146	1,064	1065	1080	1052
5	6.25	6.17	6.33	6.50	170	170	171	170	1,110	1095	1138	1140
10	6.33	6.25	6.50	6.57	173	173	174	173	1,136	1125	1155	1170
25	6.50	6.50	6.67	6.80	177	178	178	178	1,170	1165	1197	1215
50	6.92	6.75	7.00	7.00	180	180	180	180	1,230	1211	1246	1260
75	7.17	7.00	7.25	7.25	180	180	180	180	1,275	1260	1290	1293
90	7.50	7.42	7.50	7.50	183	183	184	183	1,332	1313	1346	1335
95	7.67	7.50	7.67	7.67	186	186	186	185	1,365	1350	1387	1371
99	8.08	8.00	8.17	8.17	190	190	190	190	1,479	1463	1504	1456
Mean	6.90	6.80	6.97	7.03	178.59	178.86	179.03	178.60	1,231	1216	1248	1256
Std	0.47	0.40	0.45	0.59	7.14	5.70	6.01	8.86	89.15	76.31	83.79	114.13
n (sample)	6,518	3,153	1,161	1,508	6,518	3,153	1,161	1,508	6,518	3,153	1,161	1,508
N (population)	79,623	47,973	13,043	12,996	79,623	47,973	13,043	12,996	79,623	47,973	13,043	12,996

Notes: The following types of schools are excluded from the sample: alternative schools, schools with special education emphasis, special education schools, and career/technical/vocational schools. Estimates are produced using inverse probability weights. Source: National Teacher and Principal Survey 2017-18.

Table 2. *Student Characteristics by Quintiles of the Total Hours in a School Year for U.S. Public Schools in 2017-18*

	Overall	Bottom Quintile	Second Quintile	Third Quintile	Fourth Quintile	Top Quintile
Female (%)	48.47	48.58	48.19	48.40	48.44	48.76
African American (%)	15.27	10.42	12.92	14.44	17.32	21.23
American Indian (%)	1.62	1.84	1.62	1.56	1.54	1.57
Asian (%)	3.86	6.18	4.93	3.26	2.66	2.40
Hawaiian Native / Pacific Islander (%)	0.39	0.96	0.38	0.19	0.23	0.23
Hispanic (%)	22.27	26.52	21.28	16.71	19.63	28.17
Multiracial (%)	3.27	4.11	3.83	3.36	2.75	2.33
White (%)	53.32	49.96	55.04	60.48	55.88	44.08
Free- and reduced-price lunch (%)	58.40	57.72	53.15	54.56	59.19	68.06
Average daily attendance (%)	93.33	93.08	93.28	93.27	93.38	93.63
n (sample)	6,445	1,069	1,282	1,354	1,384	1,356
N (population)	78,879	14,572	16,504	16,242	16,581	14,979

Notes: The following types of schools are excluded from the sample: alternative schools, schools with special education emphasis, special education schools, and career/technical/vocational schools. Source: National Teacher and Principal Survey 2017-18.

Figures

Figure 1: Conceptual Framework of Time in School

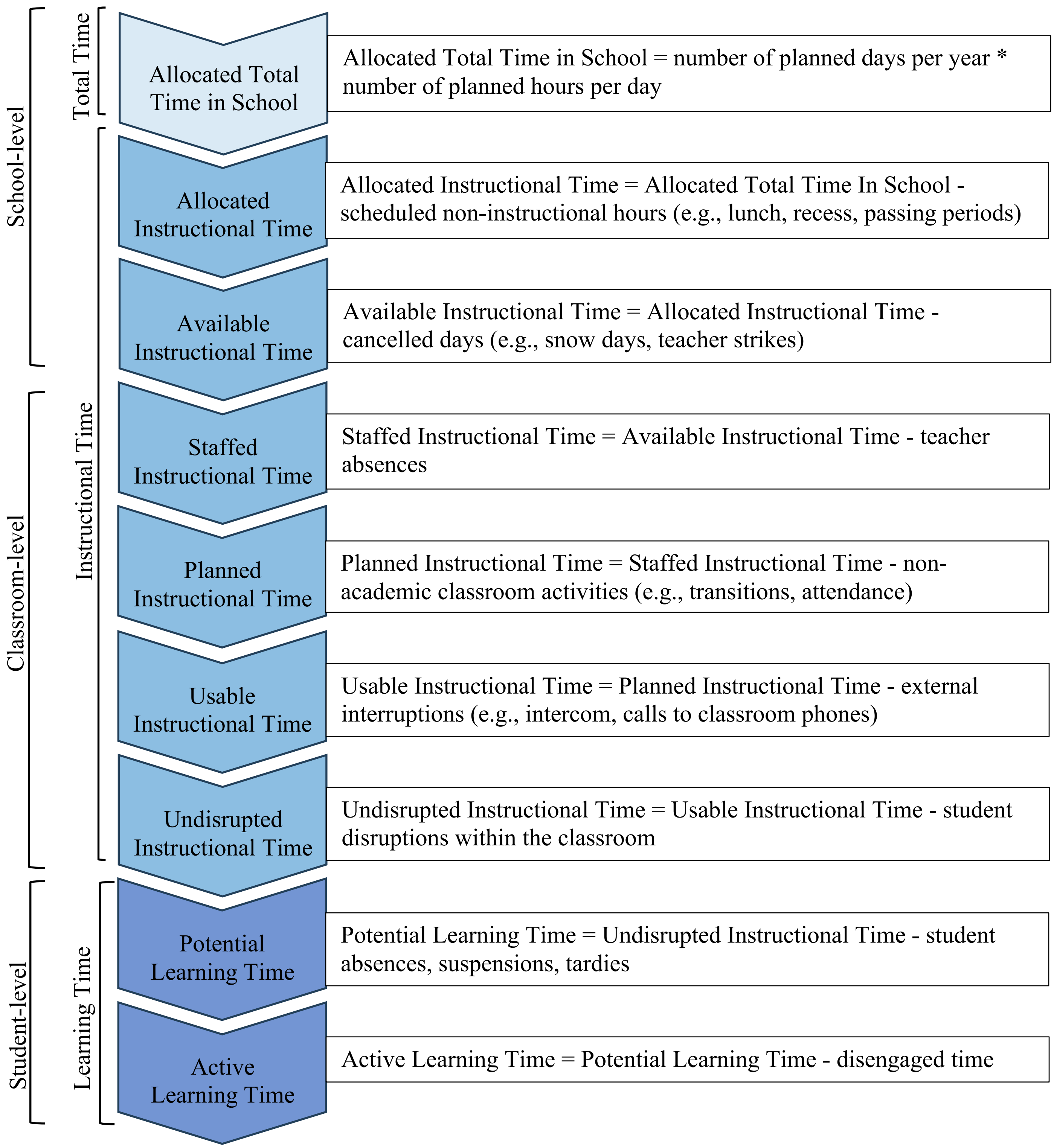
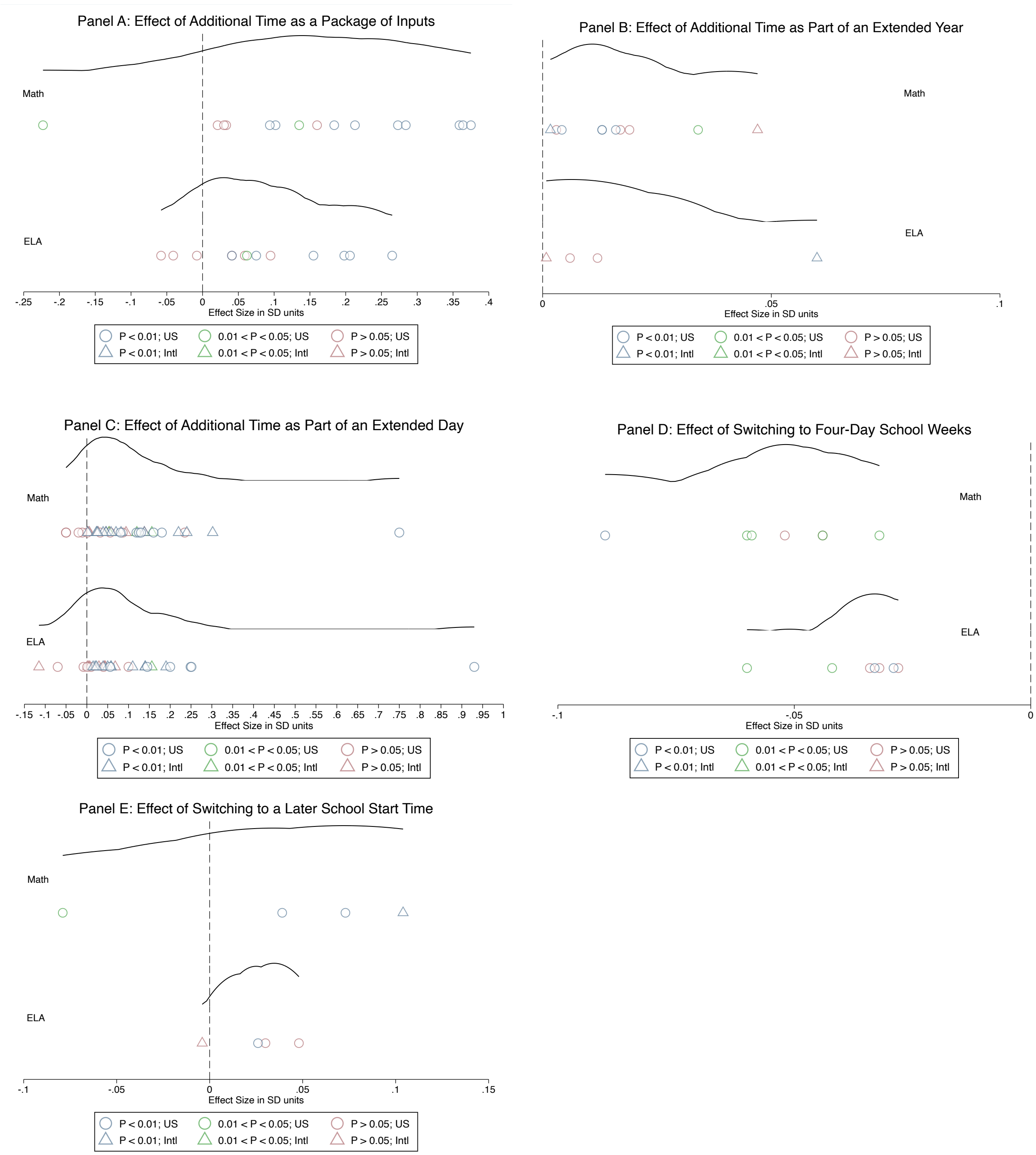


Figure 2. Effect sizes of the effect of total time/instructional time on student achievement from studies capable of supporting causal inferences.



Notes: This figure shows the effect size in standard deviation units from the body of literature reviewed in this paper. The figure includes only studies that reported or where we could calculate effect sizes in standard deviations on a math or English language arts (ELA) standardized exams. We present average estimates by subject for each study. We also exclude one outlier study – Fitzpatrick et al (2011) – because the amount of additional time added (250 days) greatly exceeds the amount of time added in other studies. For more details see Online Appendix A.

Figure 3. Scatterplot of the intended instructional hours in a school day and days in a school year for lower-secondary schools across countries using 2021 data collected by the OECD.

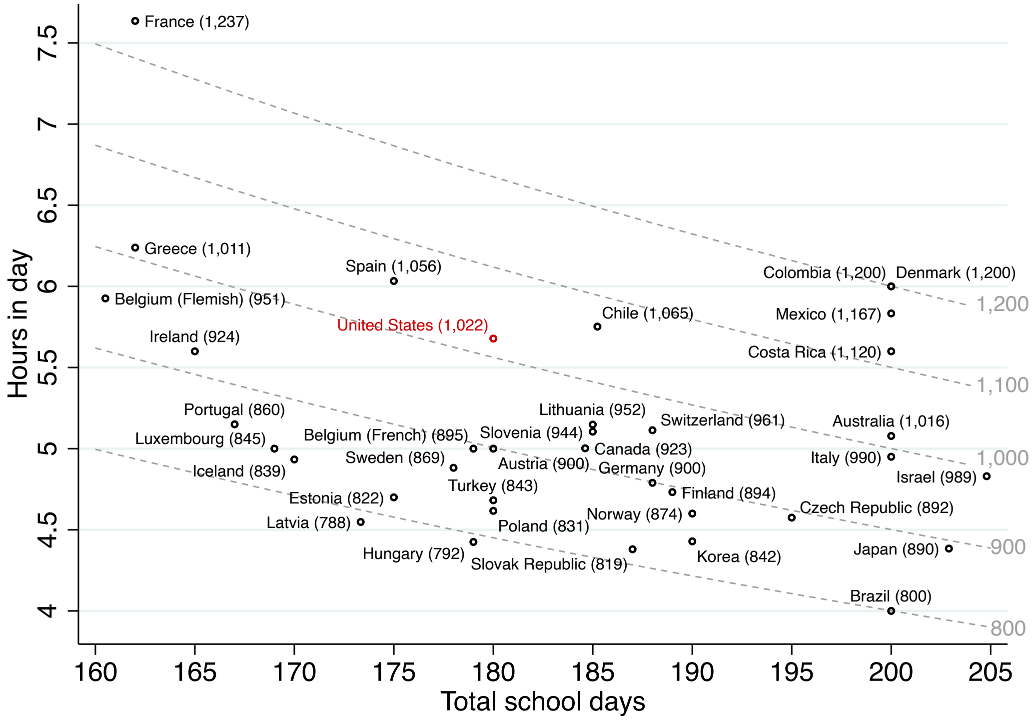
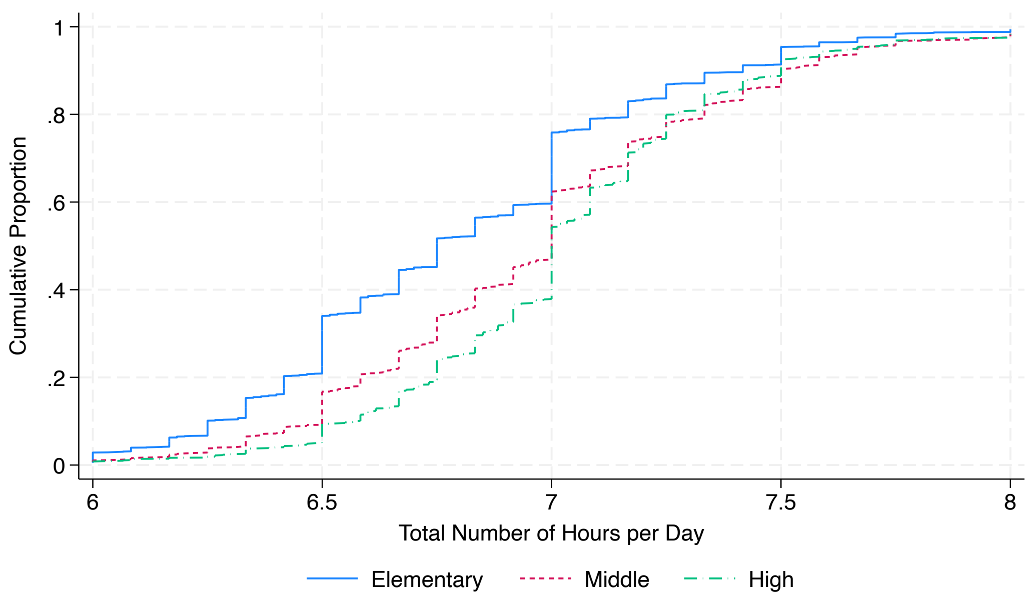
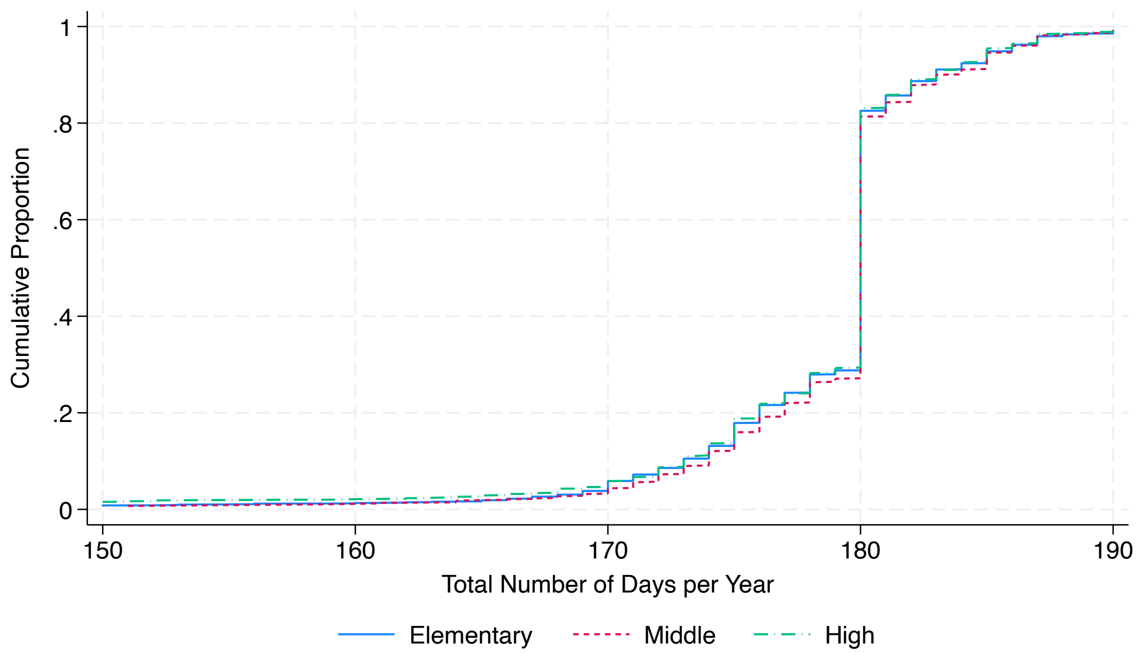


Figure 4. The cumulative distribution of learning time across U.S. Public Schools using data from the 2017-18 National Teacher and Principal Survey.

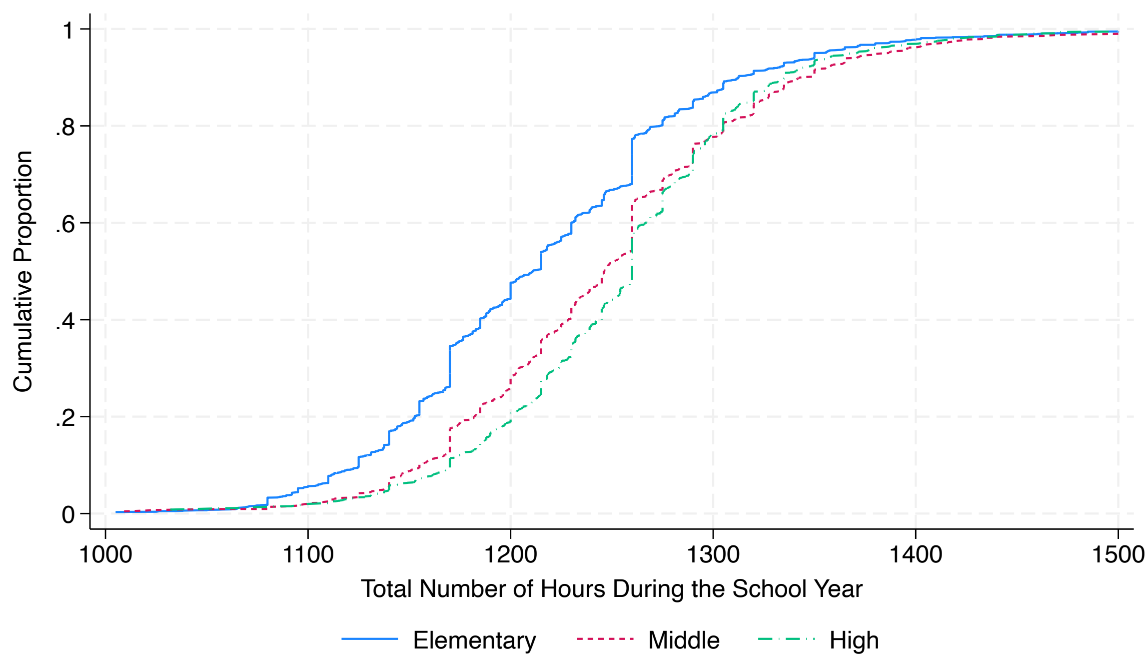
Panel A: Hours per Day



Panel B: Days per Year



Panel C: Total Hours per Year



Notes: Figures exclude schools below the 1st and above the 99th percentiles.

Figure 5. Scatterplot of the total hours in a school day and days in a school year for U.S. public schools using data from the 2017-18 National Teacher and Principal Survey

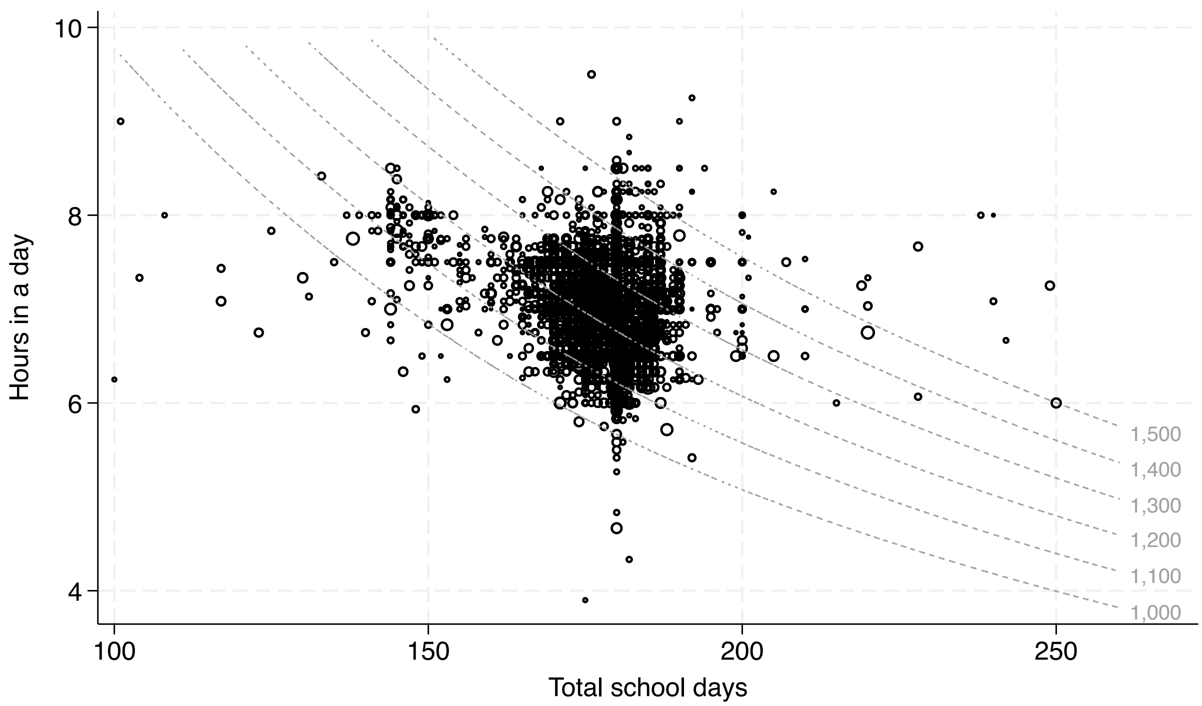
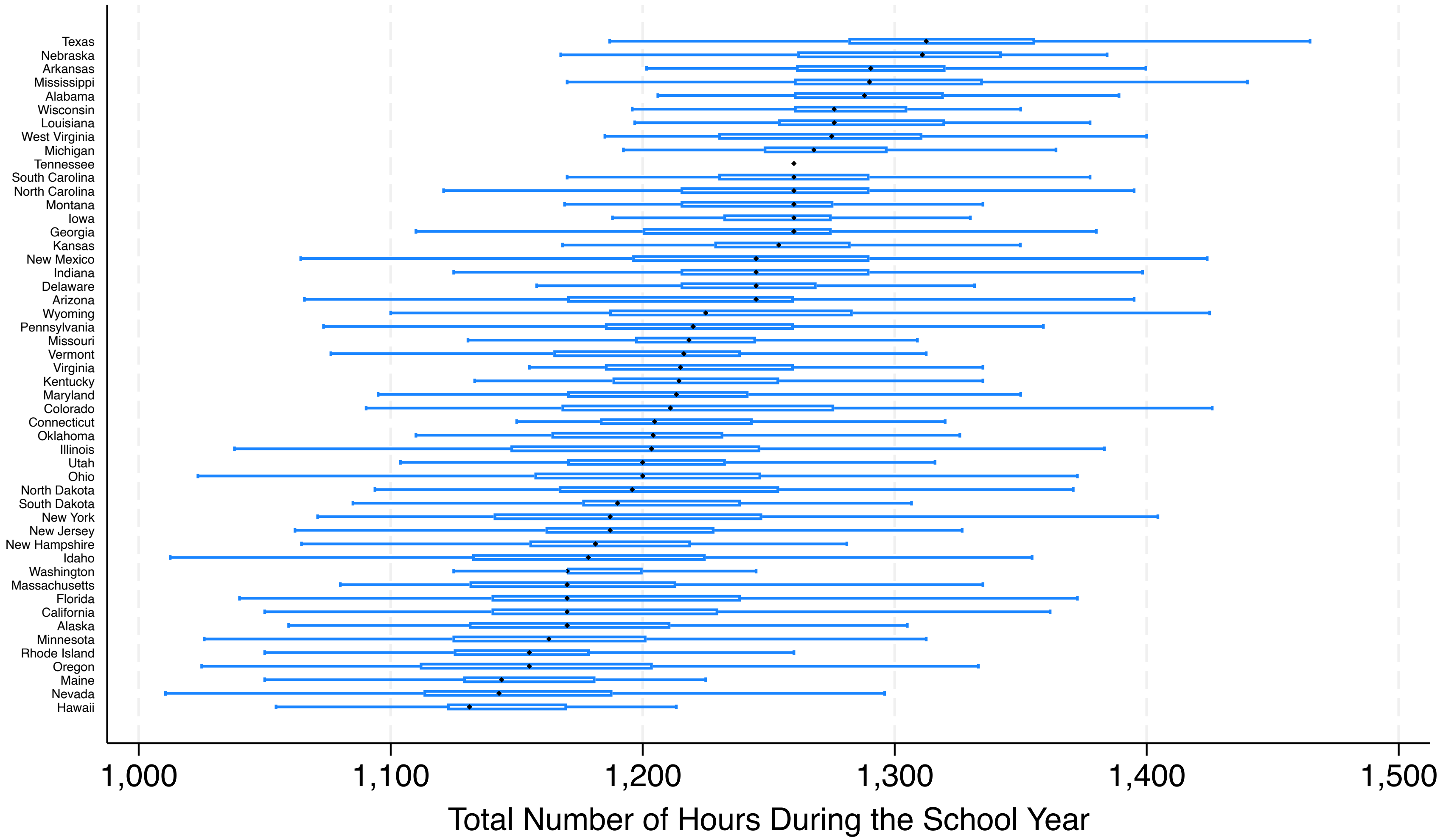


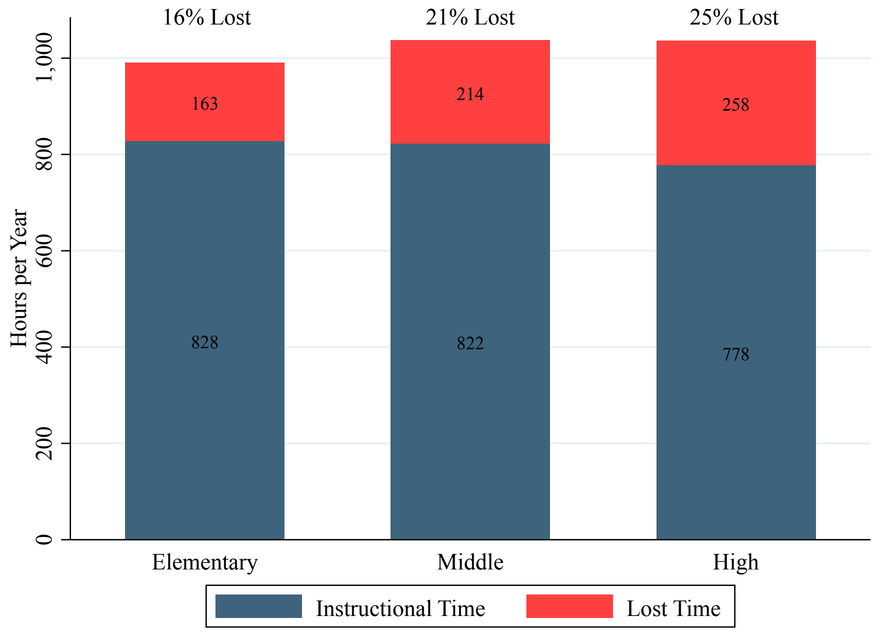
Figure 6. Box-plots depicting the variation in total hours in a school year for U.S. public schools across states using data from the 2017-18 National Teacher and Principal Survey.



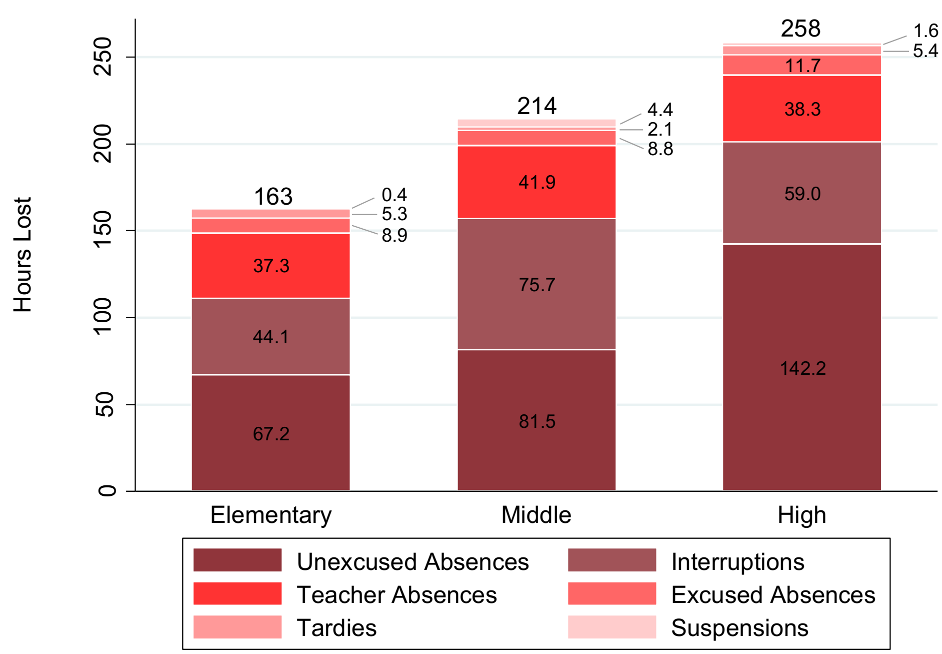
Notes: Boxes represent 25th to 75th percentiles with medians indicated with black diamonds. There is no variation among schools in Tennessee because the vast majority of sampled schools had exactly 1260 hours.

Figure 7. Instructional time loss by school level in Providence Public Schools in 2016-17.

Panel A: Lost instructional time



Panel B: Components of lost instructional time



Online Appendix A: Causal Studies of Time in School

A. Increased Learning Time as a Package of Inputs

Author(s), Date	Was time added or subtracted?	How much time was added or subtracted? (Minutes and Percent of Baseline)	Elementary, Middle, or High	Location (Country if not in U.S.; state if within U.S.)	Research Design	Effect Size (in Standard Deviation Units unless otherwise specified) * p<0.05, ** p<0.01	Outcome(s)
Abdulkadiroglu et al. (2011) ♦	Added	Pilot Schools: 90 hours, 8% increase Charter Middle Schools: 390 hours, 35.14% increase Charter High Schools: 290 hours, 26% increase	Elementary, Middle, High	MA	IV	0.033 0.062* -0.223* -0.041 0.021 -0.058 0.359** 0.198** 0.364** 0.265**	Math, per-year, pilot elementary ELA, per-year, pilot elementary Math, per-year, pilot middle ELA, per-year, pilot middle Math, per-year, pilot high ELA, per-year, pilot high Math, per-year, charter middle ELA, per-year, charter middle Math, per-year, charter high ELA, per-year, charter high
Angrist et al. (2012) ♦	Added	700 hours per year 58.3% increase	Elementary, Middle	MA	IV	0.375** 0.155**	Math, per-year ELA, per-year
Angrist et al. (2013) ♦	Added	Unclear[10]	Middle, High	MA	IV	0.213** 0.075**	Math, per-year, middle ELA, per-year, middle

♦ Included in Figure 2 visualization. Figure 2 includes all studies that report the effect of an addition of time or a change in time structure on a standardized achievement measure in grades K-12. When a study includes estimates for multiple years, we include only the first year.

‡ Baseline not indicated in the paper.

						0.273** 0.206**	Math, per-year, high ELA, per-year, high
Dobbie & Fryer (2011) ♦	Added	50% more school‡[11]	Elementary, Middle	NY	IV	0.160 0.095 0.284** 0.059	Math, per-year, elementary ELA, per-year, elementary Math, per-year, middle ELA, per-year, middle
Fryer (2014) ♦	Added	265 hours, 21% increase	Elementary, Middle, High	TX	RCT (elementary), IV (middle and high)	0.135* 0.041 0.102** -0.008	Math, elementary Reading, elementary Math, middle and high Reading, middle and high
Hoxby & Murarka (2009) ♦	Added	Unclear[12]	Elementary, Middle	NY	IV	0.094** 0.041**	Math Reading
Schueler et al. (2017) ♦	Added	200-300 hours‡	Elementary, Middle, High	MA	DiD	0.184** 0.297** 0.030 0.097**	Math, 1 year after Math, 2 years after ELA, 1 year after ELA, 2 years after

B. Extending the School Year

Author(s), Date	Was time added or subtracted?	How much time was added or subtracted? (Minutes and Percent of Baseline)	Elementary, Middle, or High	Location	Research Design	Effect Size (in Standard Deviation Units unless otherwise specified) * $p<0.05$, ** $p<0.01$	Outcome(s)

[10] Paper does not specify the typical number of hours per day or days per year in a traditional public school in Massachusetts for comparison but does state that charter schools in its sample are in school for 1445 hours per year.

[11] Students who are behind grade level are reported to have been in school even more than the typical 50% increase, with authors estimating students behind grade level attend school "for twice as many hours as a traditional public school student in New York City."

[12] Charter schools in New York City are in session for 1,524 hours per year. There is no comparison figure reported for traditional New York City public schools.

Aguero and Beleche (2013)	Varied before test	Between 4-28 days variation.[13]	Elementary, Middle	Mexico	FE	Effect sizes are not possible to convert to SD units.	
Aucejo & Romano (2016) ♦	Varied before test	Between 5-20 days variation.	Elementary	NC	FE	0.0017** 0.0008	Math Reading
Fitzpatrick et al. (2011)	Added	250 days	Elementary	U.S.	FE	1.4** 1.4**	Math Reading
Goodman (2014)	Subtracted	1 day (<1% decrease)	Elementary, Middle, High	MA	IV	-0.005 -0.003	Math ELA
Hansen (2011) ♦	Added	1 day‡[14]	Elementary, Middle	CO, MD, MN	IV	0.019 0.003 0.016** 0.013** 0.013** 0.0042*	Math, 8th grade, CO Math, 3rd grade, MD Math, 5th grade, MD Math, 8th grade, MD Math, 3rd grade, MN Math, 5th grade, MN
Leuven et al. (2010) ♦	Added	1 month‡	Elementary	Netherlands	IV	0.060** 0.047	Language, 2 years after Math, 2 years after
Marcotte (2007)	Subtracted	1 SD (19.1 in) increase in snowfall per year[15]	Elementary, Middle	MD	IV	Unit: percentage point change in percent scoring satisfactory -0.063** -0.049** -0.049*	 Math, 3rd grade Math, 5th grade Math, 8th grade Reading, 3rd grade

[13] The amount of time before a test was administered depended on the province and the timing of a major festival as well as heat-related school cancellation.
[14] The author leverages the timing before a test and also the effect of cancelled school. To make the effects on achievement comparable, the author estimates the effect of an additional day of schooling regardless of how many days were actually cancelled or adjusted.
[15] This paper cannot estimate the number of days each district closed during the year due to the snowfall but demonstrates that snowfall varies across the state and from year to year, leading to exogenous variation.

						-0.041** -0.010 -0.005	Reading, 5th grade Reading, 8th grade
Marcotte & Hemelt (2008)	Subtracted	1 day‡	Elementary, Middle	MD	IV	Unit: percentage point change in percent scoring satisfactory -0.527** -0.508** -0.403** -0.136 -0.271** -0.286**	Math, 3rd grade Reading, 3rd grade Math, 5th grade Reading, 5th grade Math, 8th grade Reading 8th grade
Parinduri (2014)	Added	6 months‡	Elementary	Indonesia	RD	Unit: years 0.67-0.87** Unit: percent change 21-29%**	Educational Attainment Likelihood of Graduating HS
Pischke (2007)	Subtracted	13 weeks for 2 years (35.14% decrease)	Elementary	W. Germany	DiD	Unit: percent change 23-29%**	Likelihood of Elementary Grade Repetition
Sanz & Tena (2021)	Subtracted	2 weeks‡	High	Spain	DiD	-0.146**	Average across all subjects, 10th grade
Schueler (2020) ♦	Added	25 hours (over one week) ‡	Middle	MA	RCT	0.017	Math
Sims (2008) ♦	Added	1 week‡	Elementary	WI	FE	0.034* 0.006 0.012	Math Language Reading

C. Extending the School Day

Author(s), Date	Was time added or subtracted?	How much time was added or subtracted?	Elementary, Middle, or High	Location	Research Design	Effect Size (in Standard Deviation Units unless	Outcome(s)

		(Minutes and Percent of Baseline)				otherwise specified) * p<0.05, ** p<0.01	
Aguero et al. (2021) ♦	Added	1.5 hours per day (28.57% increase)	Middle	Peru	RD	0.24** 0.14**	Math Reading
Amsden et al. (2005)	Added	3.5 hours per day (140% increase)	Elementary	DE	RCT	Unit: Percentage point difference 22pp[16]	DIBELS-measured likelihood of being a reader by the end of second grade
Barrios Fernández and Bovini (2017) ♦	Added	45-120 minutes (average 27% increase)	Elementary	Chile	DiD	0.003 0.020**	Math Reading
Battistin & Meroni (2016) ♦	Added	2 hours per day (22.72-45.45% increase in math time; 19.48-32.47%, increase in language time)	Middle	Italy	DiD	0.302** 0.054 0.046 -0.115 0.042 0.004	Math, bottom tercile schools[17] Math, middle tercile schools Math, top tercile schools Language, bottom tercile Language, middle tercile Language, top tercile
Bellei (2009) ♦	Added	1.45 hours per day (27% increase)	High	Chile	DiD	0.07** 0.05**	Math Language
Berthelon et al. (2016) ♦	Added	45-120 minutes (27% increase)	Elementary	Chile	IV	0.14*	Reading Comprehension
Cabrera-Hernandez (2020) ♦	Added	3.5 hours per day (78% increase)	Elementary	Mexico	DiD	0.006 0.007 0.025 0.035 0.103*	Math, 1 year after Language, 1 year after Math, 2 years after Language, 2 years after Math, 3 years after

[16] This paper does not indicate the statistical significance of the outcome measure.
[17] In this paper, the authors do not report results for all schools but instead report results by terciles of school performance the pre-intervention year.

						0.102* 0.107 0.113*	Language, 3 years after Math, 4 years after Language, 4 years after
Cannon et al. (2006) ♦	Added	Half-Day to Full-Day‡	Elementary	U.S.	IV	0.119** 0.145**	Math Reading
Cannon et al. (2011) ♦	Added	Half-Day to Full-Day‡[18]	Elementary	CA, English Learners only	DiD	0.125** 0.001 -0.011 -0.008	Reading, kindergarten Reading, 1st grade ELA, 2nd grade Math, 2nd grade
Cattaneo et al. (2017) ♦	Added	1 hour per week‡	High	Switzerland	FE	0.046-0.059**	Average of Math, Reading, Science Scores
Checkoway et al. (2013) ♦	Added	At least 300 more hours per year‡	Elementary, Middle	MA	CITS	-0.02 -0.05 -0.05 -0.07 0.01 0.04 0.04 0.00 -0.06 -0.05 -0.05 -0.11 -0.11 -0.05 0.08 -0.05 -0.05 0.03 -0.10 -0.09	Math, 4th Grade, 1 year after Math, 6th Grade, 1 year after Math, 8th Grade, 1 year after ELA, 3rd Grade, 1 year after ELA, 4th Grade, 1 year after ELA, 7th Grade, 1 year after Science, 5th Grade, 1 year after Science, 8th Grade, 1 year after Math, 4th Grade, 2 years after Math, 6th Grade, 2 years after Math, 8th Grade, 2 years after ELA, 3rd Grade, 2 years after ELA, 4th Grade, 2 years after ELA, 7th Grade, 2 years after Science, 5th Grade, 2 yrs after Science, 8th Grade, 2 yrs after Math, 4th Grade, 3 years after Math, 6th Grade, 3 years after Math, 8th Grade, 3 years after ELA, 3rd Grade, 3 years after

[18] Full-day kindergarten in Los Angeles Unified School District, where the study takes place, is 320 instructional minutes per day with 180 days in the year. No definition of half-day is provided for comparison.

						-0.04 0.01 0.09 0.03 0.04 0.13 -0.03 0.03 -0.09 0.03 0.28** 0.10	ELA, 4th Grade, 3 years after ELA, 7th Grade, 3 years after Science, 5th Grade, 3 yrs after Science, 8th Grade, 3 yrs after Math, 4th Grade, 4 years after Math, 6th Grade, 4 years after Math, 8th Grade, 4 years after ELA, 3rd Grade, 4 years after ELA, 4th Grade, 4 years after ELA, 7th Grade, 4 years after Science, 5th Grade, 4 yrs after Science, 8th Grade, 4 yrs after
Cortes & Goodman (2014) ♦	Added	45 minutes of math per day (100% increase)	High	IL	DiD	0.081** Unit: % change 3.95%	Math, 9th Grade High school graduation rate
Cortes et al. (2015) ♦	Added	45 minutes of math per day (100% increase)	High	IL	RD	0.086 0.235 0.180** Unit: % change 19.22% 38.57%*	Math, 10th grade Math, 11th grade ACT Math, 11th grade HS graduation within 4 years College enrollment
Dahmann (2017) ♦	Added	3.7 hours per week on average (12.5% increase)	High	Germany	DiD	0.068 0.138 0.089	Verbal Numerical Figural
Dominguez & Ruffini (2021)	Added	45-120 minutes (Average 30% increase)	Elementary, Middle, and High	Chile	DiD	Unit: % change 2.6%** 1.5%** 7.7%**	 High school graduation rate College enrollment rate College graduation rate
Figlio, Holen, & Ozek (2018) ♦	Added	1 hour per day (Average 15% increase)	Elementary	FL	RD	0.056**	Reading

Friesen et al. (2022) ♦	Added	Half-Day to Full-Day‡	Elementary	Canada	DiD	0.027 0.029	Numeracy Reading
Gibbs (2014a) ♦	Added	Half-Day to Full-Day‡	Elementary	IN	DDD	0.100 0.001 0.056	Reading, 1st Grade Reading, 3rd Grade Math, 3rd Grade
Gibbs (2014b) ♦	Added	Half-Day to Full-Day‡	Elementary	IN	IV	0.249**	Literacy
Gottfried et al. (2019) ♦	Added	Half-Day to Full-Day‡	Elementary	U.S., Students with disabilities only	FE	0.18** 0.20** -0.04 0.00 -0.03 -0.05	Math, 1 year after Reading, 1 year after Math, 2 years after Reading, 2 years after Math, 3 years after Reading, 3 years after
Hincapie (2016) ♦	Added/ Subtracted[19]	Half-Day to Full-Day‡	Elementary, High	Colombia	FE	0.082* 0.044 0.138* 0.110*	Math, 5th grade Language, 5th grade Math, 9th grade Language, 9th grade
Huebener et al. (2017) ♦	Added	2 hours per week (6.5% increase)	High	Germany	DiD	0.053* 0.058** 0.057	Math Reading Science
Jensen (2013) ♦	Added	"One extra classroom hour per year"[20]	High	Denmark	DiD	0.0021** 0.0011	Math, 9th grade Writing, 9th grade
Kraft (2015) ♦	Added	8 hours per week‡	High	MA	DiD	0.032 0.251**	Math ELA
Lavy (2015) ♦	Added	1 hour per week‡	High	PISA countries	FE	0.058**	Composite of math, science, and language test scores

[19] In the 1990s and 2000s, in Colombia, as demand for schooling fluctuated, schools facing high demand due to population growth often shifted to operate on two 4- or 5-hour shifts rather than a 7-hour day and then switched back later. This paper exploits both these additions and subtractions of time.

[20] In 2003, the Danish Ministry of Education fixed the number of classroom hours per year in a subject-group-cohort specific manner and increased the classroom hour minima by 4%. Effect sizes for the paper are calculated based on the addition of one classroom hour per year.

Lavy (2019) ♦	Added	1 instructional hour per week (22% increase)	Elementary	Israel	FE & IV	0.039**	Composite of math, science, English, and Hebrew.
Lee et al. (2006) ♦	Added	15.7 hours per week (100% increase)	Elementary	U.S.	FE	0.75** in school-level SD units 0.93** in school-level SD units	Math Literacy
Meroni & Abbiati (2016) ♦	Added	30-60 hours per year‡	Middle	Italy	DiD	0.12* null[21]	Math Language
Meyer & Van Klaveren (2013) ♦	Added	55 hours per year‡	Elementary	Netherlands	RCT	0.094	Math
Orkin (2013)	Added	1.5-2.5 hours per day (37.5-62.5% increase)	Elementary	Ethiopia	DiD	Unit: odds ratio of proficiency 2.17* 1.12 3.51*	 Numeracy Reading Writing
Padilla-Romo (2022) ♦	Added	3.5 hours per day (78% increase in time per day)	Elementary	Mexico	DiD	0.024** 0.015** 0.070** 0.046** 0.108** 0.068** 0.143** 0.090** 0.137** 0.108**	Math, 1 year later Language, 1 year later Math, 2 years later Language, 2 years later Math, 3 years later Language, 3 years later Math, 4 years later Language, 4 years later Math, 5 years later Language, 5 years later
Rivkin & Schiman (2015) ♦	Added	1 hour per week‡	High	PISA countries	FE	0.023**	Average of math and reading score
Rosa et al. (2022) ♦	Added	3.5 hours per day (78% increase)	High	Brazil	FE & IV	0.20-225** 0.13-193**	Math Language

[21] Authors report a one percentage point increase in correct answers but do not convert this to SD units, though they do report the effect is a null. As authors do not provide the mean or SD of correct answers, we cannot calculate the SD effect by hand.

Taylor (2014) ♦	Added	Additional math class[22]	Middle	Florida	RD	0.16-0.18** -0.03-0.00 0.10-0.14** 0.06-0.07	Math, 1 year later Reading, 1 year later Math, 2 years later Math, 3 years later
Warburton et al. (2012) ♦	Added	Half-Day to Full-Day‡	Elementary	Canada	IV	0.156*	Composite of Reading, Numeracy, and Writing
Wu (2020) ♦	Added	1 hour per day‡	Middle	TIMSS countries	FE	0.026**	Math and Science
Zvoch et al. (2008)	Added	Half-Day to Full-Day‡	Elementary	Unidentified school district in U.S.	FE	Unit: mean rate of skill acquisition 0.43**	Literacy

D. Structure of School Time

a. Four-Day School Weeks

Author(s), Date	Was time added or subtracted?	How much time was added or subtracted? (Minutes and Percent of Baseline)	Elementary, Middle, or High	Location	Research Design	Effect Size (in Standard Deviation Units unless otherwise specified) * p<0.05, ** p<0.01	Outcome(s)
Anderson & Walker (2015)	No time changes.	N/A	Elementary	CO	DiD	Unit: percentage point change 7.41** 3.80	% proficient or above in Math % proficient or above in Reading
Kilburn et al. (2021) ♦	Subtracted	58 hours per year (4.78% decrease)	Elementary, Middle, High	CO, ID, MO, NM, OK, SD	Matched DiD	-0.044 -0.028	Math ELA
Morton (2020) ♦	No time changes.	N/A	Elementary, Middle	OK	DiD	-0.052 -0.032	Math ELA

[22] Middle school students were quasi-randomly assigned to either take two math classes or take one math class and an elective. In this way, the total time in school did not change but instructional hours in math increased by 100%.

Morton (2022)	No time changes.	N/A	High	OK	DiD	Unit: ACT Scores 0.18 0.03	 Math Reading
Morton et al. (2023) ♦	Neutral or subtracted.[23]	Not specified.	Elementary, Middle	CO, IA, KS, MT, ND, WY	DiD	-0.06* -0.06*	Math, school year gains Reading, school year gains
Thompson (2019) ♦	Subtracted	3.6 hours per week (10.68% decrease)	Elementary, Middle	OR	DiD	-0.044* -0.033**	Math Reading
Thompson (2021) ♦	Subtracted	3-4 hours per week‡[24]	Elementary, Middle	OR	DiD	-0.059* -0.042*	Math Reading
Thompson, Tomayko, et al. (2021) ♦	Neutral or subtracted.[25]	Not specified.	High	OR	FE	-0.09** -0.034	Math Reading
Thompson & Ward (2022) ♦	Subtracted	Not specified.	Elementary, Middle	AZ, GA, ID, KS, MN, MO, MT, NM, NV, OK, OR, SD	DiD	-0.032* -0.029**	Math ELA

b. School Start Times

Author(s), Date	Was time added or subtracted?	How much was start time changed? From what baseline?	Elementary, Middle, or High	Location	Research Design	Effect Size in Standard Deviation Units * p<0.05, ** p<0.01	Outcome(s)

[23] Some of the four-day school weeks preserved the same total instructional time as five-day schools while others cut total time.
[24] The author reports that the amount of time lost depends on whether a school is making a permanent shift to a four-day school week, in which they typically lose 3.03 hours per week, or a transitory switch, in which case they lose 4.24 hours per week.
[25] This paper compares students who switch to a four-day school week upon high school entry in ninth grade to those students who remained on a five-day school week for their high school career. Some of the four-day school weeks preserved the same total instructional time as five-day schools while others cut total time.

Bastian & Fuller (2018) ♦	No time changes.	At least 1 hour later (from 7:30 a.m.)[26]	High	NC	FE	-0.079* 0.047 0.030 Unit: ACT points -0.183	Math Science English ACT composite score
Bastian & Fuller (2023) ♦	No time changes.	At least 30 minutes later (from before 8 a.m.)[27]	Middle	NC	FE	0.039** 0.026**	Math Reading
Edwards (2012)	No time changes.	1 hour later‡	Middle	NC	FE, DiD	Unit: percentile points 1.778 ** 0.979*	 Math Reading
Heissel & Norris (2019) ♦	No time changes.	1 hour later‡	Elementary, Middle, High	FL	IV	0.073** 0.048*	Math Reading
Hinrichs (2011)	No time changes.	1 hour later‡	High	MN	FE	-0.005	ACT composite score
James et al. (2023)	No time changes.	50 min later (from 7:30 a.m.)	High	MN	DiD	Unit: GPA points 0.17** 0.14**	 Weighted GPA, 1 year after Weighted GPA, 2 years after
Kim (2022) ♦	No time changes.	1 hour on average later[28]	Middle, High	South Korea	DiD	0.104** 0.035 -0.004	Math Korean English
Lenard et al. (2020)	No time changes.	40 mins earlier (from 8:05 a.m.)	High	NC	DiD	Unit: ACT points -0.167	 ACT composite score

[26] This paper places schools in four start time windows: before 7:30 a.m., 7:30-8:00 a.m., 8:00-8:30 a.m., and 8:30-9:00 a.m. The authors used the before 7:30 a.m. category as the reference group, and we report their effect sizes for the 8:30-9:00 a.m. group.
[27] This paper compares schools with start times before 8 a.m. to those with start times at or after 8:30 a.m.
[28] In the treated province (Gyeonggi), most schools shifted their start times to 9 a.m. from a range of previous start times. "In July 2014, just before the policy implementation, 54.8% of high schools in Gyeonggi had a start time between 7:40 and 8:00. 8.2% had a start time before 7:40 and 37.0% had it between 8:00 and 9:00. There was no high school with a 9:00 attendance time in July 2014 in Gyeonggi."

Online Appendix B

Appendix Table B1. Allocated Total Time in U.S. Public Schools Across Schooling Levels in 2017-18

	Hours Per Day			Days Per Year			Total Hours per Year		
	Average	Median	Median Rank	Average	Median	Median Rank	Average	Median	Median Rank
Texas	7.46	7.50	1	177.52	177.00	36	1324	1313	1
Nebraska	7.32	7.40	2	177.69	178.00	34	1300	1311	2
Arkansas	7.23	7.25	3	179.13	178.00	34	1296	1291	3
Mississippi	7.20	7.13	8	180.46	180.00	2	1299	1290	4
Alabama	7.14	7.17	6	180.39	180.00	2	1288	1288	5
Louisiana	7.23	7.20	5	176.15	180.00	2	1273	1276	6
Wisconsin	7.18	7.17	6	178.62	180.00	2	1282	1276	6
West Virginia	7.09	7.00	11	180.47	180.00	2	1279	1275	8
Michigan	7.05	7.00	11	180.04	180.00	2	1270	1268	9
District of Columbia	7.01	6.75	31	181.95	180.00	2	1275	1260	10
Georgia	6.97	7.00	11	179.56	180.00	2	1251	1260	10
Iowa	6.99	7.00	11	179.72	180.00	2	1256	1260	10
Montana	7.06	7.00	11	176.96	180.00	2	1248	1260	10
North Carolina	6.96	7.00	11	180.24	180.00	2	1255	1260	10
South Carolina	7.10	7.00	11	180.11	180.00	2	1278	1260	10
Tennessee	7.07	7.00	11	179.70	180.00	2	1271	1260	10
Kansas	7.28	7.25	3	173.04	174.00	45	1259	1254	17
Arizona	6.96	7.00	11	176.49	180.00	2	1226	1245	18
Delaware	6.95	7.00	11	179.24	180.00	2	1246	1245	18
Indiana	6.89	6.92	25	180.33	180.00	2	1243	1245	18
New Mexico	7.07	7.00	11	176.28	180.00	2	1243	1245	18
Wyoming	7.23	7.08	9	171.16	175.00	39	1235	1225	22
Pennsylvania	6.80	6.75	31	180.62	180.00	2	1228	1220	23
Missouri	7.04	7.00	11	172.90	174.00	46	1218	1218	24
Vermont	6.83	6.83	28	177.05	176.00	37	1209	1216	25
Virginia	6.77	6.75	31	180.57	180.00	2	1223	1215	26
Kentucky	6.98	6.92	25	175.40	175.00	39	1224	1214	27
Maryland	6.73	6.67	36	180.66	180.00	2	1216	1213	28
Colorado	7.18	7.08	9	171.57	174.00	46	1229	1211	29
Connecticut	6.69	6.63	40	181.63	182.00	1	1215	1205	30
Illinois	6.77	6.80	30	177.21	176.00	37	1201	1204	31
Oklahoma	7.15	7.00	11	169.21	173.00	48	1207	1204	31
Ohio	6.74	6.73	35	178.66	180.00	2	1204	1200	33
Utah	6.68	6.67	36	179.74	180.00	2	1201	1200	33
North Dakota	6.88	6.83	28	176.59	175.00	39	1215	1196	35
South Dakota	7.04	7.00	11	170.80	172.00	51	1202	1190	36
New Jersey	6.62	6.58	41	180.89	180.00	2	1197	1187	37

New York	6.67	6.50	43	181.36	180.00	2	1210	1187	37
New Hampshire	6.64	6.67	36	179.29	180.00	2	1190	1181	39
Idaho	6.97	6.92	25	170.49	175.00	39	1184	1178	40
Alaska	6.73	6.58	41	176.60	175.00	39	1188	1170	41
California	6.59	6.50	43	181.02	180.00	2	1193	1170	41
Florida	6.58	6.50	43	181.13	180.00	2	1192	1170	41
Massachusetts	6.56	6.50	43	180.52	180.00	2	1184	1170	41
Washington	6.56	6.50	43	180.32	180.00	2	1183	1170	41
Minnesota	6.72	6.67	36	174.13	173.00	49	1171	1163	46
Oregon	6.76	6.75	31	172.47	173.00	49	1164	1155	47
Rhode Island	6.44	6.42	49	180.27	180.00	2	1161	1155	47
Maine	6.54	6.50	43	178.26	175.00	39	1166	1144	49
Nevada	6.54	6.35	50	177.44	180.00	2	1157	1143	50
Hawaii	6.34	6.25	51	180.33	180.00	2	1143	1131	51

Notes: The following types of schools are excluded from the sample: alternative schools, schools with special education emphasis, special education schools, and career/technical/vocational schools. Source: National Teacher and Principal Survey 2017-18.

Online Appendix C: Time Loss

Working with PPSD, we collected data on a range of factors that reduced potential learning time during the 2016-17 school year. We use bell schedules to calculate the total number of instructional hours in each PPSD school. These estimates exclude non-instructional time such as lunch, recess, and passing periods. We then draw on detailed administrative records to estimate the amount of allocated instructional time (AT_s) in school *s* that is actually lost instructional time. Averaging within school levels, *l*, we first estimate the potential instructional time (PT_l) per school year for students at PPSD elementary, middle, and high schools as follows:

$$PT_l = \frac{1}{N_l}\sum_{s=1}^{N_l}[\underbrace{(AT_s - TAbs_s)}_{\text{Total time teacher is present}} * \underbrace{(1 - Inter_l/AT_s)}_{\text{Proportion of time that instruction is undisturbed by outside interruptions}} * \underbrace{(1 - [SAbs_s + Susp_s + Tardy_s]/AT_s)}_{\text{Proportion of time students are present in class}}]$$

The intuition behind this formula is a three-step process that aligns with our Conceptual Framework (Figure 1). First, we calculate the total amount of instructional time at a school in which regular full-time teachers are present, assuming little to no meaningful instruction occurs during absences ($TAbs_s$). We scale this measure of total instructional time with a regular full-time teacher by the proportion of time undisturbed by outside interruptions ($Inter_l$) based on estimates from a companion study which tracked interruptions during more than 60 hours of classroom observation in five PPSD schools (Kraft & Monti-Nussbaum, 2021). Finally, we scale the remaining instructional time by the proportion of time that the average student in a given school is not absent ($SAbs_s$), suspended ($Susp_s$), or tardy ($Tardy_s$). This provides an estimate of the total potential time that both teachers and students are present and instruction goes uninterrupted by external disruptions.

In this section, we outline how each component of the lost instructional time (LT_l) equation below is calculated. All calculations draw on data from the 2016-17 academic year. As shown below, each component of time lost is calculated for each school, s. Next, we average these values across all schools of the same level, *l*: elementary, middle, and high school. The resulting LT_l describes the instructional time lost per student across the academic year at the average elementary, middle, or high school in PPSD.

Allocated Instructional Time (AT_s): To estimate the total instructional time in a school, we use data from bell schedules to calculate the average amount of instructional hours during the school year for each PPSD elementary, middle, and high school. These estimates exclude non-instructional time such as lunch, recess, and passing periods.

Lunch: For each school, we divide the duration of lunch in minutes by 60 and then multiply it by 180 to calculate the total number of hours per school year spent on lunch.

Recess: For each elementary school, we divide the duration of recess in minutes by 60 and then multiply it by 180 to calculate the total number of hours per school year spent on recess. According to bell schedules, middle and high schools do not have recess.

Passing Periods: For each middle and high school, we divide the duration of a passing period in minutes by 60 and multiply it by one less than the number of periods per day. We then multiply this total by 180 to calculate the total number of hours per school year spent in passing periods. As a conservative approach, we assume that elementary schools do not have passing periods.

Teacher Absences ($TAbs_s$): We estimate the number of instructional hours lost per student due to teacher absences in a school as follows:

$$TAbs_s = \underbrace{TotalTchAbsDays_s * (DailyInstHours_s - 1)}_{\text{Total teacher absences for a school in hours}} * \underbrace{(Stu/Tch\ Ratio_s)/TotalStus_s}_{\text{Number of students experiencing teacher absence}}$$

We first estimate the total number of teacher absences for the entire school year, including partial days, across all full-time teachers in PPSD based on detailed human resource records provided by the district. We then convert this total number of days into instructional hours by multiplying this total by the number of daily instructional hours in a school, assuming teachers have an hour-long preparation period each day. Next, we multiply the total number of teacher absence hours per year by the student-to-classroom teacher ratio in a school to scale the total number of teacher absence hours into total number of teacher absence hours experienced by students. Finally, we divide the total number of teacher absence hours students experience by the number of students in a school to estimate the average number of instructional hours that students lose over the course of a year due to teacher absences in a given school.

Interruptions ($Inter_l$): To estimate the number of lost hours due to interruptions from outside of class, we draw upon original data collected by Kraft and Monti-Nussbaum (2019). The authors organized a team of researchers to observe 63 classes across five high schools in PPSD and found a typical high school class in PPSD experiences an average of 2.8 interruptions per hour for an average combined interruption and disruption length of 71 seconds (0.0197 hours). We then use these estimates to predict the number of hours lost due to interruptions at each school level. We accomplish this by leveraging teacher survey data on the frequency of interruptions per hour reported on the district teacher survey. Teachers in the participating high schools reported 4.0 interruptions per hour on average, while the average across all high school teachers was 4.3 interruptions per hour. The average frequency of interruptions reported among middle school and elementary school teachers was 5.7 and 3.4, respectively. We use these comparable measures across school levels to scale our high school estimates by the ratio of the average reported level of interruptions to the average reported level in the five participating schools for which we have observational data. Finally, we first multiply lost interruption time per hour by the number of instructional hours in a day at each school and then by the number of days in the school year to estimate the annual hours lost to interruption at each level of schooling.

$$Inter_{HS} = 2.8 * 0.0197 * \left(\frac{4.3}{4.0}\right) * DailyInstHours_s * 180\ days$$
$$Inter_{Middle} = 2.8 * 0.0197 * \left(\frac{5.7}{4.0}\right) * DailyInstHours_s * 180\ days$$
$$Inter_{Elem} = 2.8 * 0.0197 * \left(\frac{3.4}{4.0}\right) * DailyInstHours_s * 180\ days$$

Student Absences ($SAbs_s$)*:* This gives the amount of time lost per student, per year due to excused and unexcused absences at a given school.

Unexcused Absences: We divide the total number of unexcused absences in a school for the entire year by the total number of students in that school to calculate the average number of unexcused absences per student. We assume that a student misses all the instructional time in a day when they are absent and multiply the average number of unexcused absences per student by the number of instructional hours in a day. This gives us the total amount of time lost per year per student due to unexcused absences.

Excused Absences: We calculate the total number of excused absences by totaling the number of full and partial day excused absences. Next, we perform the same calculation for all excused absences as for unexcused absences. This gives us the total amount of time lost per year per student due to excused absences.

Suspensions ($Susp_s$): We divide the total number of in-school suspensions in a school for the entire year by the total number of students in that school to calculate the average number of in-school suspensions per student. We assume that a student misses all the instructional time in a day when they are suspended and multiply the average number of in-school suspensions per student by the number of instructional hours in a day. This gives us the total amount of time lost per year per student due to in-school suspensions at a given school. We perform the same calculation for out-of-school suspensions as for in-school suspensions and add them together.

Tardies ($Tardy_s$): We divide the total number of tardies in a school for the entire year by the total number of students in that school to calculate the average number of tardies per student. In PPSD, students are marked as tardy as long as they show up before half of the school day is over. We assume that a student misses an hour of instructional time when they are tardy and multiply the average number of tardies per student by an hour. This gives us a conservative estimate of the amount of time lost per student, per year due to tardies at a given school.