sociological science

Teacher Sorting and Inequalities in Student Achievement: Unequal Exposures and Differential Returns to Teacher Qualifications

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Abstract: Teachers play a formative role in shaping children's school experiences and ultimately, their educational outcomes. In this study, I use full population Danish administrative data to explore the consequences of unequal access to qualified teachers in three steps. First, I document strong patterns of teacher–student sorting in Denmark, one of the world's most equal societies and generous welfare states. In short, teachers from higher socioeconomic backgrounds and with higher prior academic achievements tend to select into schools serving high-achieving children from privileged backgrounds. Second, I investigate the effect of exposure to teachers with different qualifications on students' test score performance. To facilitate causal estimates, I exploit plausibly exogenous shocks to teacher changes induced by parental leave spells, which, I show, are unrelated to an extensive set of observed classroom characteristics, including student well-being and measures of classroom climate. Third, I explore differentials in the impact of teacher qualifications by students' socioeconomic background. I find no consistent evidence of differential teacher effects, implying that teacher-induced learning inequalities are mainly driven by unequal exposure to highly qualified teachers, rather than unequal returns to qualifications. This suggests that policies equalizing access to qualified teachers may reduce learning disparities.

Keywords: education; inequality; teachers; stratification; schools; achievement

Reproducibility Package: Information on accessing the administrative register data and all code used in the analysis is available at: https://github.com/s-aj-hassan/Teacher-Sorting-Achievement.

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A central concern in sociology is how schools contribute to the persistence—or reduction—of social inequality. Extensive research has debated whether schools primarily reproduce social advantage or provide opportunities for mobility (Bourdieu and Passeron 1977; Bowles and Gintis 1976; Downey, Workman, and von Hippel 2019; Raudenbush and Eschmann 2015; Passaretta and Skopek 2021). Yet, much of this literature has treated schools as black boxes, paying limited attention to the specific mechanisms within them that generate unequal outcomes. One such mechanism concerns teachers. Despite their central role in instruction, assessment, and the allocation of learning opportunities, we know relatively little about how teachers contribute to inequalities in learning outcomes (for reviews, see Morgan and Shackelford 2018; Reimer 2019).

Previous studies have documented stark socioeconomic and racial inequalities in access to qualified and effective teachers (Hanselman 2018, 2019; Kalogrides and Loeb 2013). These inequalities in learning opportunities arise, in part, because teachers seek out schools with high-achieving and socially advantaged students

(Lankford, Loeb, and Wyckoff 2002) and, in part, because parents with more resources can afford to select into neighborhoods and school districts with higher quality schools (Eshaghnia, Heckman, and Razavi 2023). These patterns of teacher–student sorting create social inequalities in *exposure* to qualified teachers. Yet, the unequal distribution of teachers only matters for inequality in outcomes if teacher qualifications causally impact students' learning. Moreover, if qualified teachers do improve learning, the resulting impact on inequality depends on whether all students benefit equally. In other words, teachers may contribute to learning inequalities through two distinct mechanisms: *unequal exposure* to qualified teachers across schools (teacher–student sorting) and *unequal returns* to those qualifications among students from different social backgrounds.

In this study, I examine how teachers contribute to inequalities in student achievement by addressing two sources of teacher-induced inequality: unequal exposure to qualified teachers and unequal returns to those qualifications. Using full population administrative data from Denmark that link all teachers and students in public schools between 2013 and 2018, I address these questions in three analytical steps. First, I descriptively map how teachers with different qualifications are distributed across schools, documenting the extent and behavioral drivers of teacher–student sorting. Second, I estimate the impact of several measures of teacher qualifications—including certification (i.e., Teacher College completion), subject-specific specialization, and experience—on students' test score performance. To obtain causal estimates, I leverage quasi-experimental variation in teacher changes over time, induced by teachers' parental leave spells. Third, I examine whether the benefits of being taught by a qualified teacher differ by students' socioeconomic background.

I make the following five contributions to the literature on schools and educational inequalities. First, I address a crucial part of the "black box" of school inequality in quantitative sociological research (see Morgan and Shackelford 2018) by treating teachers as institutional actors whose qualifications are socially distributed resources, and potentially consequential drivers of student achievement. Second, I document patterns of teacher–student sorting based on socioeconomic background even in Denmark, one of the world's most equal societies and generous welfare states. Despite unionized teacher salaries, I show that teachers with higher qualifications systematically sort into schools serving advantaged student populations. However, this does not necessarily imply that teachers contribute to inequalities in children's learning outcomes. I argue that the uneven distribution of teacher qualifications is only consequential if they causally impact student achievement. Third, to establish this link, I facilitate causal estimates of the effect of exposure to teachers with different qualifications by leveraging plausibly exogenous changes in teacher assignment over time, induced by teachers' parental leave spells. I show that teachers' probability of taking parental leave is unrelated to an extensive set of school and classroom characteristics, including lagged measures of disruption, well-being, and test score performance, adding confidence in the identification strategy. Fourth, I show that teacher qualifications have substantial effects on students' test scores, equivalent to at least about 12 percent of the total contribution of schooling to learning gains. Because this estimate reflects a conservative lower bound, the true impact of qualified teachers may be even greater. I find no consistent evidence

that these effects vary by students' socioeconomic background. Taken together with the evidence of teacher–student sorting, this pattern implies that teachers contribute to educational inequality primarily through unequal exposure to qualified teachers rather than through unequal returns. This finding highlights that policies reducing teacher sorting could meaningfully narrow achievement gaps. Fifth, I focus on specific, observable indicators of teacher qualifications—certification, subject specialization, and experience—rather than teacher value added, which has been the dominant focus of prior research (see Chetty, Friedman, and Rockoff 2014; Koedel, Mihaly, and Rockoff 2015; for a discussion of value-added models and why they are rarely used in sociological research, see Morgan and Shackelford 2018; Reardon and Raudenbush 2009). Unlike value-added measures, this approach identifies which qualifications are causally consequential for students' learning and which are not, and therefore offers clear policy leverage: teacher qualifications are institutional features that can be shaped through teacher training, recruitment, and placement policies—a point I return to in the discussion.

1 Background

1.1 Teacher Sorting and Unequal Learning Environments

Previous studies have documented profound social and ethnic inequalities in the learning environments that children experience in school, including the qualifications of their teachers (Hanselman 2019). Most studies focus on the role of parents' residential sorting behavior in producing these inequalities, such as advantaged families' willingness to pay for access to school districts with higher quality schools (Lareau and Goyette 2014). For instance, a recent study from Denmark, where all schools receive equal per-pupil funding, estimates that parents are willing to pay 3 percent more in house prices in exchange for access to better schools, as measured by peer and teacher quality (Eshaghnia et al. 2023). Importantly, a growing literature discussed below emphasizes the role of teacher–student sorting in reinforcing these inequalities in learning opportunities, the topic of this study.

Like students, teachers are not randomly assigned to schools upon graduating from college but are sorted into them based on their preferences, skills, and expectations of the student body and work environment in the school. Several studies from the United States find that teachers with higher qualifications and more teaching experience tend to work at schools serving high-achieving children from advantaged families, thereby generating social and ethnic inequalities in learning opportunities both across and within schools (Clotfelter, Ladd, and Vigdor 2005; Kalogrides and Loeb 2013; Kalogrides, Loeb, and Béteille 2013). Moreover, these patterns of teacher–student sorting are reinforced as poorer schools and schools with a larger share of minority students are less able to attract and retain qualified and experienced teachers (Feng 2014; Hanushek, Kain, and Rivkin 2004). For instance, when teachers in New York State move schools, they, on average, move to a school with 50 percent fewer poor students (Lankford et al. 2002). In short, in addition to the sorting of students into schools based on socioeconomic background, teachers also play an active role in reinforcing uneven learning opportunities via their sorting behavior.

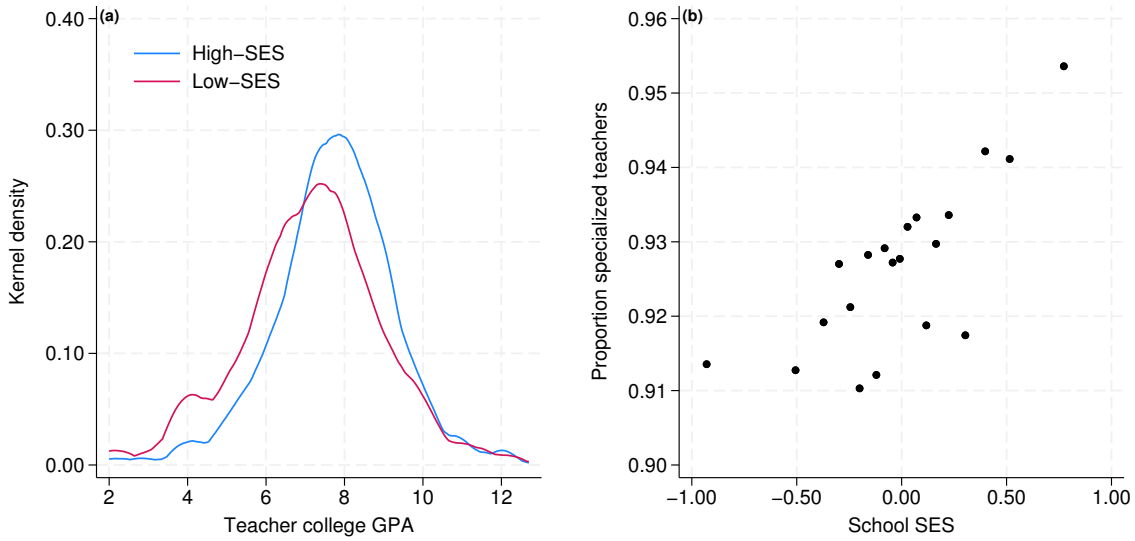

Figure 1: Distribution of teacher qualifications in Danish public schools by SES.
Notes: Panel (*a*) shows the distribution of teachers' academic performance—as measured by average GPA from Teacher College—in low (below median) and high (above median) SES schools. Panel (*b*) shows the proportion of teachers who teach subjects that they specialized in during Teacher College, by the school's average student body SES. For details on the SES index, see Appendix B in the online supplement.

Although most of the literature on teacher–student sorting is based on evidence from the United States, inequality in learning opportunities is not exclusively an American phenomenon. To preview findings, Figure 1 shows descriptive evidence on the relationship between teacher qualifications and the socioeconomic composition of schools in Denmark, the context of this study. Even in Denmark, which is usually touted as one of the most equal societies in the world, access to highly qualified teachers is strongly related to students' socioeconomic background. Figure 1a shows the distribution of teachers' academic performance, as measured by average GPA from Teacher College, across schools serving low- and high-SES students, as measured by their parental education, income, and employment. Schools serving advantaged students have a higher concentration of teachers who are academically skilled and performed well during their degree program, whereas schools serving disadvantaged students employ teachers with lower academic qualifications. Figure 1b shows the relationship between school SES and the proportion of teachers who specialized during Teacher College in the subjects they currently teach. Danish public schools generally have a very high proportion of specialized teachers in core subjects. Yet, the likelihood of being taught by a specialized teacher varies by the student body's socioeconomic composition. Compared to the most disadvantaged schools, students enrolled in high-SES schools are about 5 percentage points more likely to be taught by a specialized teacher.

These patterns of teacher–student sorting can hardly be explained by economic incentives, as teacher salaries are unionized in most countries, including Denmark and the United States. Instead, previous studies have pointed to teacher preferences for teaching motivated and high-achieving children (see Neild and Farley-Ripple 2008). Qualitative evidence suggests that teacher–student sorting is, to a large

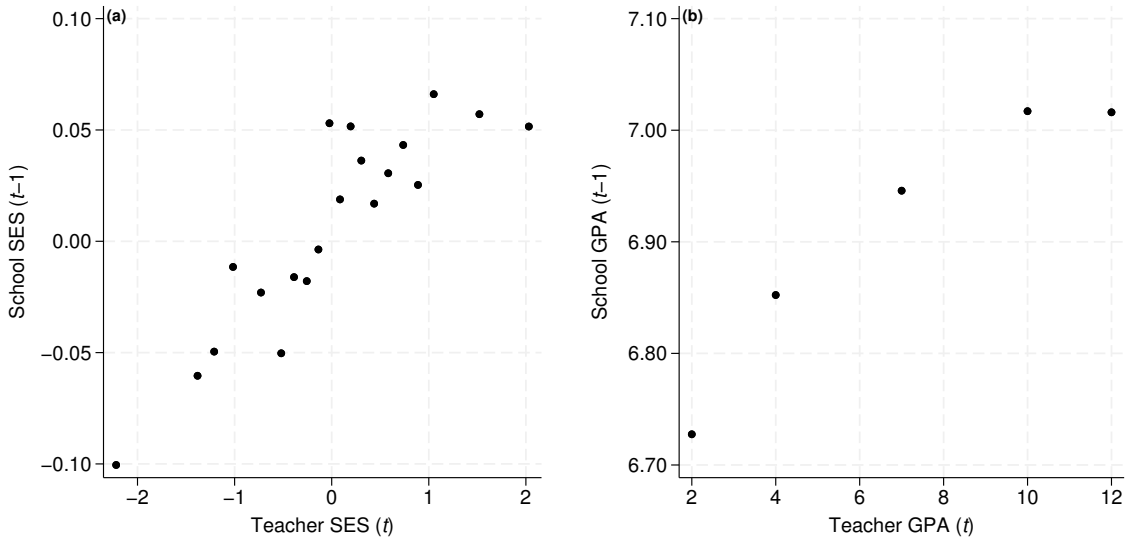

Figure 2: Evidence of teacher–student sorting in Denmark based on (*a*) socioeconomic status and (*b*) academic achievement.
Notes: This graph shows the relationship between teacher characteristics in the year they graduated from college (*t*) and the characteristics of their first school of employment measured in *t* - 1.

degree, driven by the teachers' expectations of the student body and their perceptions of work-related challenges associated with teaching in poorer neighborhoods. In his early work on schoolteachers in Chicago in the 1940s, Howard Becker describes the career of a teacher as one characterized mainly by "horizontal movements" (Becker 1952b). Teachers usually move between different schools but more or less remain at the same occupational level throughout their professional careers. Their main objective when moving between schools, Becker suggests, is to minimize work problems by finding students who are "easier" and more satisfying to teach. These problems include classroom disruption and learning difficulties, both of which are strongly related to the school's socioeconomic composition (Becker 1952a). For instance, upon graduating from Teacher College, one teacher in Becker's study describes his experience in the following way:

> When you first get assigned, you almost naturally get assigned to one of those poorer schools, because those naturally are among the first to have openings, because people are always transferring out of them to other schools. Then you go and request to be transferred to other schools nearer your home or in some nicer neighborhood (Becker 1952b:473).

To provide direct evidence of teacher sorting that takes place following graduation from Teacher College, Figure 2 relates teacher characteristics to average student characteristics aggregated at the school level for six full cohorts of teacher graduates from all Danish Teacher Colleges between 2013 and 2018. Student characteristics are taken from the teacher's first school of employment and are measured 1 year prior to the teacher's graduation, and the relationships therefore reflect teachers' pure sorting behavior, rather than student responses to teacher characteristics. Figure 2a

describes the relationship between teachers' socioeconomic status—measured using their parents' income rank, employment status, and educational attainment at teacher age 15—and the school's average student socioeconomic status. Teachers who grew up in affluent and highly educated families are likely to select into schools serving children from similar backgrounds. Figure 2b further shows that teachers who performed well in Teacher College are likely to select into schools with academically well-performing students. Overall, these teacher–student sorting patterns imply that students from less privileged backgrounds are less likely to be exposed to highly qualified teachers.

1.2 Teacher Impacts on Student Achievement

The descriptive evidence discussed above documents a substantial degree of teacher–student sorting, implying that teachers with higher qualifications and high-achieving students systematically sort into the same schools based on matched characteristics and preferences. Although this observation highlights crucial social disparities in access to learning opportunities, it also complicates the task of providing a satisfactory answer to a more fundamental question: how much do teacher qualifications matter when it comes to improving students' test scores? If teachers systematically sort into schools based on observed characteristics, it is likely that they also do so based on unobserved characteristics—such as motivation, teaching styles, and expectations and attitudes—which complicates the identification of teacher qualification effects on student outcomes. An extensive literature within economics relies on value-added models to estimate the effect of being exposed to effective teachers on student outcomes. Essentially, value-added models identify a teacher's contribution to her students' test score gains by relating her students' performance in a given year to their predicted test score growth based on test scores from previous years. If a teacher's students perform better than the prediction, the teacher is assigned a high value-added score, and vice versa (for a review of value-added models, see Koedel et al. 2015).

One attractive feature of value-added models is that they need not specify any explicit measure of teacher qualifications, such as credentials or years of experience. "Better teachers" are simply teachers who are effective at improving student test scores, regardless of their qualifications and characteristics. Predicted teacher value-added scores can then be used as an independent variable to estimate the effect of highly effective teachers on student outcomes. For instance, Chetty et al. (2014) exploit variation in teacher mobility across New York schools to estimate the effect of being assigned an average primary school teacher, compared with one from the bottom of the value-added distribution. They find that exposure to an average teacher increases an individual's lifetime income by as much as 10,000 USD. Within sociology, value-added models have also been used to estimate teacher effects on children's social and behavioral skills (Jennings and DiPrete 2010).

Nonetheless, sociologists have generally been skeptical about the value of using value-added models to estimate teacher effects (for a discussion, see Morgan and Shackelford 2018). Beyond well-known methodological concerns—non-random assignment of teachers to students (Rothstein 2009) and noise in teacher-specific estimates (Bitler et al. 2021)—the value-added framework also leaves the *mechanisms*

of teacher effects unspecified and offers limited insight into the attributes through which teachers influence learning. It treats teacher impacts as statistical residues rather than as outcomes of identifiable qualifications and institutional arrangements. Consequently, we know relatively little about which specific teacher characteristics and qualifications enhance student learning.

In this study, I therefore pursue an alternative strategy that centers on teacher qualifications—formal, observable indicators, such as certification, subject specialization, and experience—that are embedded in the institutional organization of schooling. These measures have been shown in descriptive studies to predict student performance (Kelly, Pogodzinski, and Zhang 2018; Clotfelter, Ladd, and Vigdor 2007; Hill, Rowan, and Ball 2005), yet their causal effects remain unclear. By focusing on teacher qualifications rather than value-added scores, I aim to identify which qualifications are causally consequential for student learning and to situate teacher impacts within a sociological framework that links institutional staffing practices to the reproduction of educational inequality. This approach also has direct policy relevance, as teacher qualifications are tangible and politically manipulable aspects of the teacher workforce—a point I return to in the discussion.

1.3 Differential Returns to Teacher Qualifications

The impact of qualified teachers may vary by students' socioeconomic background. This is implied by both cumulative disadvantage theory (DiPrete and Eirich 2006) and compensatory advantage perspectives (Bernardi 2014), although they predict different directions of the social gradient effects.

Cumulative disadvantage theory suggests that students from advantaged backgrounds may reap disproportionately greater benefits from exposure to higher-quality learning environments, such as more qualified teachers, thereby compounding preexisting disparities in learning opportunities. One possible explanation, drawn from the child development and early literacy literatures, is that advantaged students enter school with a larger stock of skills, which they are better able to build upon during primary and elementary education (Buckingham, Beaman, and Wheldall 2013). Similar hypotheses are suggested in the economic literature on human capital formation, which suggests that children from socioeconomically advantaged families are able to improve academically at a faster rate during school—compared to disadvantaged students—even conditional on being exposed to the same learning environment because of early human capital investments (Cunha and Heckman 2007).

Conversely, compensatory advantage perspectives highlight that exposure to better teachers may compensate for student disadvantages, such as insufficient resources or poor educational opportunities outside of school (Bernardi 2014). For instance, students from disadvantaged backgrounds may benefit more from high-quality teachers if they spend less time at home on educational activities or if their parents lack the necessary skills to assist with homework. This alternative perspective is consistent with the empirical literature on school effectiveness using seasonal comparisons of students' academic growth rates during the academic year versus summer vacations. These studies find that the social gap in cognitive abilities grows faster when children are outside of school than during the academic year,

suggesting that exposure to structured learning opportunities benefits children from disadvantaged backgrounds more than their advantaged peers (Downey et al. 2019).

These perspectives suggest that teacher qualifications may heterogeneously impact students from different socioeconomic backgrounds. Understanding whether such differentials exist is crucial both for sociological theories of how schools reproduce inequality and for policy making. If the effects of teacher qualifications are *uniform*, then inequality in student achievement arises primarily through unequal exposure to qualified teachers, implying that redistributing teacher resources could substantially reduce social disparities. By contrast, if the effects are *differential*, however, then teachers would shape inequality even under equal exposure, as the same teaching resources would generate unequal learning gains across social groups—whether reinforcing or mitigating existing disparities. Due to the conflicting predictions of cumulative disadvantage and compensatory advantage perspectives, I do not have any prior expectations on whether teacher qualification effects are stronger among students with lower versus higher socioeconomic backgrounds.

2 The Danish Context

Three features of the Danish education system make it an ideal setting for studying inequalities in learning opportunities and the impact of teachers on student achievement: high public spending on education, a standardized national curriculum, and a highly homogeneous teacher force. Together, these features create a context where variation in educational quality and teacher sorting should, in principle, be limited. Denmark is, therefore, arguably a "least-likely case" for observing teacher-induced inequalities, allowing a strong test of whether institutionalized equality can eliminate disparities in access to qualified teachers and their benefits.

Denmark is widely considered to provide a very high level of equality of opportunity through its universal welfare state. Public investment in education is among the highest in the EU and OECD countries (OECD 2020), and the vast majority of children attend publicly funded schools administered by local municipalities. Schooling is compulsory for 10 years (grades 0–9, typically ages 6–15), and all students—whether in public or private schools—follow a standardized national curriculum designed to ensure that all children receive the same instruction in school. In the final year of compulsory schooling, students sit national exams in core subjects such as Danish, English, mathematics, and science before continuing to upper-secondary education (either vocational or academic) or leaving the education system.

In this study, I focus on the elementary and middle school period (i.e., until grade 9), which constitutes the period of compulsory schooling in Denmark. This period is chosen for two reasons. First, the absence of academic tracking during this stage creates a relatively uniform schooling experience across social backgrounds, unlike systems such as Germany's, where early tracking is strongly linked to socioeconomic status (Kruse 2019). Second, early schooling is a formative period: research shows that learning opportunities in these years are particularly formative and

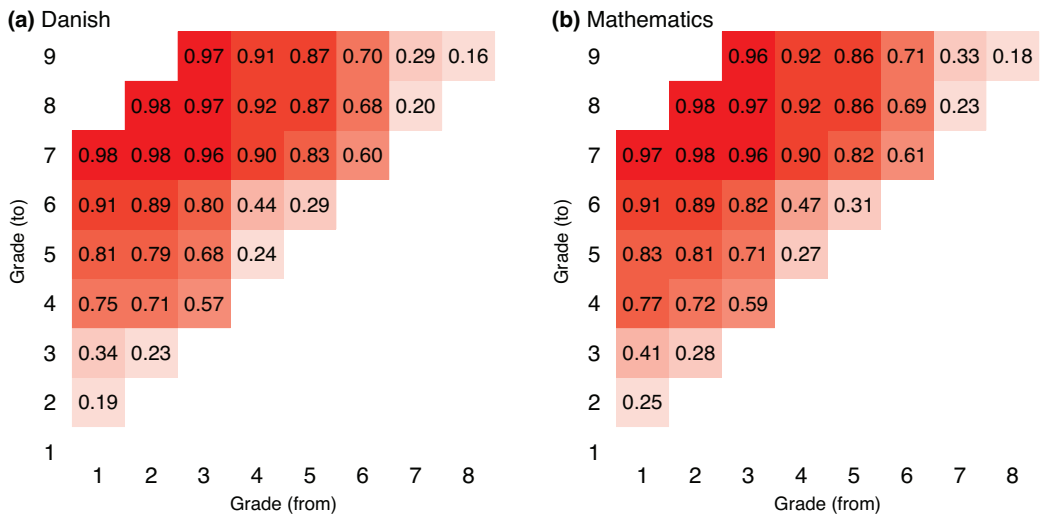

Figure 3: Probability of experiencing a teacher change between any two grades by subject. (*a*) Danish and (*b*) mathematics.
Notes: This figure shows the proportion of classes experiencing a teacher change between any two grades. The *x* axis shows the origin grade, and the *y* axis shows the destination grade. For instance, between grades 3 and 4, 57 percent of classrooms had a teacher change in the subject of Danish.

highly predictive of subsequent academic success (Heckman, Pinto, and Savelyev 2013).

The Danish teacher force is also highly homogeneous, with a standardized path into the profession. Prospective teachers complete a 4-year professional bachelor's degree at a public Teacher College, where they receive broad training in pedagogy, complete school internships, and specialize in three subjects (for instance, Danish, English, and history). After graduation, teacher hiring is decentralized: there are no formal mechanisms for assigning teachers to schools, a Teacher College degree is not required (though often preferred), and teachers apply directly to schools, with appointments made by principals and school administrators. Since a 2007 reform, most Danish public schools have organized grades into three educational stages—pre-preparatory (0–3), intermediate (4–6), and lower secondary (7–9)—with subject specialization tied to age group. Because my data cover the period between 2013 and 2018, most schools in my dataset group grades according to these stages. Importantly for the empirical strategy that follows, students are very likely to experience teacher changes *between* educational stages but typically retain the same teacher within a stage. Figure 3 illustrates this pattern by showing the probability of a teacher change between any two grade-years in the core subjects, Danish and mathematics.

3 Data and Measures

Does exposure to qualified teachers impact students' educational outcomes? In addition to the institutional features outlined above, the Danish context is an ideal setting to answer this question due to the extensive level of detail in the

administrative registers. Most other data sources do not allow for the linkage of students to teachers in exact classrooms while also containing longitudinal student achievement data, detailed information on students' educational records, teacher qualifications, and demographic and socioeconomic characteristics of both students and teachers. Below, I describe the data sources used and the construction of key variables.

3.1 Data

The recently released teacher–student database covers the full population of students and teaching staff in all Danish public schools in the years 2013–2018. The database is collected by Statistics Denmark from each school's administration every year and contains detailed information on which teachers taught which classrooms in all subjects in a given year. The database links students and teachers in exact classrooms through unique classroom identifiers and personal identifiers for both teachers and students. This allows me to construct yearly panels linking students to their primary teachers—the teacher responsible for most of the instruction in a given subject—in the two core subjects, Danish and mathematics, in every grade throughout compulsory schooling. Importantly, it is possible to link both teachers and students, through their unique personal identification numbers, to other administrative registers with information on various demographic, educational, and socioeconomic characteristics covering the full population of Danish residents since 1980.

In the observation period, students in public schools had to take mandatory national standardized exams, described below, at multiple periods throughout compulsory schooling in Danish and mathematics. Students sit Danish exams every second year from grade 2 until grade 8 and mathematics exams in grades 3 and 6. Accordingly, I construct one analytical sample for each subject that contains matched teacher–student observations in each subject. I require that students are observed in at least two test periods, as the empirical strategy described below models within-student test score growth as a function of differential exposure to teacher qualifications over time. The Danish (mathematics) sample contains 372,756 (113,292) observations pertaining to 186,378 (56,646) students who shared 14,543 (4,972) teachers in 1,117 (1,012) schools. The two analytic samples vary in size because of differences in the number of tests taken between subjects.

3.2 Outcome Variables

Student test scores are obtained from the Danish National Test database. Since 2009, the Danish National Tests have been mandatory for all children enrolled in public schools. Students take standardized tests in reading (Danish) in grades 2, 4, 6, and 8, and in mathematics in grades 3 and 6. Each test is approximately 45 minutes long and is computer-based and adaptive, such that the complexity of the questions presented to a student is updated during the duration of the test to give a more accurate estimate of the student's ability in the subject.

Because the tests are entirely computer based, they are unlikely to be influenced by teacher bias, which is particularly important for this study. In each subject,

the students are examined in three "profile areas" which are (1) numbers and algebra, (2) geometry, and (3) mathematics in use for mathematics, and (1) language comprehension, (2) decoding, and (3) reading comprehension in Danish. The final test score for each of these components is calculated on a Rasch-Logit scale (for further details, see Beuchert and Nandrup 2014). To obtain measures that are comparable over time, I first standardize the test scores from each profile area by grade, year, and subject and average the standardized test scores from the three profile areas. I then standardize the averaged test score again by year, grade, and subject to ensure that the final outcome variable has a mean of 0 and a standard deviation of 1.

3.3 Teacher Qualification Measures

I rely on several measures, described below, capturing different aspects of teacher qualifications, informed by previous descriptive studies documenting correlations between these measures and students' academic performance.

Teacher certification. Studies from the United States provide conflicting findings regarding the relationship between "teacher certification" and students' educational outcomes (Kelly et al. 2018). However, the process of obtaining a teacher certification in the United States (e.g., via the National Board for Professional Teaching Standards) is very different from the Danish context studied here, where a "teacher certification" means that the teacher has completed a 4-year program equivalent to a professional BA degree. I therefore expect that having a certified teacher in Denmark will improve students' test score performance. I obtain this measure from the education register, which contains educational records for all residents in Denmark since 1980. The measure is a binary variable indicating whether the teacher had graduated from a Teacher College before the beginning of the academic year.

Subject specialization. Teachers' content knowledge has consistently been shown to predict student outcomes, especially in mathematics (Hill et al. 2005). I, therefore, expect this variable to exert a strong positive influence on students' test score performance. The teacher–student database, described above, contains annual information on which subjects teachers specialized in teaching either during Teacher College or subsequently through additional training. From this, I construct a yearly binary variable indicating whether the teacher had specialized in the given subject (Danish or mathematics).

Teaching experience. A consistent finding in the literature is that teaching experience, measured as the number of years taught, is positively related to students' test score performance within the teacher's first few years of teaching but then levels off after around the second year of teaching (see Clotfelter et al. 2007). I construct a binary measure indicating whether the teacher is a non-novice teacher, that is, had already taught for more than 2 years before the beginning of the academic year. To construct this variable, I rely on annual records from the Danish Employment Classification Module register, which is available from 1976.

Cognitive skills. Teachers' cognitive abilities and skills have been shown to be positively related to students' academic development (Hanushek, Piopiunik, and Wiederhold 2019). I use teachers' high school GPA as a proxy for their cognitive

skills. Unlike the United States, high school marks in Denmark are nationally normed and standardized and are assessed by at least one external examiner. Therefore, they are highly reliable measures of academic skill.

Credentials. A number of studies find that measures of "teacher selectivity," such as test scores from Teacher College or the prestige of their undergraduate institution (in the U.S. context), are related to improved student outcomes (see Wayne and Youngs 2003). Unfortunately, final marks from higher education programs (including Teacher College) are only available for individuals graduating from 2004 onward. I am therefore unable to use this measure in the main analyses, as most teachers (around 70 percent) in the analytic samples graduated before 2004 and therefore have missing values on this variable. However, I am able to use this measure in the descriptive analyses examining the role of teacher–student sorting following graduation from Teacher College in recent cohorts.

3.4 Socioeconomic Status

I construct a socioeconomic index based on parental education, income, and employment records, similar to the composite measure used by Bjerre-Nielsen and Gandil (2024). I measure these parental variables at child age 5, before the child enters school, and at teacher age 15 in order to minimize the number of missing values in the teachers' parental variables. To ease the interpretation of the findings in the main analyses, I use a binary variable that indicates whether the individual comes from a low- or high-SES family based on whether the SES score is below or above the median in their birth cohort. For further details on the construction of the SES measures, see Appendix B in the online supplement.

3.5 Parental Leave Spells

The empirical strategy, discussed below, relies on teacher changes induced by parental leave spells, which are relatively long in Denmark. Following childbirth, parents are entitled to 52 weeks of parental leave. Since 1997, and thus, throughout the period covered by my dataset, parental leave payments have been centralized, with all transactions administered by the central government and providing near-full wage compensation during leave—regardless of whether the parent works in the public or private sector. Out of the 52 weeks, 4 are earmarked for mothers before childbirth, 14 are earmarked for mothers after childbirth, and 2 are earmarked for fathers after childbirth. The parents can divide the remaining 32 weeks between them as they wish. In addition, the Danish government introduced an optional childcare leave in 1994. The reform granted all parents with children younger than age 9 the right to 52 weeks of (additional) paid leave per child. Parents who wish to make use of this paid leave scheme can do so before the child turns 9, and some parents may therefore combine parental leave with paid childcare leave.

Because all parental leave payments are made from public authorities directly, I am able to obtain very precise and reliable parental leave spells by linking teachers, through their unique personal identifiers, to the employment register (DREAM). The register contains detailed information on all Danish residents' employment status and social benefits transactions on a weekly basis. This allows me to measure

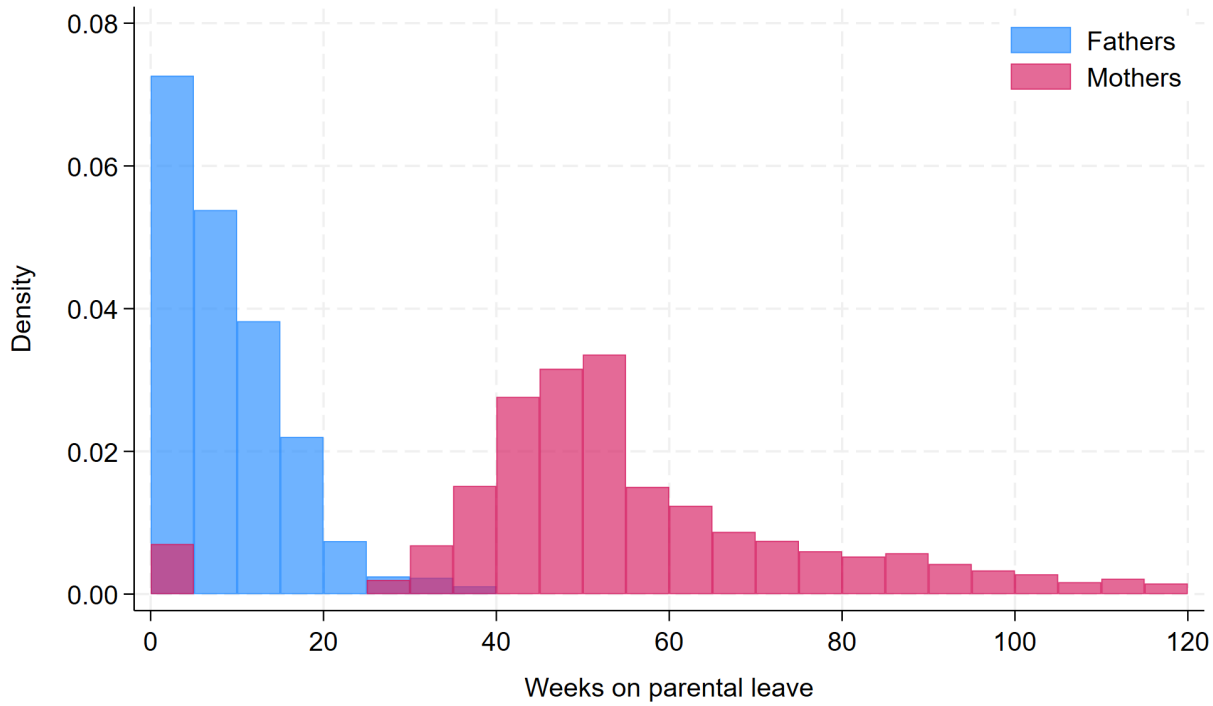

Figure 4: Length of parental leave spells for female and male teachers in Danish public schools.

exactly when the teacher went on parental leave and for how long. Based on this data source, I construct a variable that counts the number of weeks each teacher went on parental leave in every school year. I exclude weeks that overlap with the summer break to avoid over-counting the extent of the parental leave spell. Figure 4 shows the distribution of parental leave spells for teachers employed in Danish public schools following a childbirth. The figure shows that most female teachers in Denmark take at least around a year of parental leave when they become mothers, and that male teachers go on parental leave for much shorter periods. Importantly, parental leave spells are considerably long and are therefore potentially impactful on children's learning experiences because of teacher changes that may imply a decay (or improvement) in teacher quality from the children's perspective.

4 Analytical Strategy

Assessing the impact of teacher qualifications on students' educational outcomes is complicated by selection issues related to unobserved teacher–student sorting, as discussed in detail above. To overcome these issues, I exploit variation in teacher changes within an educational stage induced by parental leave spells, which provide a plausibly exogenous source of variation in exposure to different levels of teacher quality from the students' perspective. Although parental leave spells may not be exogenous to teacher characteristics—for example, skills, preferences, teaching style, and other unobserved factors—that may affect the quality of instruction, the

timing of when a teacher decides to go on parental leave is arguably unrelated to student characteristics. I, therefore, exploit variation in within-student exposure to qualified teachers over time induced by teachers' parental leave spells. An important implication of this design is that the estimates identify the causal effect of being exposed to teachers with a given qualification, rather than the isolated effect of the qualification itself. Because qualifications are potentially correlated with other teacher attributes (e.g., motivation or teaching style), the coefficients capture the joint effect of qualifications and these related characteristics. I return to the implications of this distinction in the discussion.

Specifically, I leverage two sources of variation for identification. First, the availability of longitudinal test score data for the same student allows me to compare within-student test score growth over time in a fixed effects approach that eliminates bias from time-invariant student characteristics. Second, I utilize the plausibly exogenous variation in teacher quality over time, induced by parental leave-related teacher changes, described above. The model takes the following form:

$$y_{itm} = \alpha_i + \gamma Q_{it}^{\Delta} + \lambda_m + \epsilon_{itm}, \tag{1}$$

where y is student i's test score in grade t, α_i is a student fixed effect, and γ identifies the effect of having a qualified teacher (e.g., having a teacher who specialized in mathematics) in a given year. Q^{Δ} measures changes in teacher qualifications over time that are exogenously induced by teachers' parental leave spells:

$$\begin{aligned} Q_{it}^{\Delta} &= \left[Q_{jt} - Q_{jt}\right] \cdot \left(1 - Z_{jt-1}\right) + \left[Q_{jt} - Q_{jt-1}\right] \cdot Z_{jt-1}, \\ &= Q_{jt}^{A} - Q_{jt}^{C}. \end{aligned} \tag{2}$$

Here, Q_{jt} is the quality of student i's teacher (j) in time period t, and Z_{jt-1} is a dummy variable that indicates whether student i's previous teacher is on parental leave due to a birth in the previous year $t-1$ (i.e., is currently absent due to a parental leave spell). The intuition is that the quality of the new teacher Q_{jt}^{C} can be used to measure the counterfactual teacher quality that the student would have been exposed to, had the actual teacher Q_{jt}^{A} not been on parental leave. Estimates of γ can therefore be interpreted as reduced form effects of within-student changes in exposure to teacher qualifications. I also control for cohort dummies λ_m to account for scaling differences in test scores over time.

4.1 Asymmetric Effects and Social Differentials

In addition to the main analyses described above, I also estimate models that account for asymmetries in teacher effects by distinguishing between positive and negative teacher qualification effects. This is because returns to teacher qualifications may differ depending on whether the "replacement teacher" is worse or better than the original teacher. In other words, the impact of experiencing a negative shock to teacher qualifications may not be equal to the additive inverse of the impact of a positive shock.

To address this source of heterogeneity, I split the change in the teacher qualification variable into two indicators: one for positive changes ($Q_{it}^{\Delta+} = Q_{it}^{\Delta} > 0$, i.e., a

positive "shock" to teacher quality) and one for negative changes ($Q_{it}^{\Delta-} = Q_{it}^{\Delta} < 0$, i.e., a negative "shock" to teacher quality), and estimate the following model:

$$y_{itm} = \alpha_i + \gamma_1 Q_{it}^{\Delta+} + \gamma_2 Q_{it}^{\Delta-} + \Phi C_{it} + \lambda_m + \varepsilon_{itm}, \quad (3)$$

where γ_1 and γ_2 are the impact of positive and negative changes to teacher quality, respectively, Φ is the impact of any teacher change, and the remaining parameters are similar to those in Equation 1. Note that Equation 1 is a special case of Equation 3 that assumes that the effect of Q_{it}^{Δ} on y is symmetric around 0 (s.t., $\gamma_2 = -\gamma_1 = \gamma$).

Finally, I also explore social differentials in teacher qualification effects on students' test score performance by estimating Equation 3 separately for high- and low-SES students.

4.2 Credibility of the Exogeneity Assumption

As with all quasi-experimental approaches, verifying the exogeneity assumptions is challenging. For instance, it may be the case that teachers who are assigned certain types of classrooms (e.g., classrooms with many disruptive students) are also more likely to go on parental leave. If this is the case, and if students in these classrooms are also less likely to perform well academically, then this identification strategy may fail. To alleviate this issue, I investigate whether an extensive set of student and classroom characteristics in a given year t are related to the likelihood that a teacher goes on parental leave in the following year $t+1$. Specifically, I estimate the following equation:

$$Z_{jc,t+1} = \alpha + \tau U_{ct} + \mathbf{x}_j'\beta + v_{jct}, \quad (4)$$

where $Z_{jc,t+1}$ is a dummy variable indicating whether teacher j in classroom c went on parental leave in year $t+1$, and U_{ct} is a classroom characteristic (e.g., the classroom's average test score or share of minority students) measured in time period t. In these models, I only control for teacher age dummies and teacher gender, $\mathbf{x}$. I also report estimation results for going on parental leave after 2 years (i.e., in $t+2$) in separate models to make sure that I capture all parental leave decisions. Importantly, the classroom characteristics U_{ct} include a very extensive set of variables and cover student performance, socioeconomic and demographic characteristics, and qualitative aspects of the classroom environment obtained from an annual full population school well-being survey. The survey contains questions about whether the student was bullied, felt motivated in the classroom, whether the student felt that the classroom atmosphere was disruptive, whether the student could hear the teacher during class, and other similar items (see Appendix C in the online supplement for further details).

Figure 5 summarizes estimation results from the above-mentioned balancing exercise, describing the likelihood that a teacher goes on parental leave conditional on classroom characteristics. The results from this exercise reveal that all coefficients are essentially zero: no estimate falls outside the range -0.002 to 0.001, and 23 of the 24 estimates are statistically insignificant at the 5 percent level. These results indicate that teachers in more "disruptive" or disadvantaged classrooms are not more likely to go on parental leave. The results add confidence to the empirical strategy

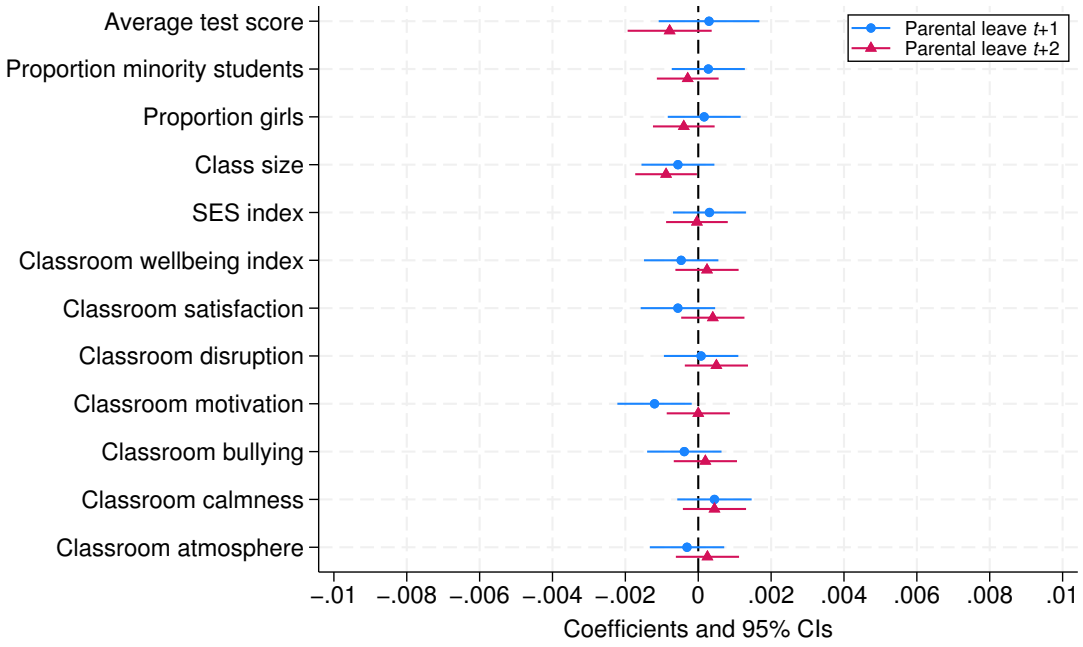

Figure 5: Summary of estimation results testing whether classroom characteristics predict teachers' parental leave spells.
Notes: For a full estimation table, see Table A1 in the online supplement.

and imply that teacher changes induced by parental leave spells are unrelated to indicators of the classroom environment. Of course, it is impossible to rule out that other unobserved classroom variables would predict teachers' parental leave decisions. However, it is worth noting that the well-being and classroom environment measures included here are usually the sort of variables that researchers typically consider "unobserved" in most other datasets because of their qualitative nature.

5 Results

5.1 Main Results

Table 1 shows results from the main analyses, specified in Equation (1), that relate teacher qualifications to students' test score performance in reading (A) and mathematics (B). Each column contains estimates from a model where test scores are regressed on the teacher qualification change variables separately. Overall, I find that exposure to teachers with higher qualifications improves students' test scores in both subjects, although estimates from some qualification measures are small and statistically insignificant at the 5 percent level. Results for mathematics are generally less precisely estimated, although they reveal the same patterns. I return to the issue of imprecision in the mathematics sample shortly.

Turning to the point estimates for the specific qualification measures, Table 1 shows that students who were exposed to a certified teacher (i.e., a teacher with a 4-year degree from a Teacher College) improved their test score performance by

Table 1: Main results: teacher qualification effects on students' test score performance in reading (Danish) and mathematics.

	A. Reading				B. Mathematics			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Certified	0.053*				0.038			
	(0.023)				(0.043)			
Specialized		0.064**				0.059*		
		(0.024)				(0.025)		
Experienced			0.025				0.051	
			(0.016)				(0.028)	
High school GPA				0.007				-0.000
				(0.006)				(0.011)
N (observations)	372,756	372,756	372,756	215,032	113,292	113,292	113,292	49,570
N (students)	186,378	186,378	186,378	107,516	56,646	56,646	56,646	24,785
N (identifying obs.)	1,041	1,007	2,056	8,597	398	861	841	3,156

Notes: Standard errors clustered on individual (student) identifiers in parentheses. *N* (observations) refers to the total number of observations in the sample, *N* (students) refers to the number of unique students, and *N* (identifying obs.) refers to the number of observations in the sample that experience a change in teacher quality due to parental leave. All models include student, grade-year, and cohort fixed effects. *$p < 0.05$; **$p < 0.01$.

about 5 percent of a standard deviation in reading and about 4 percent of a standard deviation in mathematics, although the results are only statistically significant in the reading sample. In both samples, the impact of subject specialization is both substantively and statistically significant, with effect sizes around 6 percent of a standard deviation. The impact of subject specialization is also larger in magnitude, compared to the certification measure, in both samples, implying that teachers' content knowledge may matter more than formal certification for improving students' test scores. I find no evidence that exposure to experienced teachers or teachers with higher academic skills—as measured by their high school GPA—impacts students' test scores in either subject. It is, however, important to note that the estimates for the experience measure are substantively nontrivial, although statistically insignificant. Moreover, the null effect for high school GPA is informative beyond its face value. To the extent that GPA proxies teachers' cognitive skills, the absence of an effect suggests that the estimates for certification and specialization are unlikely to be driven solely by differences in underlying cognitive ability rather than the qualifications themselves.

Importantly, the estimated effect sizes are sizeable when compared to estimates of the overall impact of schooling on students' learning growth. For instance, typical estimates of the contribution of a year of schooling to students' learning growth range from about one-quarter to one-third of a standard deviation (see Woessmann 2016). Using 0.25σ as an estimate for the overall contribution of schools to student learning and 0.06σ as an estimate for the impact of having a specialized teacher, we can calculate the relative impact of teacher qualifications as roughly $(0.06 \cdot 0.5)/0.25 \approx 12$ percent of the overall school contribution to learning (note that

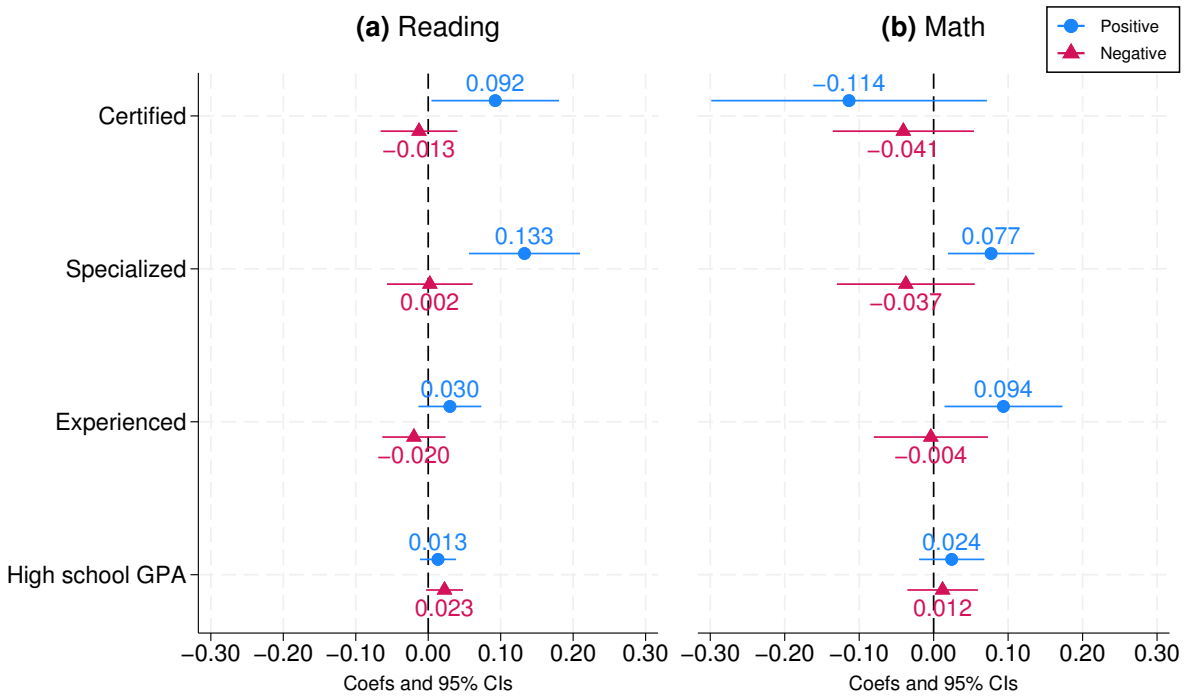

Figure 6: Asymmetric effects of teacher qualifications on students' academic performance in reading (Danish) in panel (*a*) and mathematics in panel (*b*).
Notes: This figure summarizes results from Equation (3) and plots the parameter estimates (and 95 percent CIs) $\widehat{\gamma}_1$ and $\widehat{\gamma}_2$, which give the returns to positive and negative changes in teacher quality, respectively. For a full estimation table, see Table A2 in the online supplement.

I multiply the teacher effect by 0.5 because my analyses rely on students' learning growth between 2 years for the Danish sample).

As noted above, the results for mathematics are less precisely estimated. This imprecision is likely driven by a smaller sample size in the mathematics sample and, more importantly, less variation due to parental leave spells in the mathematics sample. This is because mathematics teachers are often men (see Fig. 4), and there is, therefore, less variation in teacher changes due to parental leave in this sample. The ratio of female to male teachers is 85:15 in the Danish sample and 60:40 in the mathematics sample. Finally, the models in Table 1 assume that teacher effects are symmetric, which may also distort the estimates. I relax this assumption below. However, note that the estimated effect sizes here thus represent a lower bound on the impact of positive changes in teacher qualifications on students' test score performance.

5.2 Asymmetric Teacher Effects on Student Learning

Figure 6 summarizes estimation results from models that allow for asymmetric teacher effects—see Equation (3) for specifications—for the reading (Danish) sample in Figure 6a and for mathematics in Figure 6b. These models allow for the possibility

that the impact of improvements in teacher qualifications is different in magnitude than the impact of declines in teacher qualifications. To start, it is important to note that the estimates for mathematics are generally noisier due to the sample size and variation issues discussed in the previous section. Segregating the mathematics sample further into smaller subsets based on negative versus positive teacher quality changes amplifies this problem.

Overall, the results in Figure 6 indicate that students benefit from positive changes in teacher quality but are not adversely affected by negative changes. For example, transitioning to a certified or specialized Danish teacher from a non-certified or nonspecialized one improves student test scores by approximately 10–13 percent of a standard deviation. Conversely, students' test score performance remains unaffected when experiencing negative changes in teacher quality, such as moving from a certified teacher to a non-certified one. I interpret these results as compelling evidence that the impact of a highly qualified teacher is enduring. Highly qualified teachers may instill foundational academic skills in students that persist even when students are later exposed to less qualified teachers. This suggests that the benefit of having a qualified teacher can have a long-lasting positive effect on a student's academic trajectory. Although this pattern is intriguing, the underlying mechanisms—whether skill persistence, motivation, or self-efficacy—lie beyond the scope of this article and merit further investigation in future research.

5.3 Differential Returns to Teacher Qualifications

I now turn to the social gradient analyses, which speak to cumulative disadvantage and compensatory advantage mechanisms (DiPrete and Eirich 2006; Bernardi 2014). As discussed earlier, both theories imply that teacher qualification effects are heterogeneous across student socioeconomic status but predict opposite directions. Figure 7 summarizes estimation results from models that allow for asymmetric teacher effects, similar to those above, by teacher qualification measure and subject, estimated separately for low- and high-SES students. I focus on the certification and specialization measures here because the main analyses discussed above revealed that the remaining qualification measures had no impact on students' test score performance.

Figures 7a and c show results for the reading (Danish) sample for the teacher certification and specialization measures, respectively. On both measures, low-SES students benefit more from positive changes in teacher qualifications, compared to high-SES students. For instance, in Figure 7a, the effect of a positive teacher change is 22 percent of a standard deviation for low-SES students but null and statistically insignificant for high-SES students. The specialization measure in Figure 7c reveals a similar pattern. This initial observation adds support to the compensatory advantage hypothesis. However, it is important to note that all of these estimates are noisy and that the confidence intervals for the low- and high-SES groups are overlapping, suggesting that the evidence for social gradients in teacher qualification effects is inconclusive—despite using full population data. This overlap indicates that we cannot clearly determine whether the impact of teacher qualifications varies significantly between these socioeconomic groups. Figures 7b and d show the

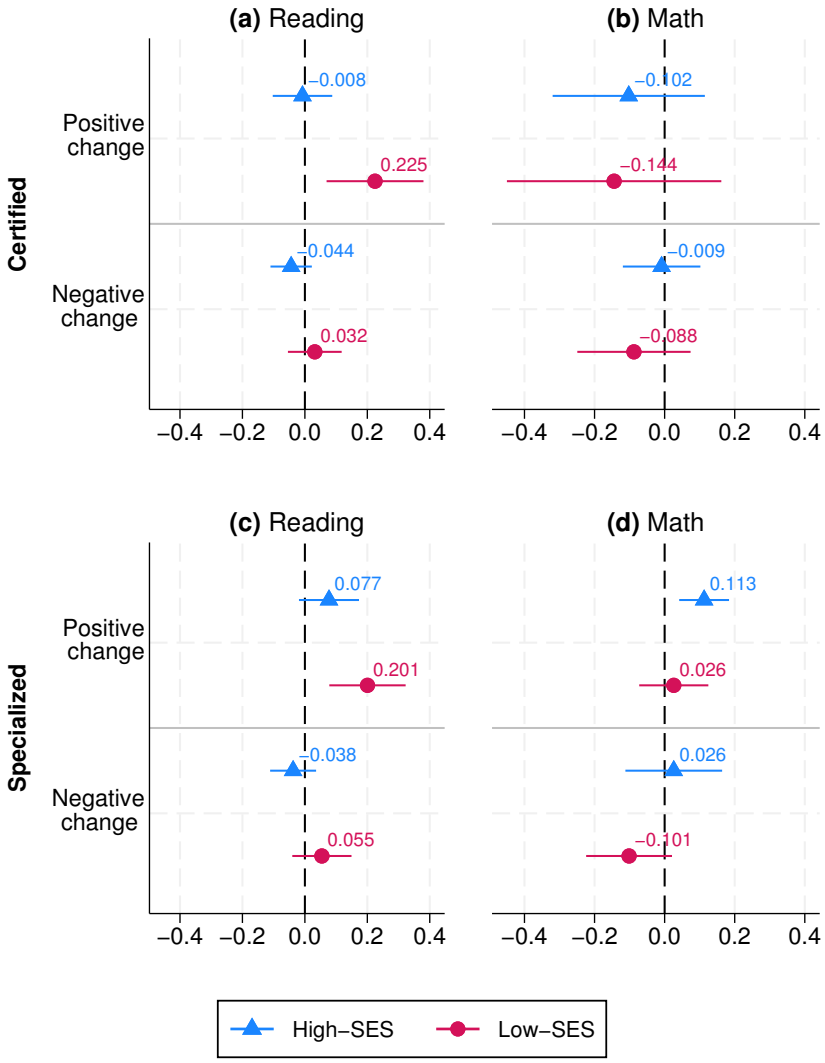

Figure 7: Asymmetric teacher qualification effects by subject and students' socioeconomic background. *Notes*: This figure summarizes results from Equation (3), separately for low- and high-SES students, and plots the parameter estimates $\widehat{\gamma}_1$ and $\widehat{\gamma}_2$, which give the returns to positive and negative changes in teacher quality, respectively. For a full estimation table, see Table A3 in the online supplement.

corresponding estimates for the mathematics sample, where all estimates—both for negative and positive changes—are statistically insignificant and imprecise, except for the estimate for a positive change in teacher specialization for high-SES students. This finding further highlights the inconclusiveness of the evidence supporting the differential effect by socioeconomic background hypothesis. Taken together, these results suggest that social disparities in student achievement arise primarily from unequal exposure to qualified teachers rather than from unequal returns to teacher qualifications, underscoring the central role of teacher sorting in the reproduction of educational disparities.

6 Discussion

Although sociologists have documented disparities in access to qualified teachers (e.g., Hanselman 2018; Kalogrides and Loeb 2013; Kalogrides et al. 2013), the question of how teachers contribute to student achievement—and the implication of teacher sorting for educational inequalities—remains understudied (for discussions and reviews, see Morgan and Shackelford 2018; Reimer 2019). This limitation is crucial because inequalities in exposure to highly qualified teachers only matter if teacher qualifications causally impact students' educational outcomes.

In this study, I examined how teachers contribute to educational inequality by analyzing both *unequal exposure* to qualified teachers and *unequal returns* to those qualifications. The findings demonstrate that even in Denmark—one of the world's most egalitarian societies—teachers with higher qualifications systematically sort into schools serving socially advantaged students. Despite uniform salaries and standardized training, teachers' employment choices produce unequal exposure to qualified teachers across schools. These disparities have meaningful consequences for students' learning: exposure to a qualified teacher increases student test performance by roughly 6 percent of a standard deviation per year, corresponding to at least 12 percent of the total schooling effect on learning. Because this estimate is conservative, the true influence of qualified teachers is likely greater, as shown in the asymmetric effects analyses. At the same time, the results show little evidence that these effects vary by students' socioeconomic background. Taken together, these findings imply that teachers contribute to educational inequality primarily through *unequal exposure* to qualified teachers rather than through *unequal returns* to those qualifications.

These results advance sociological research on education in several ways. First, they contribute to long-standing debates over whether schools mitigate or reproduce social inequality (Bowles and Gintis 1976; Downey et al. 2019). By specifying the mechanism through which inequality emerges—teachers' sorting across schools—the study moves beyond documenting school-level effects to explaining how everyday organizational processes inside schools sustain social advantage. Second, the findings speak to theories of cumulative and compensatory advantage (DiPrete and Eirich 2006; Bernardi 2014). The lack of clear social gradients in returns to teacher qualifications suggests that teachers' contributions to inequality depend less on differential responsiveness across students and more on the institutional allocation of teacher resources. In other words, the distribution of qualified teachers—rather than differences in how students respond to them—is the key driver of teacher-induced inequality, at least at early educational stages. Third, these results highlight that even in systems designed to promote equality, institutionalized career preferences and school-level hiring processes can reintroduce inequality through subtle, non-financial channels.

From a policy perspective, the findings underscore the importance of addressing teacher sorting as a mechanism of inequality. Because teacher qualifications—such as certification, specialization, and experience—are observable and politically manipulable, equalizing their distribution across schools represents a viable strategy for reducing disparities in learning opportunities. Yet, redistributing qualifications

alone may not be sufficient if the underlying organizational dynamics that shape teacher placement—such as preferences for working conditions, peer composition, or neighborhood characteristics—remain unaddressed. Efforts to equalize opportunity, therefore, require institutional reforms that make disadvantaged schools more attractive and sustainable environments for qualified teachers. My analyses relied on teacher qualification measures rather than value-added scores. Setting aside the econometric debate regarding bias and precision in teacher value-added measures (see Rothstein 2009), focusing on qualification measures comes with at least two advantages. First, obtaining causal evidence on the effect of specific qualification measures has a clear policy potential. For instance, the stock and distribution of certified teachers—or teachers who specialize in mathematics—are directly manipulable through political instruments, such as investments in teacher education. Second, most of the sociological literature on educational inequalities and teacher sorting focuses on teacher qualification measures rather than value-added (e.g., Kalogrides and Loeb 2013; Kalogrides et al. 2013). My findings, therefore, directly relate to and expand upon this sociological literature by documenting the causal effects of teacher qualifications on children's test score performance.

Several limitations merit discussion and point toward directions for future research. First, the analyses focus exclusively on students' academic performance, yet teachers influence a broader range of outcomes—including motivation, socioemotional skills, and aspirations (see Jennings and DiPrete 2010; Jackson 2018). Future research should examine whether inequalities in exposure to qualified teachers also shape these noncognitive dimensions. Second, the study captures effects during compulsory schooling; subsequent work should investigate whether early exposure to qualified teachers affects longer-term outcomes, such as upper-secondary completion and college entry. Third, although Denmark provides a "least-likely" context for teacher-induced inequality, this also means that the observed effects may represent lower-bound estimates. In more stratified systems—such as the United States or Germany—where teacher labor markets are more decentralized and school quality is more variable, teacher sorting and its consequences are likely even more pronounced. Fourth, although the parental leave design addresses sorting on student and classroom characteristics, it does not isolate qualifications from unobserved teacher-level attributes—such as motivation or pedagogical style—that may correlate with obtaining them. The estimates, therefore, capture the causal effect of exposure to teachers with a given qualification, together with potential correlated teacher attributes, rather than the isolated effect of the credential itself. The null effect of teachers' high school GPA reported above offers reassurance against one prominent candidate—underlying cognitive ability—but cannot rule out other correlates. Designs that exploit within-teacher variation in credentialing over time, for instance, through mid-career training, could help disentangle these channels in future work.

Overall, the findings demonstrate that teachers are not merely individual actors who deliver instruction but institutional agents whose placement and qualifications structure the opportunities available to children. Even in egalitarian systems, inequality can persist through the organizational allocation of human capital across schools. Understanding and addressing these processes is therefore central to

explaining why educational inequalities endure despite policies designed to equalize opportunity.

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