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Scaling standards-aligned instruction through teacher leadership: methods, supports, and challenges

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Abstract

Background: The Common Core Standards for Mathematics and Next Generation Science Standards were adopted by states with the goal of preparing students with knowledge and skills needed for college, careers, and citizenry. Adopting these standards necessitated considerable changes in instructional practice. While teacher leadership is known to be important for instructional change, there is little research that articulates the processes through which that influence occurs, and how contextual factors constrain or support those processes. This paper provides a case study of efforts in the Chicago Public Schools to promote widespread instructional change around standards reform through a teacher leader model using retrospective from 2013 to 2017 interviews with 16 math and science teacher leaders serving grades 6–12, along with quantitative analysis of district-wide data showing patterns of change and professional learning. It builds off prior research to articulate a framework of how teacher leaders promote instructional change.

Findings: There were five patterns of teacher leader action: *inspiring others*, *sharing with colleagues*, *working in collaboration*, *advocating for change*, and *providing individual support*, and an interplay between teacher actions and school-level contextual factors, with some contextual factors more important than others for different types of actions. In particular, sharing and collaborative work were facilitated in schools with designated collaboration time, trusting relationships, and colleagues who were also trained and knowledgeable about the new standards. The degree of collective efficacy the teacher leaders felt seemed to be driven mostly by the presence of other knowledgeable change agents in the school.

Conclusions and implications: The study adds to the existing literature on teacher leadership by articulating the mechanisms through which teachers exert influence around instructional improvement of their school peers and providing examples of each. Further, the study illustrates how these mechanisms are facilitated or constrained by the larger school context. Together, the articulation of mechanisms and contexts, along with illustrative examples, provides a guide for supporting instructional change through teacher leadership in schools and districts.

Keywords: Common Core, instructional change, NGSS, professional learning, teacher leadership

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The Common Core Standards for Mathematics (CCSS-M) released in 2010, and the Next-Generation Science Standards (NGSS) published in 2013 introduced ambitious math and science learning goals that required new learning and changes in practice on the part of teachers. This presented a challenge for district leaders across the country as they considered how to structure professional learning for teachers to enable large-scale instructional change and meet the goals of the policy. As states transitioned to the new standards, there were major challenges in providing sufficient high-quality professional development (Kober et al., 2013; Perry et al., 2015; Rentner & Kober, 2014; Shernoff et al., 2017; Zhang et al., 2015). With the high demand for training, many districts struggled to reach the sheer number of teachers (Frazer, Porter & Ramsey, 2014; McLaughlin et al., 2014). In the Chicago Public Schools (CPS), the fourth largest public school district in the USA, district leaders developed a strategy for reaching a staff of over 22,000 teachers working in over 650 schools by developing math and science "teacher leaders." Teacher leaders were expected to work on improving their own teaching, then use formal and informal approaches to influence instructional change in their schools. In this model, and in this paper, teacher leaders are defined as those who have particular expertise in standards-aligned instructional practices and have been tasked with actions that serve to influence the instructional practices of other teachers for the purpose of promoting instructional change within their school.

The CPS context is one instance of recent district and state-wide efforts to scale standards-aligned instruction by leveraging the expertise of teachers to support the professional learning of other teachers (e.g., Curtis, 2013; Kaufman et al., 2016; Larson et al., 2013; Tyler et al., 2019). However, as such teacher leader models have emerged, the processes by which teacher leaders actually influence changes in their colleagues' teaching has not been clearly articulated (e.g., Berg & Zoellick, 2018; Cooper et al., 2016; Nguyen et al., 2019). Further, while research has established that specific aspects of the school organizational context (e.g., collaboration, collegiality, leadership, learning opportunities) are key to effective teacher professional learning (Kraft & Papay, 2014), we know much less about the ways in which the nature and content of teacher peer interactions are shaped by specific school-level factors (Coburn et al., 2013; Wenner & Campbell, 2017).

This paper provides a case study of the efforts of the district to promote widespread instructional change through a teacher leader model. It adds to the existing literature on teacher leadership by articulating the mechanisms through which teachers exert influence around instructional improvement of their school peers. It builds a conceptual framework for describing the work of teacher leaders, and then shows how those mechanisms are facilitated or constrained by the larger school context, providing descriptive examples. This paper is structured around two main research questions:

RQ1. What were the practices teacher leaders used to support instructional change?
RQ2. In what ways did school-level factors shape the practice of the teacher leaders?

The question of how teacher leaders supported instructional change is particularly relevant if there is evidence (1) that instruction actually changed under the district's teacher leader model and (2) that teachers participated in substantial amounts of professional learning in their schools. Therefore, before describing the processes through which teacher leaders exerted influence, we also ask two preliminary questions:

PQ1. Were there changes in instructional practices, aligned to the practice standards, in the district during the period of standards implementation?
PQ2. To what extent did teachers report engaging in professional learning from activities promoted by the teacher leader model?

To answer these preliminary questions, we use quantitative data from district-wide surveys of students and teachers. For the first question, we examine change over time in students' reports of the degree to which they engaged in different types of work in their math and science classes from before implementation of the teacher leader model (the 2011–2012 school year) through the 2017–2018 school year. For the second, we examine teachers' reports of the frequency of their participation in professional learning around the standards from different sources, including the types of activities promoted by the teacher leader model in 1 year, 2017–2018. This was the only year that we have responses to these questions from teachers. These analyses provide insight into the broader context of the teacher leader initiative, and also provide motivation for learning more about the processes used by teacher leaders in this period of standards reform in Chicago.

Theory and research on teacher leadership

Getting students to meet new standards depends on changing the technical core of instruction in a school. This requires not only shifts in technical knowledge, but also trust among teachers that those shifts will benefit students if they try them, as well as time for teachers to build new teaching skills (Le Fevre, 2014). Making these deep, sustained, school-wide changes in practice depends on strong supports for teachers. The Theory of Essential

Supports (Bryk et al., 2010) describes the interplay between multiple supports in the school for sustained improvement in instruction and student learning. In this model, sustained improvement is dependent on school principals, but their influence is indirect, influencing classroom instruction and student learning through other organizational school processes: professional capacity among teachers and school staff, learning climate, and parent community ties. Professional capacity includes individual teachers' knowledge and skills, as well as professional learning and a school-based professional community that is oriented toward continuous improvement, facilitated by relational trust among members of the school community (Bryk et al., 2010), pp. 50-70. The model posits that successful school leadership is inclusive—fostering input and leadership from those who will implement change, and actively involved in instructional improvement—not leaving it to the discretion of individual teachers. While all of teacher leadership need not be a result of principals' initiative, research suggests that principal leadership is a critical factor for developing and supporting teacher leadership (Leithwood & Mascall, 2008; York-Barr & Duke, 2004). Thus, principals who are successful at improving student learning in their schools do so by developing and supporting teacher leadership around instructional change.

How is teacher leadership enacted?

In their seminal literature review, York-Barr and Duke (2004), p. 287 defined teacher leadership as "the process by which teachers, individually or collectively, influence their colleagues, principals, and other members of school communities to improve teaching and learning practices with the aim of increased student learning and achievement." In recent years, literature on teacher leadership has converged on this conception of "leadership as influence" (e.g., Berg & Zoellick, 2019; Cooper et al., 2016; Nguyen et al., 2019), placing influence as a function of actions, rather than the teacher's formal title, roles, or responsibilities. There is evidence that teacher leadership is a lever for improving student outcomes (Robinson et al., 2017; Sebastian et al., 2016; Sebastian et al., 2017), but a recent comprehensive literature review on teacher leadership reveals only a handful of empirical studies that describe and outline exactly the process through which teacher leadership works (Nguyen et al., 2019). Nguyen et al. conclude "The current empirical base on teacher leadership would benefit from more empirical studies that explore exactly how teacher leadership, as a process of influence, is exerted."

In those few studies, time for collaboration with school colleagues emerges as a key mechanism through which instructional change occurs. Supovitz et al. (2010) found that teachers who reported more frequent engagement in peer collaboration, such as examining and discussing student work, reported making instructional changes to a greater extent. Cooper et al. (2016) similarly found that teacher leaders influenced their peers to integrate new instructional practices into their repertoire by facilitating reflective dialog about instructional issues and collaboratively grappling with challenges. In a case study documenting teacher leadership activities in the context of routine practice, Fairman and Mackenzie (2015), p. 68 broke down the use of time with colleagues further, describing five mechanisms through which they observed teachers exerting influence: (1) *modeling* professional attitudes or dispositions, such as commitment to professional learning, openness to new ideas and approaches, and willingness to take risks; (2) *sharing* ideas, work, resources, and personal reflections with colleagues; (3) *coaching* colleagues in the use of new curricula, instructional practices, or other initiatives; (4) *collaborating* with colleagues in planning, co-creating, or evaluating curricula and instructional practices; and (5) *advocating* for change in practice by engaging with administrators, colleagues, and the broader community. In this study, we build on the findings of these prior studies, further refining and articulating how teacher leaders exert influence, and providing operationalized examples.

How do school-level factors affect teacher leaders' influence?

The school principal plays a critical role in developing a context that either facilitates or constrains teacher leadership. Prior studies have identified a number of factors that influence teacher leader efficacy to enact instructional change, including the degree to which administrators provide motivation for change through school goals and vision, and the conditions in the school under which teachers do their work, including school structures and policies that support the change effort (Leithwood et al., 2008; Mangin, 2007; Stein et al., 2016). The context for teacher leaders is further shaped by the skills and dispositions of their colleagues, including the degree to which there are trusting relationships among teacher leaders and their peers, a shared commitment to change among school staff, and a sense of collective efficacy among staff to implement change (Angelle & Teague, 2014; Coburn et al., 2013; Cooper et al., 2016; Hunzicker, 2017; Jacobs et al., 2016; Klein et al., 2018; Nguyen et al., 2019; Seashore Louis & Lee, 2016; Wenner, 2017; Wenner & Campbell, 2017; York-Barr & Duke, 2004). In the present study, we show how these factors influenced the methods teacher leaders used to advance standards-aligned instructional change and facilitated or impeded their efforts.

The Chicago context

CPS is a large heterogeneous urban school district with about 350,000 students, where 82 percent of students qualify for free or reduced-price lunch. While math test scores in Chicago are lower than the national average, gains on math tests are at the 96th percentile of districts nationwide (Reardon & Hinze-Pifer, 2017), and math scores improved significantly from 2011 to 2017 (National Center for Education Statistics, 2020).

The CPS math and science initiatives for professional learning (PL) around the standards had many common elements. The plans emphasized new instructional practices, not just content. The vision of the district office overseeing math and science instruction was that every day in every classroom, students will actively make sense of and construct solutions to complex problems; productively contribute to the learning community to support a culture of collaboration, risk taking and innovation; and regularly reflect on and communicate their understanding of disciplinary ideas. Efforts in both math and science were focused on developing teacher leadership, which is broadly construed as social influence. Teachers became leaders not through a change in their formal roles or responsibilities, although some held formal leadership roles, but by way of their participation in PL experiences that positioned them as sources of expertise. The district's expectation was that teachers participating in professional learning should share what they were learning, and the changes they were making in their own instruction, with others. The implicit theory was that these interactions would drive instructional change among their peers.

In math, three teachers per elementary (grades K-8) school and two per high school were designated as "teacher leaders" who would attend regional "Teacher Leader Institutes" (TLIs), beginning in the 2012–2013 school year. The TLIs were focused on supporting "high-quality" instruction, including understanding the content and practice standards, applying materials designed to encourage discourse around mathematical concepts (e.g., Math Talks), employing high-cognitive demand tasks, promoting student discourse, using formative assessments—MARS tasks (MARS, 2012)—and developing growth mindsets among educators and students. The district also incorporated professional learning around the Teaching for Robust Understanding (TRU) Framework (Schoenfeld, 2016), which emphasizes creating equitable, student-centered learning environments.

High-quality instructional practices were a major component of the TLIs across all years, but TLIs in 2014–2015 and later years also included topics around how to share learning at the school level (e.g., working with adult learners), and supporting professional learning with colleagues through public practice. Following the TLIs, teacher leaders were expected to share their learning with other teachers and administrators in their building by collaborating to review student work, inviting a peer into their classroom to observe, observing another person's classroom, and providing constructive feedback, or engaging others in informal conversation about what they were learning. Teacher leaders from all schools had access to TLIs in mathematics. In addition, some schools also had access to "math team learning communities" attended by teacher leaders together with their administrators. These provided time for the teams to develop school-based professional learning plans and provided opportunities to share strategies across school teams.

Because of funding limitations, the science TLI program was limited to about a quarter of schools. As with the TLIs in math, the TLIs in science included time to learn about the content and practice standards, and a focus on high-quality instruction, including productive talk in the classroom and instructional coherence. There were also goals around building capacity for improvements in science instruction across the school. CPS sponsored other standards-focused science PL opportunities available to all teachers or particular teacher groups based on grade level or disciplinary content area. Many offerings were focused on leadership development and, in fact, referred to their participants as "teacher leaders." What emerged over time was a model in which the district developed small groups, or "pockets" of science teacher leaders in addition to those trained through the TLIs.

To further support consistency in instructional practice, CPS developed a repository of standards-aligned tools and resources for math instruction and housed them on the CPS Knowledge Center, an internal district website accessible to all district staff. These included a list of recommended K-12 math curricula aligned to CCSS-M, standards-aligned lessons, instructional units, student activities, and tools for conducting peer observations. In TLIs, teacher leaders were encouraged to share these resources with colleagues upon returning to their buildings as an additional way to support standards-aligned instruction.

Methods

The findings reported here are part of a larger, mixed methods exploratory study to identify the plans CPS put in place to achieve the goals of the CCSS-M and NGSS; understand the nature and extent of variability in plan participation across schools and teachers; and explore relationships between plan participation and student achievement in math and science in grades 6–12. Here, we focus on the second aim of the larger study, using

qualitative interviews from teachers to discern the ways in which teacher leaders supported instructional change throughout the school. However, the larger study provides a context for understanding the role teacher leadership played in carrying out instructional change in the district. Therefore, we also present some findings from analysis of district-wide quantitative data.

To understand how the adoption of mathematics and science standards might lead to better and more equitable student outcomes, we first identified the combination of approaches that CPS central office had instituted to support standards-aligned instruction in mathematics and science. The research team conducted a document review and targeted interviews with six district leaders including the Director of Mathematics, the Director of Science, and two specialists from each department. We also interviewed two university partners that worked closely with central office staff to conceptualize and implement the chosen approaches. These data, in combination with feedback from district leaders, were synthesized to produce comprehensive summaries of plan components representing the district's efforts to support teachers and schools to bring about instruction aligned with the CCSS-M and NGSS. After learning that the district plans were organized around a teacher leader model, a subsequent round of interviews captured the experiences of teacher leaders.

Participants in the teacher leader interviews

The research team sampled CPS schools from which to recruit math and science teacher leaders for interview participation, aiming for variation in school contexts, subjects taught (math and science), city neighborhood, and grade level. Recruitment took place in collaboration with CPS central office staff who used attendance records from district-facilitated PL meetings to identify 6–12th grade math and science teacher leaders within the selected schools who had participated in the TLIs. The district supplied email addresses for all teacher leaders in the selected schools, and the researchers then invited those teachers to participate. Twenty teacher leaders expressed interest in participating, with more science teachers responding than math teachers. We engaged in word-of-mouth recruitment to obtain additional volunteers in math to improve the balance by subject. The final sample of teacher leader participants included seven math teacher leaders and nine science teacher leaders (16 teacher leaders, in total) representing 13 CPS schools located across Chicago. Of these schools, six served students in grades 9–12, four served students in grades PreK-8, and three served students in grades 7–12. The schools varied in terms of school size, student socioeconomic status (ranging from 38 to 97% designated low income), and student English proficiency (ranging from 0.2 to 48% with limited English proficiency). During the time covered by the retrospective interviews (2013–2017), all teachers in the sample were working as full-time classroom teachers with no release time from teaching duties. Even so, many of these teachers held official instructional leadership roles in their schools. See Table 1 for a list of the characteristics of the respondents and their schools.

Data collection

Two research team members conducted 16 teacher leader interviews in the summer and fall of 2018. Interviews were conducted in person and over the phone, ranged from 30 to 60 min, and were recorded and transcribed. All interviews followed a semi-structured interview protocol (Lune & Berg, 2017) asking participants to retrospectively describe events and experiences that took place over the 5-year period between 2013 and 2017, in which CPS implemented standards-focused math and science professional learning plans. Questions asked teachers to describe the standards-related professional development they received, their professional experience, their school leadership role, the methods by which they exerted influence on their peers to enact standards-aligned instruction, and the supports and barriers they experienced in these efforts. Some of the questions in the protocol were derived from the district-wide surveys used in the larger study so that the team could get a deeper understanding of teachers' thinking behind different responses, while others were developed based on the elements in the district plan. Although not a focus of the current study, teacher leaders also described their own journey in understanding the standards and their personal experiences using standards-aligned instructional practices in their classrooms.

As with any research methodology, there are some limitations to using retrospective interviews. Saldaña (2013) notes two issues with retrospective interviews. First, people do not always understand their own motives for action, and they cannot always articulate why they act in certain ways. In our study, teacher leaders might have been more likely to remember activities that were particularly positive or negative, so their practices that were less memorable may not have been discussed in the interviews. Teacher leaders also may have assigned meaning to their actions in retrospect after observing the consequences. They may not have been fully aware of the ways in which their practices influenced others in the school or may have thought particular actions had a larger effect on others than they actually did. The second concern noted by Saldaña is that retrospective interviewees can be inaccurate in recalling specific

Table 1 Teacher leader participants and school characteristics

Teacher leader characteristics			School characteristics			
Pseudonyms	**Grade level**	**Subject**	**School**	**School size** [a]	**% Low income** [b]	**% Limited English** [b]
Neil	High	Science	1	Medium	75–90	25–50
Nina	High	Science	2	Medium	75–90	< 10
Whitney	High	Math	3	Medium	75–90	< 10
Russell	High	Math	4	Medium	50–75	< 10
Sarah	High	Science	4	Medium	50–75	< 10
Theresa	High	Math	5	Medium	75–90	25–50
Lester	High	Science	6	Large	25–50	< 10
Courtney	High	Science	7	Large	50–75	< 10
Colin	High	Science	7	Large	50–75	< 10
Hannah	High	Math	8	Very Large	25–50	< 10
Morris	Middle, High	Math	9	Medium	50–75	< 10
Olivia	Middle, High	Science	9	Medium	50–75	< 10
Sandra	Middle	Science	10	Small	> 90	25–50
Brenda	Middle	Science	11	Medium	> 90	25–50
Bella	Middle	Math	12	Large	> 90	25–50
Valerie	Middle	Math	13	Medium	> 90	25–50

[a]School size categories were determined using the guidelines for classifying schools serving grades 9–12 and 6–8 provided by the California Department of Education (2000), and using the guidelines for classifying schools serving grades PreK-8 provided by Lee & Loeb (2000)
[b]Values obtained from publicly available school records from the 2018–2019 school year located on the CPS district website

points in time (dates, periods, etc.) and tend to describe experiences as more gradual. This concern was mitigated through checking dates and periods with informants in the math and science departments and with a university partner.

Data analysis

The lead author coded the interview transcripts using MAXQDA software. We took a directed content analysis approach to coding and analysis. With a directed content analysis, the researcher uses existing theory or prior research as guidance for initial codes. As analysis proceeds, additional codes are developed, and the initial coding scheme is revised and refined to extend or refine existing theory (Hsieh & Shannon, 2005).

The coding of teacher leader practices was initially guided by Fairman & Mackenzie's description of five broad strategies they observed teacher leaders using to influence their colleagues' instruction: Modeling, Sharing, Coaching, Collaborating, and Advocating (Fairman & Mackenzie, 2015). While these categories provided a useful starting point to understand and organize the range of strategies teacher leaders use, they were presented as illustrative examples, rather than operational definitions, and therefore required further clarification and refinement.

For example, in describing the strategy of "coaching," the authors noted that "when teachers were hesitant to teach outside their subject area, their teammates gently prodded them to take risks and expand their teaching repertoire but also provided support or coaching" (pp. 68-69) but did not delineate how coaching may be carried out or in what context. We coded any instance of working with other teachers in a supportive role to improve instruction under this category, which included formal coaching relationships as well as more informal mentoring and provision of instructional feedback to another teacher in the context of peer observation/feedback cycles. We re-named "coaching" as "providing individual support" to emphasize one-to-one assistance in a range of contexts while eliminating confusion that may result in using the term "coaching," which connotes a formal role (e.g., "Instructional Coach").

Similarly, in describing "modeling," Fairman and Mackenzie (2015) provided examples of teachers being committed to their own professional development and their openness to new ideas and teaching approaches, while also noting this strategy was "…less direct, and did not always involve working through relationships." (p. 68). We initially used the code "Leading by Disposition" to encompass actions consistent with this description, which places teachers' *innovative disposition* as the locus that entices other teachers to consider making their own instructional changes, rather than "modeling," which connotes deliberate demonstration. Through the coding process, in considering teachers' recollections of how they feel they influenced others' practice without explicit intent, we re-named the code as "inspiring others." This

change represents the use of new teaching approaches (consistent with Fairman & Mackenzie's research) coupled with visibility of practice that coincidentally sparked others' interest.

Through the process described in the examples above, we generated operational definitions for each code representing teacher leader methods of influence, and we reviewed codes within and across teacher leader cases in reference to each other and to the operational definitions.

Coding of school-level factors was informed by a conceptual framework articulating the range of organizational contexts and conditions that influence intervention implementation (Century et al., 2012). This general framework organizes factors into "characteristics related to people in the organization" (in our case, individual teachers and school administrators) and "structural characteristics of the organization." Segments that did not fit into the initial categories because they reflected context-specific factors (e.g., "level of proficiency with the standards"; "standards-based grading policy") were labeled as emergent codes. Where applicable, school-level codes were further identified as perceived supports or as barriers to teacher leader influence. Attribute coding (Saldaña, 2013) was used to track descriptive information including years of teaching experience, courses and grades taught, formal school leadership role, and participation in standards-focused professional learning provided by CPS and other organizations.

The final list of codes is provided in Additional file 1. One person did all of the coding but shared the results of the coding for feedback with project team members and a professional colleague at multiple points. Research staff periodically met with our district partners to share interim findings and elicit feedback. Midway through the coding process, researchers shared specific aspects of teacher leader practices and specific school-level factors we were consistently hearing in the teacher interviews in each of our provisional categories, to verify accuracy. Following completion of coding, the coder also asked one of the teacher leader interviewees for feedback on the codes, as well as one of the district informants, and both felt the descriptions resonated with their perceptions of teacher leader practice. The project team used quantitative data to corroborate the interview data, when possible.

Written case summaries were created for each teacher leader that included key interview segments describing their perceptions about their methods of influencing instructional change and perceived school supports and barriers to their efforts. The purpose of these summaries was to identify actions and factors that teacher leaders perceived as particularly important in their efforts, while also identifying activities and factors that they felt were less essential. Following this, a teacher leader code matrix was created to display the presence of key activities and factors indicated by each teacher leader (Miles et al., 2020) to enable cross-case comparison on key variables (i.e., methods of influence, school supports, and school barriers).

The research team received district feedback to verify contextual information, such as timelines and details about district initiatives mentioned by teacher leaders. The team also engaged in peer debriefing through ongoing consultation with a professional colleague who served as a CPS professional development provider and instructional coach. Through these discussions, the research team received analytic feedback, verified contextual information, and obtained more detailed descriptions of district-sponsored PL experiences and standards-aligned instructional resources.

District-wide surveys

CPS teachers and students in grades 6–12 participate in annual surveys where they answer questions about their experiences in school. Their responses are used to produce school reports about school climate and organization. Student survey response rates ranged from 74 to 83% from 2012 through 2018, the years reported in this study. Between 100,000 and 130,000 students in grades 6–12 responded to survey questions about practices in their math and science in each year.

Student survey

For math classes, survey questions asked students to report how often they engaged in the types of learning activities that should be observed in classes with teaching aligned with the CCSS-M and were consistent with the practices emphasized in district-sponsored professional development around the standards. These included practices such as discussing possible solutions to problems with other solutions and writing a few sentences to explain how they solved a math problem. The science practice questions were less closely aligned with the NGSS as they were developed in years before the NGSS existed. However, they included questions that asked about active engagement of students through hypothesis/question generation, writing about science, and making interpretations with data. See Additional file 2 for the specific questions in the measures.

Responses to the banks of student questions for both math and science practices were aggregated to measures through Rasch analysis (Wright & Masters, 1982). To show changes over time, we used regression models predicting student reports of practices in each year with student covariates, school fixed effects, and dummy variables representing each year. The excluded year was

2011–2012, which was prior to the first professional learning workshops provided by the district around the standards. Thus, the coefficients on the year dummy variables represent the difference in practices relative to the year before any professional learning. Student covariates were included to adjust for any differences in the backgrounds of students responding to the surveys across time. By incorporating school fixed effects, we captured changes in student-reported practices within schools over time, rather than any changes in which schools were attended by students across the years.

Teacher survey

In 2018, surveys of teachers included questions about teachers' perceptions of the CCSS-M and the NGSS and engagement in standards-focused professional learning. All schools in the district participated in the surveys, although teacher participation was voluntary. Response rates were 80% in 2018. To decrease the burden on survey respondents, teachers who taught both math and science were randomly assigned to answer questions about only one subject. About half of math and science teacher respondents taught both subjects, so the data represents only about 60% of teachers in each subject. We only use data from teachers who indicated that their students were in grades 6–12. The total sample of teachers included 1723 middle-grade and 919 high school teachers responding to questions about the CCSS-M, and 782 middle-grade and 685 high school teachers responding to questions about the NGSS. We present simple frequencies of the responses of teachers to answer preliminary question 2.

Findings

Before describing the ways in which teacher leaders promoted instructional changes in their schools, we provide evidence about the degree to which there were changes in instruction in the district during this time period based on district-wide surveys, as well as the degree to which teachers engaged in professional learning around the standards in ways consistent with the district's teacher leader model.

Students engaged more frequently in standards-aligned practices

Based on annual surveys of all students in the district, there were considerable increases in the frequency in which students engaged in standards-aligned practices in their math and science classes, building gradually over time (see Table 2). Compared to students with similar backgrounds in the same schools in 2011–2012, practices were higher by about 0.3 standard deviations by 2017–2018 in the middle grades, while in the high schools they were higher by about 0.2 standard deviations. In the middle grades, changes seemed to co-occur in math and science. Most schools serving middle grades in CPS serve grades K-8 and have self-contained classes. Thus, there could have been spillover in terms of learning instructional techniques.

Table 2 Changes in student reports of instructional practices in math and science classes relative to 2011–2012, in standard deviations

		Math practices	Science practices
Grades 6–8			
First year of TLIs in math	2012–2013	0.075***	0.103***
First year of TLIs in science	2013–2014	0.054***	0.099***
CCSS-M full implementation	2014–2015	0.163***	0.212***
NGSS full implementation	2015–2016	0.193***	0.215***
	2016–2017	0.197***	0.236***
	2017–2018	0.307***	0.296***
Grades 9–12			
First year of TLIs in math	2012–2013	0.073***	0.019
First year of TLIs in science	2013–2014	0.010	0.053**
CCSS-M full implementation	2014–2015	0.056**	0.080***
NGSS full implementation	2015–2016	0.146***	0.140***
	2016–2017	0.135***	0.150***
	2017–2018	0.203***	0.205***

Note: Coefficients represent changes relative to the 2011–2012 school year from regression models that control for student gender, race, ethnicity, special education status, neighborhood poverty, social status, grade level, type of math or science course, and school fixed effects. Standard errors are clustered by school. Response rates on surveys ranged from 74 to 81%, with the number of middle-grade students in each year ranging from 49,355 to 66,975 and the number of high school students in each year ranging from 49,688 to 71,670. Math and science practices were standardized around the 2011–2012 mean and standard deviation. **$p < .01$, ***$p < .001$.

The changes in student reports provide some evidence that instruction changed significantly over time. At the same time, we cannot say with certainty from this analysis that these changes were due to the implementation of the district's plan or the teacher leader model. In another study, we did find significant relationships between the degree to which teachers reported participating in professional learning around the standards and changes in math instruction and math achievement; that study did not examine science (Allensworth et al., 2021).

In math, the student-reported practices that changed the most were in applying math to situations outside of school and discussing possible solutions to problems with other students. In 2011–2012, just over half of middle-grade students said they did those things once a week or more, compared to about three fourths of students in 2017–2018. In science, the largest changes were in using evidence or data to support an argument or hypothesis; about half of middle-grade students reported doing that practice at least once a week in 2011–2012 compared to two thirds of students in 2018. Thus, the student-reported data suggest there were considerable changes in instructional practices, aligned to the goals of the standards, over time.

Teachers' reports about professional learning were consistent with the district's teacher leader model

Professional development (PD) has long been considered a primary lever for enacting instructional change, and the teacher leader model was seen as a way of enacting professional learning in a way that would reach a sizeable teaching force. In fact, peer learning was the major source of professional learning around the standards reported by teachers in district-wide surveys (see Figs. 1 and 2). In both the middle grades and the high school grades, and in both math and science, many teachers reported frequently participating in collaborative planning time and classroom observations with other teachers. About 70–80% of teachers said they participated in professional learning around the standards at least once a month in collaborative planning time, with the exception of middle-grade science teachers. Even though middle-grade science teachers were less likely than other teachers to report professional learning through in-school collaboration with colleagues,

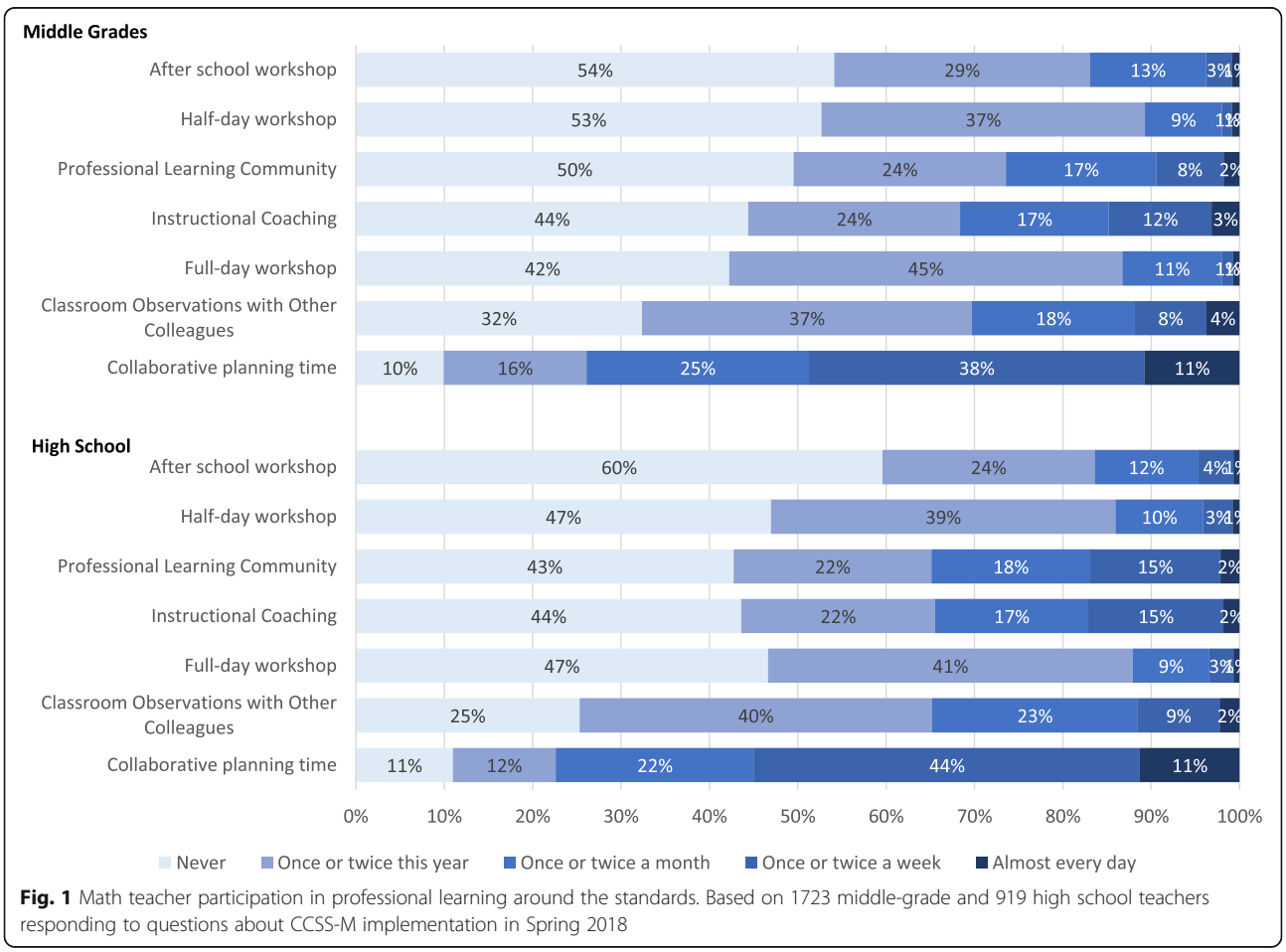

Fig. 1 Math teacher participation in professional learning around the standards. Based on 1723 middle-grade and 919 high school teachers responding to questions about CCSS-M implementation in Spring 2018

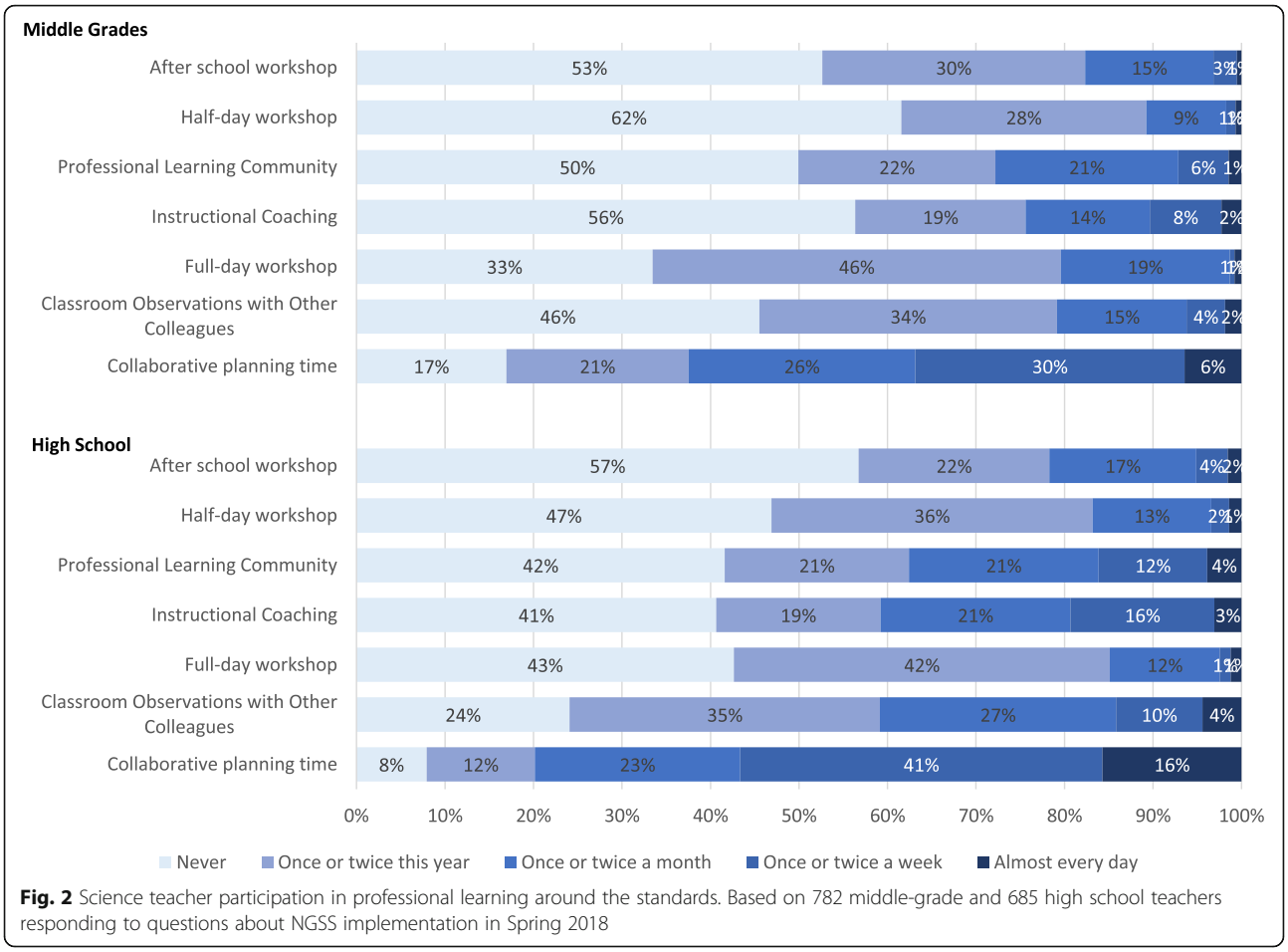

Fig. 2 Science teacher participation in professional learning around the standards. Based on 782 middle-grade and 685 high school teachers responding to questions about NGSS implementation in Spring 2018

collaborative planning time was still their most frequent source of professional learning around instructional improvement. About half of teachers also participated in coaching or a professional learning community, with about a third of teachers reporting they did so at least once or twice a month.

An additional bank of questions asked teachers about the topics that were emphasized in their professional learning around the standards, including unpacking standards, developing content knowledge, using formative assessments, developing lesson plans, selecting/using aligned materials, differentiating instruction, and developing high-quality instructional practice. Consistent with district goals, the topic that teachers reported received the most emphasis was "developing high-quality instructional practice." About half of middle-grade teachers in both math and science reported that it was a major emphasis of their professional learning, and over a third of high school teachers said it was a major emphasis.

Thus, teachers across the district reported that their most common sources of professional learning came from inside their school and that the emphasis of their professional learning was on improving their instructional practice. These district-wide data provide evidence that the district plan for implementing the standards was present in the schools, that teachers engaged in professional learning in their schools in ways consistent with the teacher leader model, and that instructional practices changed as intended. But how did teacher leaders enact instructional change? How did they support instructional change through their practices, and how did school-level factors shape those practices?

Practices used to support standards-aligned instruction

Based on our qualitative interviews, teacher leaders described five general methods of influence: (1) advocating for change; (2) providing individual support; (3) inspiring others; (4) sharing with colleagues; and (5) working in collaboration (see Table 3). We describe these methods of influence as teacher leader *practices*—a term that can have many meanings (Lampert, 2010). Here, "practices" are conceptualized both as (1) what an individual teacher leader does and learns to do better over time in their role as teacher leaders and (2) as the participation of teacher leaders in a school learning community. As in prior research, teacher leaders in this study engaged in

Table 3 Teacher leader practices to support instructional change

Category	Definition
Inspiring others	Use of new instructional approaches that are visible to others
Sharing with colleagues	Dissemination or exchange of ideas, information, resources, or practices
Working in collaboration	Work with colleagues to create, implement, or reflect on shared projects or products over time
Advocating for change	Efforts to establish systems that support instructional change
Providing individual support	Providing support to individual teachers around instructional change

multiple methods of influence in different combinations. Two methods in particular—sharing with colleagues and working in collaboration—dominated teacher leaders' stories, reflecting the activities emphasized in the CPS teacher leader model.

Advocating for change

Four of the teacher leaders advocated to establish systems that would support instructional change in their school. Often, the requests went to school administrators. For example, Sandra, a middle-grade science teacher, was able to secure a core curriculum and related professional development for her department by appealing to administration. She recalled, "I really pushed the importance of learning about these practices…We need to know this because we're confused and we can't figure it out on our own. We need help." Valerie, a middle-grade math teacher in a PreK-8 school, similarly requested support to improve her school's math scores following Common Core adoption. She told her school leadership team, "We cannot ignore math any longer. We need to do something about it." Her advocacy resulted in an increased awareness on the part of the principal, who provided two hour to deliver a school-based training.

Two of the teacher leaders talked about needing to advocate for change with both staff and school leadership. For example, Sandra, a middle-grade science teacher, talked about nudging the principal to nudge the other teachers about the importance of learning the new practices. Whitney, a high school math teacher whose department was still new to CCSS-M, approached her administration to establish a system of peer observation with feedback to promote instructional quality and consistency. She shared, "I suggested to my department that we needed to do it just because there were complaints, like … some irregularities from classroom to classroom." She also suggested changing the focus of department meetings from administrative and clerical tasks, to "mini professional developments."

Providing individual support

Nine of the teacher leaders directly supported individual teachers in achieving instructional change by fostering reflection and action. A few teacher leaders provided instructional guidance through formal systems of peer observation with feedback. For example, Colin, a high school science teacher and department chair, had the opportunity to provide observational feedback to all teachers in his science department twice per quarter. He explained, "the feedback is structured…we would also discuss in the department, so in the department meeting that week, what was seen. And also, not necessarily straight feedback either, but have conversation around like what was the goal, and what was valued." More commonly, however, teachers described providing individual support through formal or informal mentoring relationships. For these teacher leaders, the focus of their support was customized to particular teacher needs. Neil, a high school science teacher, worked closely with a fellow teacher over the course of her first year of teaching, encouraging her to "think about physics from the perspective of creating a model and using your observations to develop a model that explains them and then deploying [the] model." Whitney, a high school math teacher, informally mentored a colleague who appeared to be struggling, "offering to come in their classroom to observe, providing them with additional resources, and making suggestions."

Inspiring others

Another method of influence described by six teacher leaders involved "inspiring others" by informally letting colleagues see and consider new instructional approaches. Three teacher leaders: Hannah and Theresa, both high school math teachers, and Colin, a high school science teacher, believed that they influenced the practices of colleagues by acting as an indirect source of inspiration, "pulling" others into using new practice. A hallmark characteristic of this method involved actions that piqued others' interest or curiosity to try new things *without the explicit intention to do so*. For example, Hannah shared, "People would come to me to see how they might teach something differently…I probably am influencing others, but not aware of it unless they tell me." Theresa similarly noted, "I have heard my co-workers say, 'well I saw you do something different in your classroom, so I'm gonna give this a try.'"

This source of influence largely came out of teachers' efforts to improve their own practice, and then to make

their practice visible to colleagues. They did not go to other teachers to suggest copying a technique that had worked for them but made their innovation visible informally. For example, Colin describes the ways he involved students in more hands-on applied activities, "other teachers saw that I was taking students out of the classroom, going to nature spaces, and going to the Chicago River, and incorporating those things into the classroom. Teachers … just naturally asked like, 'How are you doing this? What are you doing?'" This did not necessarily mean that teachers were copying a particular technique or doing the new practice in the same way, rather that they were inspired to try something new. As Theresa said, "maybe they're not doing exactly what I'm doing, but I think the fact that people are trying something new because maybe they saw me try something new, I think that's good."

Sharing with colleagues

Most teacher leaders (13 of 16) shared information with colleagues, using a wide range of methods involving the dissemination or exchange of ideas, information, resources, or practices. In contrast with "inspiring others," sharing with colleagues involved more intentional sharing of information or practices. Often, they shared what they had learned at the TLIs. In terms of tangible resources, all the math teacher leaders informed their colleagues about the presence of CCSS-aligned instructional resources housed in the CPS Knowledge Center, such as math problems aligned to address specific standards, hands-on student activities, and tools for formative assessment. Some math teacher leaders also demonstrated how to use them or organized them by instructional unit to facilitate access and use. Russell, a high school math teacher, felt this led to a positive impact on teaching practices in the school, noting, "the practices are more hands-on and discovery-based…our books are probably 30 years old, and these activities… came really as a refreshment to us as educators as well as students."

Several science teacher leaders also shared instructional resources with their department or team, such as student activities targeting specific standards, assessment rubrics, grade-level expectations, and classroom visual aids (e.g., an NGSS "Science and Engineering Practices Wheel" to hang on the classroom wall). Resource sharing took place in many settings, with varying levels of engagement from other teachers in the school, from emails that were sent out widely, to team meetings, or during formal, school-based PD sessions.

More than half of the teacher leaders shared information about standards-aligned instructional practices in the context of informal conversations during common planning time or at lunch. Sometimes, these impromptu conversations were initiated by other teachers who approached their teacher leaders with questions about how to teach a particular topic or concept. Other times, teacher leaders were the ones to open the conversation by telling their colleagues about approaches they had tried and found to be particularly effective for student learning. Hannah, a high school math teacher, shared, "when I am eating lunch or have a prep period, I do ask other people about what they're doing in their classes, and I try to open up the conversation to that, and then I've learned which teachers also like to talk about that, and I've gotten ideas from them, and they from me."

Finally, five teacher leaders described instances in which they shared practices by inviting other teachers into their classroom. For some teacher leaders, invited classroom visits took place within an established "peer observation" structure, while for others, the visits were more ad hoc in nature. Sarah, a high school science teacher, regularly used demonstration as a method to spread the use of new student activities. For example, after demonstrating an activity in which students modeled physics phenomena on white boards, Sarah recalled that many other teachers adopted the activity in their own classrooms.

Some teacher leaders shared that they were reluctant to come across to their peers as too "pushy" and because of this, shared resources and practices without taking action to ensure those things were taken up by others. For example, Brenda, a middle-grade science teacher, framed the use of information she shared as a choice so as not to overwhelm her colleagues. Olivia, a high school science teacher, noted that she preferred to simply share her opinions: "I feel like I'm an NGSS ambassador almost. I'm just here for the good will, and I want to convince you that it's great, but I'm not going to give you a hard time about it either." Theresa, a high school math teacher, similarly reflected that as a teacher leader, she didn't want to be in the role of "making people do things," but wanted to simply be a "passer of information."

Working in collaboration

Eleven of the teacher leaders worked in collaboration with partners or a group of colleagues to create, implement, or reflect on shared projects or products. The large-scale instructional changes described by teacher leaders all seemed to involve collaborative efforts. For many teacher leaders in this study, the bulk of collaborative work took place within their departments, within "course teams" (i.e., groups of teachers who taught the same course) or in "vertical teams" (i.e., groups of teachers from different grade levels). For example, as Courtney, a high school science teacher describes, "we would get within our course teams, and look at the

standards that matched that course team. And break apart the standards, see what big ideas and activities can match within there."

Some teacher-led teams focused on planning standards-aligned instruction by reviewing lesson plans and the standards they address, with conversations focused on thinking about how they taught particular tasks or skills. Other teams engaged in an ongoing process of analyzing student data and adjusting the curriculum based on what they were learning. Teacher leaders also worked in teams to strategically address school-wide problems of practice related to standards-aligned instruction. Some such teams addressed issues of alignment, for example, working to ensure that assessments measured student mastery of content standards taught and that students experienced continuity of instruction from one grade level or course to the next. In addition to team-based work, a few teacher leaders also described processes of working with a single teaching partner to co-create instructional activities and assessments aligned to the new standards.

Two math teacher leaders carried out managerial activities for their respective teams, such as creating an agenda for the meetings, organizing and leading the meetings, and recording the minutes. Beyond managing meetings, however, teacher leaders emphasized the group effort over their individual contributions to discussing collaborative work. For example, all teacher leaders used the term "we" when discussing team-based work, reflecting a shared effort. As Morris, a high school math teacher, explained, "Our department was really high functioning so everybody kind of, you know, led at some point because they brought up ideas and they developed curriculum and everybody kind of does that." Nina, a high school science teacher, similarly noted, "We definitely do have some strong teachers, but that's where the collaboration comes, where we work together. So not just depending on me, but depending on each other."

School-level factors affecting teacher leadership practices

Our second research question, "In what ways do school-level factors shape the enactment of the CPS teacher leadership model?" explores the *interactions* between known school-level factors and teacher leader actions to support instructional change, described below. Consistent with prior research, teacher leaders in our study perceived that dedicated collaboration time, trusted peer relationships, school administrator support and advocacy, collective efficacy to implement standards-aligned instruction, and staff commitment to the change effort, provided optimal conditions for enacting the CPS teacher leader model for instructional change, while the lack thereof led to roadblocks. Some school-level factors mattered more than others when using particular methods of influence, and the most engaging and large-scale actions required the largest number of supports.

School administrator support and advocacy

Teacher leaders varied in the extent to which they perceived their school administrators were supportive of their efforts. Teachers felt administrator support was critical for establishing structures and resources necessary for team collaboration. For teacher leaders, having a supportive principal meant they alone did not have to bear the burden of locating time, resources, and strategies to engage their department. Some teacher leaders shared that their principals provided blocks of time within the school day for teacher leaders to conduct all-staff training on standards-aligned instruction or scheduled dedicated time for teachers to work together and learn from one another. Principals also supported teacher leaders by providing release time to engage in their own professional learning. Reflecting on her school's administration, Nina, a high school science teacher, shared, "I feel like they're incredibly supportive and thoughtful about my needs as a teacher leader, my needs as a teacher, my needs as a learner…If there's new PD opportunities, that's never a problem."

Teacher leaders were further supported by their principal's meaningful involvement in the details of their teacher leadership work. For example, Bella, a middle-grade math teacher in a PreK-8 school, shared that she and her principal attended district PL sessions together and collaborated on the best ways to share back the information with school staff. Russell, a high school math teacher, received information and resources from administrators on how to identify a mission and facilitating team meetings, which prepared him to effectively lead his course team. Hannah's assistant principal joined her high school math course team once a week and in doing so, greatly supported her team's collaborative work. She reflected, "His facilitating that conversation in those meetings, I think, was crucial to being able to share our ideas."

In contrast, teacher leaders felt that when administrators did not share a vision for standards-aligned instruction or pressured teachers to focus on other priorities, this resulted in having fewer opportunities to collaborate in teams around standards-aligned instruction and undermined their messages of urgency around the change effort. Valerie, a middle-grade math teacher in a PreK-8 school, felt that in general, teachers' professional learning emphasis was focused on areas other than math. She explained, "I feel that sometimes math is left behind and it's not given a priority like literacy…there's never time to do math PD. I continue to fight for math." Brenda, a middle-grade science teacher who also worked

in a PreK-8 school, felt similarly with regard to science, reflecting "as long as I've been teaching, the focus has always been on math and reading…oftentimes science is put on the back burner."

At the high school level, some science teachers felt that their school administrators prioritized preparing students to take the SAT—the state standardized test—over NGSS alignment, which made it difficult to convey a compelling need to focus on the standards. Courtney, for instance, noted "As a school, there is an impression that SAT are more important than aligning your curriculum to NGSS." She explained that science teachers were discouraged from having students build models of scientific phenomena, for instance, "because they won't build a model on the SAT." Neil also shared his science department also felt conflicted in their efforts to address the NGSS while at the same time "getting the SAT scores up." He noted, "There's not a whole lot of overlap and the stuff for science is kind of like an afterthought."

Staff commitment to the change effort

Schools varied in the extent to which staff as a whole were committed to the change effort. In some schools, teacher leaders who felt that most of their colleagues had embraced the new standards had to do little "pushing" because their teams already valued engaging in work to support standards-aligned instruction. This was the case for Olivia, a high school science teacher who observed:

> Over the past few years, I've seen people be a lot more interested, and engaged, and willing to change as we've seen more with NGSS, and there's been more examples, and now we have the district framework. They're just really excited about it.

Morris felt similarly about his high school math department, noting that most teachers were willing to try new things and "really dig into the Common Core" because they felt it was a better math set of standards. More generally, many teacher leaders perceived that their colleagues were open to new ideas and willing try new things that could improve student learning, such views made staff more receptive to their efforts to support instructional change.

For some teacher leaders, convincing colleagues of the value of the new standards was a harder sell. Some high school science teachers encountered resistance due to a perceived lack of external accountability for NGSS-aligned instruction. One such teacher explained, "Some teachers they say, 'Is it required? Because if it's not required, I don't have to do it.'" Another noted, "with no assessment for the Next Gen, it automatically becomes de-prioritized" while a third commented, "there's nothing the state is really doing to make you teach NGSS." Courtney speculated that many teachers in her high school science department simply did not have the time to engage with NGSS because they were focused on other priorities:

> They don't always have the time or even the desire to make sure they're incorporating everything that they can because they feel so distracted…Or they can't give time to it because they literally don't have time even if they wanted.

Finally, some teacher leaders found it difficult to influence change due to the perception that some people are simply "set in their ways." Bella felt this was her biggest roadblock as a math teacher leader, noting, "There's people who have been doing their practices for years. A lot of times, they're scared of new things, too, you know?" Theresa also felt unsuccessful in her efforts to motivate some of her colleagues, reflecting, "I think I did a good job of bringing back information. I think that maybe convincing people to try it…I don't think that I did that well." She continued, "I just think it takes a long time to get people to change."

Only a few teacher leaders described taking intentional actions to establish teacher "buy-in" to the change effort. For example, to convince teachers who expressed doubts about the value of Common Core-aligned instruction, Morris collected and shared evidence from his own classroom to show the ways in which students benefited from standards-aligned instruction. He reflected that sharing the results of his own experiment "was one buy-in piece to get people to even contemplate coming into my room, checking it out." For Morris, staff commitment to the change effort was a precursor to his ability to exert influence by sharing practices. Valerie, whose teachers were overwhelmed, took a different strategy to increase buy-in by intentionally proposing small, incremental changes that their teachers could easily incorporate in their existing lessons without much additional time or effort. Valerie felt that her staff appreciated the resources and information she shared, reflecting, "it's stuff that teachers really wanted to know about…they were very happy to see things actually all put together for them."

Mutually trusting, supportive relationships among staff

Teachers who felt their teams were "very collaborative" described a social climate characterized by ongoing communication, transparency, and mutual dependency. These teacher leaders felt that this climate afforded opportunities to exert their influence outside of scheduled team meetings. The presence of trusting, supportive peer

relationships particularly enabled teacher leaders to engage in sharing with colleagues via informal channels such as impromptu classroom visits and ad hoc conversations; these activities happened more frequently in school climates where teachers' work was perceived as interdependent and mutually beneficial. Several teachers mentioned that supportive relationships among their staff fostered feelings of safety in sharing details about their teaching without fear of negative evaluation. Neil described his high school science department in this way:

> Basically if one person's not succeeding, then that's a problem for all of us…We're always looking out for each other. We look at each other's student work, we look at each other's lessons. Like I said, and pop in on each other's classrooms. And it's small and we're pretty collegial and we collaborate really well.

Neil explained that this climate supported his influence through both sharing of practice and collaborative work, perceiving that open, transparent communication made it easier for his teachers to work toward vertical and horizontal alignment. Hannah similarly described her high school math department as optimal for sharing with colleagues, emphasizing the ease at which teachers exchange ideas and information: "There's no thought, 'Oh I'm doing this, but I'm not going to give it to this person.' Anything that anybody is doing, they're open to sharing with other teachers." Other teacher leaders described their departments as having an unofficial "open door policy" that promoted teachers making informal classroom visits, increasing the chances that teachers might "happen upon" new practices.

On the other end of the spectrum, other teacher leaders described collaboration among teachers as limited in their school. This was the case for Courtney, who explained that teachers in her high school science department only discussed instructional issues during their twice-a-month, 40-min course team meetings: "When we have that required time, then we'll work together…But, again when it's a more mandated structured time. Versus coming on their own time when they have other things potentially happening." Similarly, Lester shared that in his high school science department, interactions only took place during scheduled meeting or planning time, noting, "Nobody observes. I mean, they could if they wanted to, but at that point I think everybody's comfortable and doesn't feel that's going to be an asset, necessarily to do that." For these teachers, working within an environment where the social climate was more independent limited their opportunities to informally exert influence on their peers outside of formal collaboration structures.

Dedicated collaboration time

Different school contexts provided different opportunities, in terms of both frequency and time, for teacher leaders to meaningfully interact with their colleagues around standards-aligned instruction. Having dedicated time during the school day for the explicit purpose of teacher interaction was a critical structural element that supported their ability to share resources, share practices, and engage in collaborative teamwork—interactions promoted in the CPS teacher leader model. Recurring horizontal and vertical team meetings were the main contexts in which teachers interacted for these purposes. Bella, a middle-grade math teacher in a PreK-8 school, explained, "That's a really big practice that they support, is giving us the time to collaborate, and then we actually do take advantage of it." Theresa, a high school math teacher, was also appreciative of the time provided to her course team, reflecting:

> They do know that it takes teachers meeting with the other teachers that teach their classes to come up with things. To make those things successful. So I think the one thing that our school has always given us time.

In addition to dedicated meeting time, some teacher leaders also worked in schools with established structures for peer observation with feedback that enabled them to easily invite colleagues into their classroom to observe new practices. Sarah, for example, shared the process in place at her school enabled her high school science team to frequently demonstrate practices:

> We document in kind of a Google … I'm doing questioning today. And I put the date, and teachers who are available, they can come. Then they can view the classroom, and then we get feedback later, and we talk about it.

When teachers worked in schools without dedicated collaboration time, teacher leaders collaborated less in teams or met with teachers on their own time. Lester, for example, was a high school science teacher who felt that "we just have to do the best we can." In his department, course team meetings were scheduled for 30 min every 2 weeks, which he felt was not sufficient to work through an activity together. He continued, "[time] needs to be built into the school day in some way…I think that would really help with institutional change."

Lester and others in similar situations resorted to interacting on an informal basis. Brenda, a middle-grade science teacher, recalled that in her school, teachers engaged in "a lot of informal conversations due to our preps or our lunch" because "no one has time for anything."

Other teacher leaders who perceived insufficient time to collaborate described doing additional "legwork" to interact with colleagues, such as meeting on their own time or working to change existing school structures. For example, Morris explained that his high school math team met outside the school day:

> Of course we would meet up Saturday morning. Of course we would stay after or skip lunch during the school day… The team of teachers that I work with and the colleague at the other school that I worked with, just love math problems, you know?

Upon further reflection, Morris acknowledged that most school-based teams do not function in this way: "I'm realizing now that that's not normal. So if that's not normal but that's what it takes then how do we create the systems and structures so that it is normal and people can do it?"

Whitney, in working to create collaboration structures in her high school math department where none existed, took a very different approach. She recalled that initially, in her department "everybody was like, on their own little island" and because of high teacher turnover, "there wasn't an accountability as to what the kids had gotten, nobody knew." Whitney advocated for change, working with her principal to establish a summer planning meeting, a file sharing system for teachers to document their practices, and a monthly peer observation system. After one year of implementation, she perceived that collaboration had improved, reflecting, "We're getting there, but this is something they haven't done in the past, so in a year I did not expect us to be at 100%, but we're making strides to do that."

Knowledgeable colleagues

Teacher leaders' schools also varied in terms of their colleagues' familiarity with the new standards. Having other people in the building that were skilled and could work together fostered a sense of collective efficacy; it was not one person trying to enact change, but a team that moved forward on a goal together. The district plan intended for two or more teachers to receive training—at least in math—and provided multiple opportunities for professional learning around the standards to build teams. However, because of school turnover, and lack of time and opportunities in some schools to participate in professional learning, especially in science, not all teacher leaders had partners or teams that were working together.

In Nina's high school science department, for example, partnerships with local universities provided multiple teachers in her school with exposure to and experience with the NGSS. She recalled:

> Even before it was published, we were using the draft performance expectations and starting to think about how to redesign or refine our existing curriculum to meet those needs.

In turn, Nina did not perceive herself as the only NGSS leader in her school, reflecting, "It's not just been me by myself. It's been my colleagues and I side-by-side doing all this work." Morris, a self-described "early adopter" of CCSS-M, shared a similar experience in his high school math department, noting that he and several of his colleagues became familiar with Common Core-aligned instruction through the influence of another teacher who served as "the expert in the room." He recalled that at a certain point in time, the conversation in his department naturally shifted toward curriculum alignment, creating a natural segue for his leadership work helping colleagues incorporate standards-aligned instructional resources into their existing lessons.

In contrast, other teacher leaders found themselves as the lone messenger in a room of colleagues who were unfamiliar with the new standards and feeling overwhelmed. Thus, these teacher leaders focused on sharing information and resources supporting teachers' basic knowledge and securing additional professional development—preliminary steps for change. For example, Sandra, a middle-grade science teacher, explained:

> There's just so many components to NGSS that we just don't know where to put our focus because to focus on all three…It's supposed be like a braid of learning and it's all intertwined, but at the end of the day, it's too much.

Not wanting to overwhelm her teachers further, Sandra chose to focus on supporting only one aspect of NGSS, the Science and Engineering Practices (SEPs). To this end, she led a school-based meeting to help teachers begin to think about where they might incorporate SEPs into their instruction and gave all teachers an "SEP wheel" to hang on their wall. Three teacher leaders who sensed teachers were struggling within implementing the new standards also *advocated* for new school-wide systems to support teachers' learning and implementation of new practices. For example, Valerie described a steep learning curve for teachers in her PreK-8 school when it came to implementing the Common Core math

standards, also describing her teachers as "overwhelmed." Valerie worked with her vertical team to spearhead a system to support all teachers in providing 10 min of CCSS-M-aligned instruction per day. She recalls that "everything was given to [teachers]" including standards-aligned instructional materials, a schedule, and periodic assessments. However, she still felt that her teachers' learning needs were greater than the amount of support she could provide, stating, "There's just not enough time to cover everything that needs to be put in place."

School supports and teacher leader practices are mutually reinforcing

Teacher leader practice to promote instructional change was circumscribed by the supports and structures in their school context. At the same time, much of their work involved building better supports and structures so that they and others could take action around instructional change. For example, advocating for change could build administrator support, and broader staff commitment to instructional change. Providing individual support could lead to more trusting relationships, and more trusting relationships could lead other teachers to be inspired to learn more. Figure 3 shows this process of building supports through practices and facilitating practices through supports as a continual process of building. The practices do not necessarily have to build from one to the other; different teacher leaders take different steps. However, those represented further to the right represent a deeper engagement around change in the school and require a broader range of supports.

Advocating for change is particularly necessary when there is little support from administrators and other teachers around the change effort. It does not directly change instructional practices in the school, but it helps provide a context where others are interested and able to participate in professional learning. Providing individual support requires at least one other person who is committed to change or wants assistance. It is difficult for teacher leaders to exert their influence using any method when other teachers are not committed to the change effort. In schools where teachers have trusting peer relationships, teachers are more likely to routinely visit one another's classrooms and meet informally, which in turn supports influence indirectly by inspiring others and directly through sharing. As other teachers become inspired, they are willing to dedicate their personal time and common planning time to learning more. Sharing with others is more likely with dedicated collaboration time, trusted peer relationships, and school administrator support. Sharing with colleagues helps to build up the knowledge base around instruction in the school. Collaboration—which teacher leaders noted was associated with large-scale instructional changes in the school—requires knowledgeable colleagues who can support each other, as well as time, trust, commitment, and administrator support. Each of the supports can continually get stronger over time, facilitating more productive teacher actions, which then increase the strength of the supports, gradually building a stronger learning community.

Discussion

Making deep changes in practice is challenging for teachers, and policymakers often underestimate what it takes to realize large-scale behavior change (Hatch, 2013; O'Day & Smith, 2016). School districts face numerous inherent challenges in transforming instruction across whole populations of teachers. In the case of standards reform, which demanded significant shifts in practices, supporting teacher learning was a challenge in

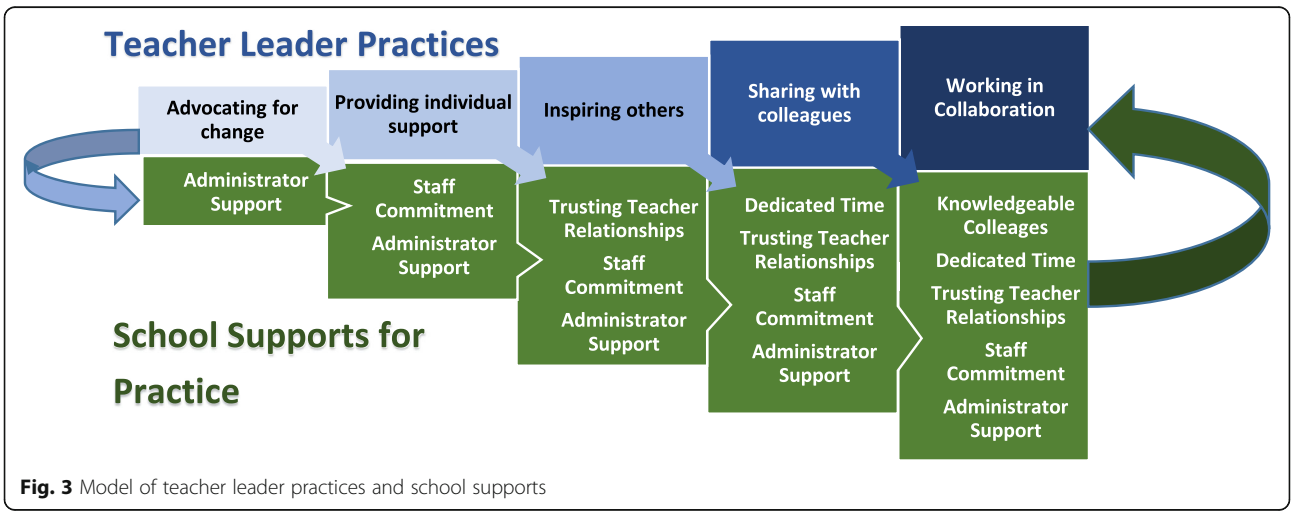

Fig. 3 Model of teacher leader practices and school supports

districts across the country. A few years after states adopted the standards, about two thirds of math teachers across the country felt that they did not have a high level of preparation to teach the new standards (Kane et al., 2016; Makkonen & Sheffield, 2016; Scholastic and Bill & Melinda Gates Foundation, 2014), especially the practice standards (Hamilton et al., 2016; Swars & Chestnut, 2016), and the majority of teachers implementing the NGSS reported the need for additional professional development (Haag & Megowan, 2015). Chicago decided to support professional learning through a teacher leader model, focused on instructional practices, and we see that students increasingly engaged in standards-aligned practices in their math and science classes during this time.

Chicago's teacher leader approach to standards implementation stands in contrast to top-down approaches of professional learning focused on uniformity of practice. In 2006–2009, for example, Chicago tried implementing a well-funded, ambitious strategy for instructional improvement in math, science, and English in 43 high schools with academically demanding, inquiry-based curriculum, sufficient materials for implementation, common assessments, directed professional development, and intensive coaching. While many teachers started off with enthusiasm about the new curriculum, they struggled to implement the challenging, student-centered tasks, and by the end of the year, many had reverted to traditional ways of teaching; after three years, the strategy was abandoned (see Sporte et al., 2009). The history of education reform has these kinds of examples, of what has been called in Improvement Science as "implementing fast, learning slow," where full-scale implementation results in failure, burn-out, and little learning or improvement (Bryk et al., 2015). Implementation of the CCSS-M and NGSS in Chicago could have easily had the same results.

The opposite to "implement fast, learn slow" is to "start small and learn fast," for example, through a networked improvement community that focuses on a common aim (e.g., new instructional practices), guided by an understanding of the problem, where implementers share knowledge as they learn from implementing what works in different contexts (Bryk et al., 2015). While not a formal networked improvement community, the district's implementation process had elements that were similar—teacher leaders were part of networked communities of teacher leaders focused on a common aim, with workshops to develop a deep understanding of the instructional practices, encouragement to try new learnings out and experiment, and then supports to share their experiences with other teachers in their school, and share learnings across schools with other teacher leaders through the TLIs. Instead of showing other teachers what to do and exerting their authority as trained experts, teacher leaders tried to build buy-in by inspiring others and then sharing practices and resources when others expressed interest in learning more. Instructional change involves numerous risks for teachers (see LeHavre, 2014; Kennedy, 2005), and this process minimized the risks that are inherent in trying new practices, allowing teachers to do what they felt they could, and to build on what worked for them. Teacher leaders received support from the TLIs and had a network of other teacher leaders and experts with whom they could collaborate, both in their school and in other places in the district. The decision to identify multiple teacher leaders per school boosted a sense of collective efficacy, so that teacher leaders felt they had knowledgeable colleagues to collaborate with in their schools. At the same time, there was considerable variation across schools in implementation, suggesting that attention to school organizational supports could facilitate changes more quickly.

While teacher leaders were the focus of change efforts, principal leadership was crucial for supporting the conditions that facilitated the practice of teacher leadership in the school. School administrator support came not only from promoting the goals of the standards in principle, but also from working with the teacher leaders to establish and support structures around collaboration and learning, setting goals around instructional change in the school, making sure there was dedicated time for professional learning, and providing help around facilitating meetings. When there is little administrator support, teacher leaders must work to build that support from the school principal by advocating for goals, vision, professional development, and structures to promote change. Opportunities for some school principals to engage in training around the new standards provided some teacher leaders with advocacy that made it easier to encourage change in their schools.

Given the importance of administrative support in creating conducive school contexts for effective teacher leadership, districts may consider the best ways to involve principals and other administrators with decision-making authority in district-wide change initiatives so they can better support teacher leaders. This could involve increasing their awareness of what makes for supportive school conditions for teacher leaders to effectively facilitate instructional change. For example, school and district leaders may benefit from knowing how teacher leaders would answer questions such as:

- Do teachers in my building feel comfortable working together?
- Do teachers in my building feel comfortable working with me?

- Do I have sufficient time, space, and resources to support instructional change?
- Does my school leader prioritize the change effort?
- Do other teachers in my building have a foundational understanding of the change effort?
- Are other teachers in my building motivated to change their instruction?
- Does my school have structures in place for communication and collaboration?
- How might we capitalize on existing collaborative work?

These reflections could then be used to both suggest courses of action for teacher leaders and inform the ways in which principals and district staff provide customized support for teacher leaders in different circumstances (e.g., those without a base of knowledge in their schools, those with few colleagues to collaborate with, and those more advanced in their efforts to implement standards-aligned instruction).

This study involved teacher leaders working in the context of standards reform, but the patterns of teacher leader action and variation in school contexts are relevant to any policies or interventions that rely on a teacher leadership model to bring about instructional change. The modes of influence identified here were similar to those identified by Fairman and Mackenzie's (2015) study of teacher influence under normal conditions, suggesting they could be used as a base for further refining and articulating the work of teacher leaders. Future professional learning models may support teacher leaders in developing customized action plans by providing opportunities for teacher leaders to reflect on their school's needs and the supports that exist, then helping them consider the full range of ways they can exert their influence.

Study limitations and future research

Our qualitative study focused on understanding the *attempts* that teacher leaders made to influence instructional change; we did not gather data to determine the extent to which colleagues of the individual teacher leaders that we interviewed *actually* changed their instruction, and if so, how much those changes were associated with standards-aligned instruction. As shown with the quantitative data, student-reported data suggest there were significant changes in instructional practices in math and science in the district under this model, and teacher-reported data suggest the largest sources of professional learning around the standards came from sources located inside teachers' schools. However, whether the school of any individual informant was successful is not known. These findings lay the groundwork for future research about the efficacy of strategies to promote instructional change through teacher leadership by identifying key variables—methods of influence and school-level factors—that can be used in further research investigating relationships between teacher leader practices, school contexts, and instructional outcomes.

Additional research is needed to verify the phenomena we have uncovered in terms of both methods of teacher leader influence. Our teacher leader sample is small, representing individuals who were fully engaged in the CPS teacher leader model and motivated to participate in research; it was not a random sample of teacher leaders. While we made efforts to represent a range of schools, it is possible that selection bias influenced the themes identified. We also acknowledge the limitations of retrospective recall, which is subject to inaccuracy and omission of details, as described previously. It would be valuable for the field for a future study to interview or observe teacher leaders as they engage in their work, as well as measure the perceptions of others in the school to corroborate impressions of instructional change among colleagues. An additional study limitation concerns our appraisal of methods of influence and school-level factors based on the perspective of one or two informants per school; ideally, data would be gathered from multiple sources of data and corroborated. Follow-up studies may capture the behaviors and impressions of teacher leaders "in real time" or use longitudinal methods to track changes in these variables over time.

Conclusions

Teacher leaders not only engage in practices that directly involve the discussion of instructional change, but work to build the supports that allow for a greater focus on instructional change in their school. In schools with insufficient organizational supports, teacher leaders must spend more time building the conditions that would support work on instructional change. The identification of school-level supports and barriers to specific methods of teacher leader influence has practical implications for schools and districts, like CPS, that seek to use a teacher leader model as a mechanism to scale standards-aligned instruction. The five methods of teacher leader influence, together with the five factors supporting teacher leader influence, could be used as a framework for guiding future research on teacher leadership and for guiding teacher leader initiatives in the future.

Abbreviations

CCSS: Common Core Standards; CCSS-M: Common Core Standards for Mathematics; CPS: Chicago Public Schools; NGSS: Next-Generation Science Standards; PL: Professional learning; SEP: Science and Engineering Practices; TLIs: Teacher Leader Institutes

Supplementary Information

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Additional file 1. Selected codes and definitions.

Additional file 2. Survey measures.

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Declarations

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Authors' contributions

AC directed the qualitative data collection and analysis for this manuscript including planning qualitative research activities; ensuring internal review board compliance; sampling, recruiting, and scheduling participants; collecting and reviewing district documents; developing interview protocols; conducting in-depth interviews; coordinating data collection across team members; coding interview data to discover patterns and relationships; synthesizing and presenting key findings in the article, and writing the first draft of the manuscript. Dr. Cassata conducted the research while at the University of Chicago. She is currently a Senior Consultant at Insight Consulting Group. EA was PI on the larger project and for this manuscript she conducted the quantitative analysis and wrote the quantitative sections; helped develop the framing, discussion and model of practices and supports; produced the three figures; led revisions of the manuscript through the review process. Both author(s) read and approved the final manuscript.

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Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Competing interests

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