

RESEARCH ARTICLE

The emergence of science teacher leadership in the context of the pursuit of teaching science for social justice

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Email: emily.lisy@uconn.edu**Abstract**

As a result of more recent events connected to the ongoing and lasting legacy of systemic racism in our society and the sparsity of research focused on both disciplinary teacher leadership (TL) and centering social justice and equity in teacher leadership literature reviews, this research investigated the ways in which science teacher leadership (STL) emerged in the context of a science department engaged in a year-long professional learning experience aimed at teaching science for social justice. Drawing on a community of practice teacher leadership identity model as a theoretical framework and qualitative research methods, we sought to characterize STL that centered social justice. Written teacher reflections, semi-structured interviews, and science lessons were collected from the six female science teachers and a female school administrator. The research revealed how STL supportive of teaching science for social justice was grounded in, among other characterizations of teacher leadership, competences like content and pedagogical knowledge, performances like inclusiveness and lesson design, and support from the structure of the year-long professional learning, and engagement in a community of practice. This research provides insights into the complex characterization and emergence of STL.

KEYWORDS

science teacher leadership, teacher leadership identity, teaching science for social justice

1 | INTRODUCTION

Wenner and Campbell (2017) in their review of teacher leadership, among other important findings, noted the scarcity of research focused on social justice and equity and disciplinary (e.g., science, math) teacher leadership. While research has increasingly focused on science teacher leadership since Wenner and Campbell's review (e.g., Barth et al., 2023; Criswell et al., 2018; Heredia et al., 2023) and a few examples can be found detailing the roles teacher leaders can play in connection to social justice and equity pursuits (e.g., Wenner & Campbell, 2018), research focused on the intersection of social

justice and equity and disciplinary teacher leadership is sparse. Given this, the current study examined the emergence and characteristics of teacher leadership within a secondary science department that took on the challenge of teaching science for social justice. It investigated the ways in which teacher leadership emerged and was characterized and supported when teachers were empowered, provided agency and time to learn about and develop, implement, and refine approaches for teaching science for social justice.

At the time of this research and during the COVID-19 pandemic, many social injustices became even more apparent (Abraham et al., 2021; Burgess et al., 2022; Diaz

et al., 2022). As schools are situated in communities where these injustices are felt the most (communities with lower socioeconomic status and predominantly marginalized student populations), teachers and teacher leaders were even more likely to concern themselves with or be positioned to find ways to address these injustices (Verma et al., 2020). Specifically related to teacher leaders, researchers like Criswell et al. (2018) explain how teacher leaders might play a role in addressing concerns like social injustices, since they are “able to empower others to promote change” (p. 1275). More specifically, teacher leaders can take risks by integrating community issues involving social justice into their classrooms and encourage collaboration with other teachers to promote change. Further, communities of practices (CoPs) of teachers, or groups of teachers with common interests and commitments engaged in similar pursuits (see Lave & Wenger, 1991; Wenger, 2000), can explore how science education can be used as a tool for social justice, while also supporting the development of ways to implement more critical and culturally relevant (Ladson-Billings, 1995) and responsive (Gay, 2000) teaching pedagogies. However, Criswell et al. (2018), and others (e.g., Park et al., 2024), stress how professional learning opportunities and collegial support are both crucial for teachers’ emergence as teacher leaders in these communities.

A community of practice can provide a supportive and collaborative environment that can help to foster science teacher leadership (Barth et al., 2023; Lotter et al., 2020; Park et al., 2024). These communities can afford science educators, both experienced and less experienced, opportunities to share their developing and expert knowledge of teaching (Bell, 2019) and pedagogical strategies rooted in experiences, resources, lesson plans, and other educational materials. Further, engaging with a community of practice affords teachers space for collaborative problem solving when taking on complex challenges like teaching science for social justice (Leonard & Woodland, 2022). More specifically, when science teachers work together to elevate a focus on social justice in classrooms they can provide peer emotional support and encouragement (Lisy & Campbell, [under review](#)). In the context of our research, we acknowledge that the concept of teaching science for social justice has been framed by several equity discourses as highlighted by the National Academies of Sciences, Engineering, and Medicine (NASEM, 2022) and Philip and Azevedo (2017). Our previous research (Lisy & Campbell, [under review](#)) surfaced that in the department in this study, teaching science for social justice emphasized increased achievement, representation, and identification with science. Additionally, the department positioned science as a tool for social transformation in connection with social justice

movements (NASEM, 2022). This involved, among other teaching practices, teachers that actively planned for examples to use in the curriculum throughout the year that highlighted diverse representation and designing sensemaking opportunities for students focused on data about particular equity and social justice issues like the geographic distribution of asthma rates situated in the communities where students lived, respectively.

Given the promise of communities of practice for supporting the emergence of teacher leadership and the challenges and complexity of teaching science for social justice, the following question guided our research: Within a science department, how was the emergence of teacher leadership connected to the pursuit of teaching science for social justice characterized?

More about the methods we used to answer our research question are shared in the methods section, but first we provide literature and the theoretical framework we used to orient to disciplinary teacher leadership aimed at the pursuit of teaching science for social justice.

2 | LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 | The emergence and development of teacher leadership

The emergence of teacher leaders presents a challenge in the field of teacher leadership, as highlighted by Trabona et al. (2019), who points out the scarcity of research on “how emerging teacher leaders navigate the structure of schools and districts, build collegial relationships, encourage collaboration, and foster educational improvements at the classroom level” (p. 472). Wenner and Campbell (2017) also identify how there is a lack of information about teacher leadership in certain disciplines such as science. Recently, teacher leaders were named not by titles, but by the actions teachers took to improve the school such as mentoring and forming professional learning communities, among others (Barth et al., 2023; Heredia et al., 2023). A community of practice beyond the classroom offers teachers the chance to develop an ongoing, broader leadership perspective (Jacobs & Crowell, 2018) that can shift teachers’ identities to include that of becoming teacher leaders (Barth et al., 2023). There are also qualities of an effective community of practice that help teacher leadership identities emerge including knowledge sharing, support, role models, alternative perspectives, and a sense of kinship among like-minded professionals (Barth et al., 2023; Park et al., 2024). In fact, Barth and colleagues revealed how teacher leaders emerged when being challenged to do more in a positive and supportive environment. The

principals' support (Cassata & Allensworth, 2021; Cooper et al., 2016; Ryan et al., 2017; Sebastian et al., 2016) and relationships in collaborative work (Bae et al., 2016; Cassata & Allensworth, 2021; Fairman & Mackenzie, 2015) are also instrumental in teacher leader development. Science teacher leaders have also emerged through efforts to reorganize classroom instruction to reduce harm to marginalized students (Heredia et al., 2023). Teacher leaders can help to model professional attitudes and dispositions to improve colleague's teaching and learning, build a collegial climate, and change structures for students and teachers (Fairman & Mackenzie, 2015). In this context with the teacher leader's important role, researchers like Criswell et al. (2018) characterize teacher leaders as individuals that are fully functioning, a reflective practitioner, learning partner, and scholar. Criswell et al. (2018) also points out that teacher leaders as scholars can be producers of knowledge.

Additionally, Park et al. (2024) discovered that CoP networks offer another productive space for cultivating the development of teacher leaders. Specifically, CoP networks offer structural elements that enable teachers and teacher leaders to engage in collaborative efforts with fellow educators, which can accommodate the exchange of interests and resources. Cole and Schlechty (1992) called for "teachers to be leaders—leaders that blaze trails into areas untouched by current educators" (p. 135) saying that teacher leaders can develop in environments that "demand reflection" (p. 136). Our research aims to contribute to a deeper understanding of how science teacher leaders emerge in educational contexts. By examining the role of CoPs, we seek to provide insights that can inform the development and support of science teacher leaders, especially as they orient to social justice and equity as an aim of their pursuits.

2.2 | Science teacher leadership connected to teaching science for social justice

York-Barr and Duke's (2004) literature review focused on teacher leadership found no studies with reference to social justice. Wenner and Campbell (2017), in their review of the literature more than two decades later, found very little research focused on teacher leadership and social justice. In a study by Jacobs and Crowell (2018), it was found that critical self-reflection, reframing, and changing classroom practice were important for social justice teacher leadership. More recently, studies can be found that focus on teacher leadership and social justice (Gümüş et al., 2021), but not specifically about science teacher leadership connected to social justice.

Jacobs and Crowell (2018) examined a graduate program focused on teacher leaders' development in relation to social justice and found that promoting critical consciousness is a key piece of this development. Beyond this, there are numerous studies that focus on social justice science teachers (Braaten & Sheth, 2016; Carlone & Johnson, 2007; Rivera, 2013) and teaching social justice in science (Dimick, 2012; Morales-Doyle, 2017; Philip & Azevedo, 2017; Rodriguez & Morrison, 2019), however, none of these studies considered teacher leadership.

When considering teacher leadership development more generally, Luft et al. (2016) identified how any framework for leadership development should include "opportunities to learn among other teachers, and an individual professional learning plan that has specific learning objectives." (p. 8). Luft and colleagues also found that areas that supported teacher leadership development were the "community of teachers and new opportunities to engage in leadership experiences." (p. 8). Professional learning communities (PLCs) at their best can support the discussion of experiences, build on current knowledge, and offer latitude for teachers to focus on what they want to learn (Leonard & Woodland, 2022; Luft et al., 2016). Specifically, Leonard and Woodland's research found how PLCs are an effective model of professional development for antiracism and the transformation of teacher identity. Our research aims to bridge this gap, by specifically exploring the intersection of science teacher leadership and social justice and equity. In addition, we hope to contribute to the understanding of how educators can lead initiatives promoting social justice and equity within science education.

2.3 | Theoretical framework

The Communities of Practice Teacher Leadership Identity Model (CoPTLM) (Campbell et al., 2019) provides a theoretical framework for understanding teacher leadership by emphasizing the importance of participation in communities of practice. It was developed out of and aligns with Wenner and Campbell's (2017) definition of teacher leaders as, "teachers who maintain K-12 classroom-based teaching responsibilities, while also taking on leadership responsibilities outside of the classroom" (p. 7). According to the CoPTLM, teacher leaders develop their leadership identity through engagement in learning together, sharing expertise, and collaborating within communities. The CoPTLM draws on Carlone & Johnson's (2007) framework as a foundation to characterize TL identity with respect to the following three constructs (i.e., central dimensions of identity):

- Competence—knowledge and understanding of supportive leadership pursuits.
- Performance—social performances of relevant teacher leader practices.
- Recognition—recognized by oneself and recognized by others as a teacher leader.

Beyond these three main constructs of identity, the CoPTLM (Campbell et al., 2019) also takes into account the following:

- CoPs—the groups with common interests and commitments engaged in similar pursuits where teacher leaders' work resides
- Structures—cultural and community schemas and accompanying resources that shape social action
- Teacher-Lens—the perspective and insights teachers have about classrooms based on their day-to-day responsibilities and commitments
- Dispositions—consistent dimensions of human personality that manifest in behavioral patterns.

How all of these features of the CoPTLM interact and intersect to characterize teacher leadership can be seen in Figure 1. For example, in Figure 1, it can be seen how CoP's might overlap (i.e., CoP #1 and CoP #2 in the figure) and how each develops competences, performances, and internal and external recognition and each CoP is overlaid on structures, teacher-lens, and dispositions that support the aims of the respective CoPs in which TLs engage.

This model integrates well with the context and goal of teaching science for social justice. The model's emphasis on recognizing teacher leaders through performances and knowledge within a CoP aligns with our examination of teacher leadership within a science department pursuing teaching science for social justice.

3 | METHODS

This case study investigated the use of a professional learning plan (PLP) which is a form of action inquiry, by a science department of six teachers in a suburban school district designed and enacted across an academic school year focused on teaching science for social justice. Science teachers were provided with opportunities to collaborate, reflect, and share their professional practice with support from science department peers and their administration. Our research examined how science teacher leadership was characterized and supported during these pursuits. Data consisted of semi-structured interviews with groups of science teachers and an administrator as well as artifacts of the PLP and lesson plans. This research was granted approval by the institutional review board and carried out with compliance with the ethical standards from the authors' institution. To safeguard the privacy of the participants, pseudonyms were consistently used throughout the study.

3.1 | Context

This research was conducted at a suburban public high school, grades 9 through 12, with a total student population of 564 during the academic year 2021–2022. The student demographic composition at this school primarily consists of White students (80.1%), followed by Hispanic students (14.2%), Asian students (3.5%), individuals of two or more racial backgrounds (1.4%), American Indian/Alaska Native students (0.4%), and Black students (0.4%). Notably, 30% of students come from economically disadvantaged backgrounds, and 31% are eligible for free or reduced lunch, according to the U.S. News and World Report's (2022) Best High School Rankings for 2022.

Within the school district in this study, each year teachers undergo evaluations that use a variety of

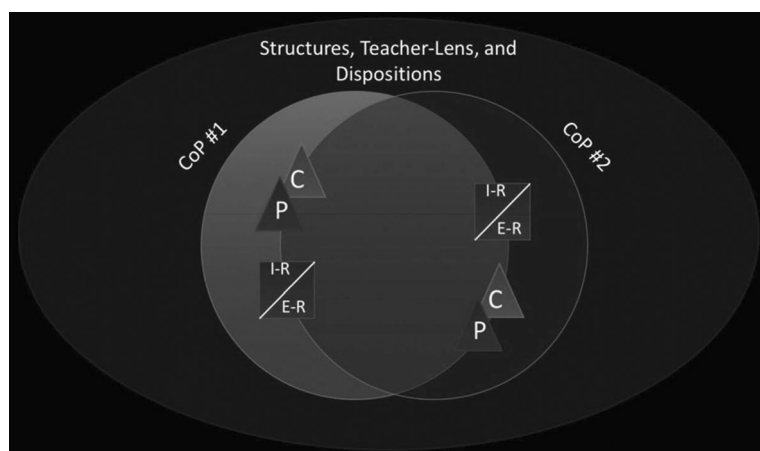


FIGURE 1 The community of practice teacher leadership model (Campbell et al., 2019, p. 190).

assessment methods including classroom observations, test scores, student and parent surveys, as well as the creation and execution of professional learning experiences. The teacher evaluation process involves the development and implementation of a professional learning plan (PLP). The PLP is aligned to district and school objectives and allows teachers to set professional learning goals that help to improve their instructional practices through reflection (action inquiry). This process is dependent on the structures in the school district and affords teachers the opportunity to engage in authentic learning, reflect on practices, collaborate and make changes in the classroom (Ryan et al., 2017). During the academic year in which this study was undertaken, the science department adopted the same district, school, teacher, and student goals for their science classrooms.

The PLP has two sections, one for teacher goals and another for student goals. In each of these sections, there are action steps (activities, strategies, and resources), criteria for measuring progress and success, and a time-frame for completing each step. Teachers provide a summary of their progress halfway through the year and at the end of the year. At the end of the year, teachers provide a summary of the results based on each of the action steps and also a reflection evaluating the extent their goals were achieved. Teachers also reflected on how their results and new learning can be applied to future teaching and learning.

The science teachers at this school met formally once or twice a month during science department meetings and professional development time. The science department meetings generally took place after school and lasted an hour, while the professional development time was part of early release days at school and lasted approximately 4 h. These meetings were time for collaboration, lesson planning, resource sharing, and peer critique as teachers worked through the action steps in their PLP. Additionally, informal discussions among science teachers regarding lessons and teaching strategies happened often.

During the academic year of this study, the science department identified social justice and equity within science as the central focus of their professional learning plan. This decision was influenced by multiple factors. These factors included the female makeup of the science department, composed largely of individuals who had previously worked in nonteaching science roles, as well as ongoing discussions about gender disparities in science and broader conversations about social justice issues. Some teachers had already incorporated lessons and conversations about social justice in their classrooms before it was the focus of the PLP. Students also expressed interest in exploring social justice topics in their science

classes particularly those who learned about it in their English classes. Additionally, the period in which this study took place saw a rise in awareness of systemic racism which contributed to the department's emphasis on addressing societal injustices.

3.2 | Participants

During the 2021–2022 school year, this study involved the participation of six science teachers and one administrator. All participants were female and identified as White. Teachers in this study had teaching experience ranging from 1 to 19 years (see Table 1 for teacher and administrator participant demographics and information).

3.3 | Data collection

Data collected included: each teacher's end of year PLP with teacher reflections and application to future teaching and learning, semi-structured interviews, and lessons the teachers developed. The interviews each lasted approximately 90 min and were completed in groups of 2 or 3 teachers. In addition, an individual, approximately 90-min, semi-structured interview was also completed with the school administrator. All interviews were audio recorded and transcribed. The semi-structured interview protocols were developed to elicit both the details about the approaches teachers used to teach social justice and equity and the equity discourses they used to frame their work. As well, because of the nature of data collected, data from the semi-structured interviews and other artifacts collected also supported our characterization of teacher leadership. With the exception of one interview, all were conducted by the first author who served as both a researcher participant and the department chair. As the first author was also a teacher in the department and participant in the study, the second author interviewed her. Additionally, the first author contributed the same artifacts as the other participants in the study. The PLPs, interviews, and lesson plans were collected to triangulate the data (Creswell, 2013; Creswell & Miller, 2000) and provide a breadth of complementary artifacts to afford a "thick" description of the phenomenon (Geertz, 1973; Lincoln & Guba, 1986).

An initial a priori coding framework was established. The codes listed here were designed to capture meaningful content related to the research question about how the emergence of teacher leadership in science is characterized and supported in a science department engaged in the pursuit of teaching science for social justice. These codes were derived from the work of Campbell et al.

TABLE 1 Participant information.

Teacher name	# of years teaching	# of years teaching at this school	# of years in another career	Demographics	Science subject area/primary grade level(s)	Teacher training
Anne	11	4	10	White female	Biology (9/10)	Master's degree in education
Beth	12	12	8	White female	Chemistry/Forensics (11/12)	Alternative route to teacher certification and master's degree in science
Clara	19	7	0	White female	Physics/Integrated Sci. (9–12)	Master's degree in education and additional master's degree in science
Dawn	18	9	1	White female	Anatomy/Env. Sci (11/12)	Alternative route to teacher certification and master's degree in science
Elizabeth	1	1	0	White female	Biology/Integrated Sci. (9/10)	Master's degree in education
Francesca	10	2	0	White female	Chemistry/ Integrated Sci. (9–11)	Master's degree in education and additional master's degree in science
Admin. name	# years as admin.	# of years as Admin. At this school	# of years teaching before becoming an admin.	Demographics	Subject area when a teacher	
Gwen	15	15	12	White female	History	

Note: All names of participants are pseudonyms.

(2019). Initially, interviews were coded using the a priori codes. The same process was applied to code lesson plans and PLPs.

3.4 | Data analysis

A modified approach based on Groenewald's (2004) phase strategy was used to guide the data analysis process. This process used a set of predetermined a priori codes to identify and categorize units of meaning identified with the data. Once identified and coded, units of meaning (i.e., any segment of data thought useful in answering our research question) were organized into overarching themes. These themes were then used to provide insights into the research question.

When coding interviews, PLPs, and lesson plans, intercoder reliability (ICR) was established. This was done by having both researchers independently review a subset (10%–25%) of the interview transcripts, PLPs, and lesson plans before comparing codes. This process was used to encourage reflection and discussion to enhance the credibility of the analysis (O'Connor & Joffe, 2020).

The ICR values, calculated based on percent agreement between coders, were as follows: 0.93 for interviews, 0.91 for PLPs, and 1.00 for lesson plans. According to Krippendorff (2004), ICR values between 0 and 0.20 are considered slight, 0.21–0.40 is fair, 0.41–0.60 is moderate, 0.61–0.80 is substantial, and 0.81–1 is nearly perfect. After establishing ICR, the first author continued coding the remaining interview transcripts, PLPs, and lesson plans, regularly consulting with the second author to discuss the data. Any uncertainties or disagreements during the ICR process or coding prompted a discussion and revisit to the source material. To increase the trustworthiness of the findings, a triangulation approach was used, cross-referencing data from interviews, PLPs, and lesson plans to identify any discrepancies. This helped to guard against potential biases that may have gone unnoticed if interviews had been the sole data source.

As an additional measure to enhance the credibility of the findings, a member-checking process was conducted with the study participants (Creswell & Miller, 2000; Lincoln & Guba, 1986; Stake, 1995). This process involved sharing the research question and the themes derived from the code analysis with the

participants. Participants were encouraged to review the research question and findings, providing feedback as they reflected on their experiences within the department throughout the academic year.

4 | FINDINGS

In this study on science teacher leadership, characteristics and support for teacher leaders as part of the CoPTLM were explored in depth. In connection to characterizing teacher leadership, teacher leaders' understanding of science content and pedagogy connected to teaching science for social justice was important. The competence in science they drew on supported them in developing instructional strategies and meaningful learning experiences for students that integrated a focus on social justice and equity in the curriculum. Teachers either recognized themselves as teacher leaders or were recognized by others as teacher leaders, something that was consequential for motivating teachers to continue to advocate for social justice in science education. The supportive structure of the PLP and the school buoyed a commitment to action inquiry, teacher reflection, and discussion of teacher learning throughout the academic year. The freedom, trust, and support from administration as well as support from colleagues was found to be important for risk taking and challenges that teachers faced. Ultimately, we found that the characterizations of teacher leadership identified were supported through opportunities for content and pedagogical connections and knowledge generation, community building and inclusiveness, the collaborative design of lessons, and being comfortable in the classroom.

4.1 | TL characterization

In this section, we examined the characterization of teacher leadership as it emerged during the implementation of teachers professional learning plans and social justice and equity lessons they developed and enacted in science classrooms. Tables 2 and 3 provide a comprehensive overview of the key findings organized by the features of the CoPTLM, as well as example quotes helpful in exemplifying each key finding. Following the tables, a detailed discussion of the CoPTLM model is provided, organized around the three primary teacher leadership identity constructs (competence, performance, recognition). The teacher lens and dispositions are interwoven into the discussion on the three primary identity constructs. Additionally, a separate subsection explores the structures associated with the CoPTLM.

TABLE 2 TL characterization with competences, performances, and forms of recognition.

Competences	Performances	Forms of recognition
Content knowledge	Inclusiveness	Self-recognition
Pedagogical knowledge	Design of lessons	Recognized by others

Competences

Content knowledge and pedagogical knowledge—I focused on environmental justice... from some of the survey data, kids didn't even know definitions of equity or social justice... So, instead of looking at gender discrimination and science, I wanted to find [a lesson] I could incorporate into what I was teaching so it didn't seem like it was separate and something different that they were never going to see again... looking at data that they could draw their own conclusions and actual data like that...is relevant to where they live... [I got] them to come to their own conclusions where they're like yeah, this actually makes sense...We looked at air pollution [and asthma rates in communities] which helps [students] understand why we were learning what we were learning (Francesca, Interview).

Performance

Inclusiveness and design of lessons—When [students] looked at case studies of injustices within medicine or science I think they had more empathy ... because they knew it actually happened versus some theoretical happening ... I think it generated a sense of agency because I had them write additional questions they had so that really fostered a discussion after each lesson ... A lot of students were more vulnerable in those discussions because they were talking about certain topics they weren't necessarily comfortable with, but it created a safe space for them (Elizabeth, Interview).

Recognition

Self-recognition—I would consider myself to be a teacher leader. I really like mentoring new teachers officially or unofficially...I just think that being a teacher leader is helpful to everybody and everybody's learning. (Clara, interview)

Recognition by others—I also think of you as a leader in the chemical department... you're the expert, you know everything. (Clara recognizing Beth, Interview).

4.1.1 | Competences

Science content and pedagogical knowledge as well as new knowledge generation were found to be important for teachers when teaching science for social justice. Equally as important were teachers' reflections and dispositions of openness to student viewpoints and willingness and humility to consider students' perspectives as valuable classroom contributions. For example, in the quote in Table 2 from Francesca illustrating competence,

TABLE 3 TL characterization with structure, teacher lens, and dispositions.

Structure	Teacher lens	Disposition
PLP/action inquiry	Bridge building	Openness
Support (peer/administrative)	Empathy	Humility
Structure		
<i>PLP</i> —I think it [the PLP] brought us closer as a department, because no matter what subject we are teaching, we are all going through the same sort of thing, teaching new social justice concepts in our classes. (Elizabeth, interview).		
<i>Action inquiry</i> —[From the data collected]. I think just how to apply it better and how to make it more relevant to students and how to not just teach for me to not just teach things that have happened in the past, but teach how to approach the future I guess, and approach their thinking. (Anne, Interview).		
<i>Support (peer)</i> —I think of when it got difficult initially [with parent push back] we all supported each other [in the department] and I think that was super helpful. We decided we were all going to be brave together and how we're going to go forward. I think if I had just been me, I would have just given up, but knowing that everybody else was going to keep trying (Anne, Interview).		
<i>Support (administrative)</i> —I felt like you were supported. Even when there was some negative parent feedback, it was very quick that the administration came and said, you know, we know you're doing this, we think it's worthy and keep doing what you're doing. I felt like that was good because it wasn't ever the climate where I was worried about my job. I would have been worried in other places (Anne, Interview).		
Teacher lens		
<i>Bridge building/empathy</i> —...before you can talk on the topic [you need] to have a basic understanding or do your research and let the kids know that you're not an expert, but you're learning as well because it's constantly evolving and changing. We do more research and our own ideas change. So that gets into the open mindedness and being empathetic... I think you have to have a foundation of a good relationship with the students that you're teaching these lessons with so that they feel vulnerable or safe talking about these topics and the same thing with your colleagues...I felt that just being more comfortable talking to kids about race through these lessons has been easier to kind of bring awareness to them about how these problems do exist...(Francesca, interview).		
Disposition		
<i>Openness</i> —In the classroom, ... [I] kind of let it flow and let the conversation go and see where it leads and really listen to kids ... I also think it's really important to be open ... I think in science there's kind of the old school like I am right I have all the answers, and just kind of moving away from that and knowing you don't have all the answers when it comes to this kind of conversation [i.e., social justice related issues] and the kid's perspectives who are in your room it's really important to listen to (Clara, interview).		
<i>Humility</i> —I've also told students in my class who brought up a perspective or thought of something in a completely different way... When someone thinks about something that I've thought about... and suddenly they bring in this new perspective I may not necessarily agree with them, but I really enjoy that kind of [perspective] I need to step back and reassess my whole thought process (Beth, Interview).		

she incorporates environmental justice into the chemistry classroom to support students' developing understanding of social justice and equity. By focusing on a topic like air pollution and asthma rates in local communities, Francesca not only engaged students but drew on her content knowledge in chemistry to connect the lesson to the curriculum on chemical reactions. Drawing on pedagogical knowledge, she used local data to facilitate a more meaningful learning experience that afforded students opportunities to draw their own conclusions related to social injustices and recognize how examples of social justice connected to their own lives and communities.

As well, science teachers' content and pedagogical knowledge was shared in this community of practice throughout the school year which helped other science teachers consider knowledge applications and pedagogical strategies in their own classrooms. As Dawn stated in an interview, “even just kind of reflecting on what some

of the teachers learned as they were doing it [enacting a specific social justice focused lesson] and what they even heard from students that they may never even thought of before” helped teachers develop and draw on their emergent pedagogical knowledge as they considered ways to teach science for social justice.

Teachers' dispositional stances of openness and humility supported them in recognizing the context-specific nature of how science and society intersect in connection to social justice concerns. Teachers emphasized the importance of open and receptive attitudes and understanding diverse perspectives that, at times, challenged their own perspectives. Clara shared the value of active listening and fostering classroom discussion that flowed naturally as a way of developing an appreciation and recognizing the significance of students' viewpoints. In Beth's interview, she shared a willingness to reconsider her own beliefs when presented with alternative

viewpoints, demonstrating the reflective nature of teaching science for social justice. Teacher content and pedagogical knowledge fostered opportunities that were complemented by dispositions of openness and humility in ways that created inclusive environments where teachers reported students being more comfortable sharing their diverse perspectives.

4.1.2 | Performance

Teachers' performances identified were creating classroom climates of inclusiveness and the design of lessons. The teacher leaders accomplished this through focusing on community building and inclusiveness inside and beyond the walls of their classroom. The design of the lessons that fostered an inclusive classroom climate and their comfort level in the classroom were key elements to these performances. Having a community of inclusiveness where teachers and students felt comfortable and safe talking about issues of social justice and equity was important for both teachers and students in classrooms. Francesca (Interview) reiterated this,

... You have to have a foundation of a good relationship with the students that you're teaching these lessons with. So that they feel vulnerable or safe talking about these topics.

As part of lesson design, the use of real-life case studies when teaching social justice in science showcases this form of teacher performance. In an example in Table 2, Elizabeth not only deepened student engagement and empathy, but also fostered a sense of student agency as they explored asthma rates locally. This demonstrated her ability to design lessons that elicited meaningful, open discussions from students connected to their communities and lives. In addition, this teacher's performance of integrating case studies as part of lesson design, fostering empathy, and facilitating open discussion helped foster a more inclusive learning environment.

Further in Table 3, Francesca emphasized the importance of cultivating a receptive and empathetic teaching perspective or teacher lens. This empathetic teacher lens fostered a comfort level in addressing discussions of subjects like race as a way of building bridges that connected matters of social justice to matters of science.

4.1.3 | Recognition

The science teachers in this study either recognized themselves as teacher leaders or were recognized by their colleagues or administrators as teacher leaders. However,

some did not think that they emerged as teacher leaders as part of their engagement in the PLP. Some may have already thought of themselves as teacher leaders before this project based on other work that they had done or were recognized by others for work that they had done previously in other CoPs. Teachers thought of themselves as teacher leaders if they helped to mentor new teachers or if they were willing to listen, share, and offer suggestions to other teachers. As Francesca said in her interview, "I [consider myself] a teacher leader at least within the department through collaboration with all of you."

In Table 2, Clara recognized herself as a teacher leader, emphasizing the importance of mentoring and fostering collaborative learning to benefit others. Although Beth did not recognize herself as a teacher leader, Clara recognized her as a teacher leader for her work and her expertise in Chemistry. This demonstrated how teacher leaders can be recognized not only through mentorship and collaboration, but also as a result of their disciplinary expertise (e.g., chemistry). This also illustrated more diverse examples of recognition for teacher leaders that are possible beyond more formal roles/titles. Interestingly, though, some teachers did not recognize themselves as teacher leaders even as evidence was found related to them being engaged in the process of developing as teacher leaders, in relation to teaching science for social justice. They felt like they were still learning and instead focused more on recognizing themselves as learners as Elizabeth (a first-year teacher) stated in her interview, "I continue to grow moving forward. I don't feel like I've mastered it yet, but I have made a good step forward this year." Others did recognize themselves as teacher leaders, "I continue to grow and continue to try different things [teaching social justice in science], I think that I would be considered a teacher leader" (Dawn, interview). While some teachers were hesitant to self-identify as teacher leaders, particularly in the context of teaching science for social justice, they did, however, share a commitment for ongoing learning about social justice and equity and fostering inclusive learning environments. This hesitation comes from the teachers' awareness that they had only recently begun to engage in the challenge of teaching science for social justice and did not perceive themselves as experts yet. The awareness of their ongoing growth in this field positions them as emerging teacher leaders in relation to teaching science for social justice.

4.1.4 | Structures

PLP/action inquiry

The structure of the PLP focused on collecting data from students as part of action inquiry to reflect and refine

lessons to improve instruction. This structure and commitment to action inquiry throughout the year provided infrastructure supportive of teachers as they engaged in this work. Science teachers collected baseline data in the form of a survey to better understand what students knew about social justice and equity issues and subsequently designed lessons where appropriate in the curriculum to improve student understanding, empathy, and their ability to see connections between social justice and science. After each lesson, data was collected in the form of surveys that guided teachers learning, as well as the design of future lessons. At each stage, the action inquiry protocol elicited teacher and student reflection to improve instruction.

Anne in her interview (Table 3) emphasized the need to continually refine teaching practices making them more relevant to student experiences. This helped demonstrate the role of action inquiry in shaping teaching practices that are responsive to the needs of students and reveals the promise of how teacher leaders engaging in action inquiry can support more equitable, relevant, and responsive forms of instruction for their students.

Support (peer/administrative)

Teacher leaders found a supportive culture, freedom, and trust crucial in their efforts to teach science for social justice. These components were fostered among teachers in the department and by administration. Science teachers were not only supported in the department though their collaborations with peers as exemplified in the quote from Anne in Table 3 (i.e., “We decided we were all going to be brave together and how we’re going to go forward”) to take on this work, they were also supported by the administration. Specifically, administrative support and strong leadership was extremely important for the success of the science teachers in this department when taking on the risk of teaching science for social justice, especially in the polarized sociopolitical climate that surrounded these efforts at the time this study was conducted (i.e., 2021–2022). This administrative support helped science teachers overcome the challenges and pressures they experienced. Anne’s additional quote in Table 3, highlights that, despite potential challenges such as negative parent feedback, the administration supported the science department’s efforts in implementing social justice lessons in the science classroom. This level of needed support created a climate where science teachers felt encouraged to continue their work without fearing repercussions related to job security. Undergirding Gwen’s, the administrator’s, support both with parents but also in creating a culture conducive to teachers learning about teaching science for social justice, was the following view:

I think the way that we see change occur is very collaborative and is very much rooted in helping staff really understand the why behind its importance and then providing time for there to be a lot of discussion about what this would look like. I think the idea of engaging staff at first to say this is important work and let’s talk a little bit about why, then, where would this work be most important in your department and not everyone has to do it the same way. So similar to science, the opportunity that was given to explore social justice and equity from where they were comfortable, and then continuing to evaluate on a regular basis and lots of reflection. It’s okay if it doesn’t go well initially and what are we going to do as a result if it doesn’t and support (Gwen, Interview).

Ultimately, administrators, like Gwen, can act as allies for teachers by providing necessary support (e.g., when engaging with parents; in providing time for collaboration and reflection) and demonstrating a level of trust in teachers as professionals capable of engaging in, learning about, developing knowledge about teaching science for social justice, and leading.

5 | DISCUSSION

The findings from this study help provide one characterization of teacher leadership aimed at teaching science for social justice, as well as the kinds of support that surrounded this form of teacher leadership. Importantly, Table 4 details what we believe are key contributions

TABLE 4 Science teacher leadership for social justice and equity.

Key findings

1. Teacher leaders felt most prepared to integrate a social justice and equity focus when it connected well with their existing disciplinary course foci and drew on their existing disciplinary specific content and pedagogical knowledge.
2. Performances connected to cultivating inclusive classrooms and the design of lessons were key to centering social justice and equity in science classrooms.
3. Perhaps the most important influence on science teacher leadership focused on teaching science for social justice were structures, specifically the PLP and action inquiry, that fostered peer and administrative support, as well as time, space, and a focus on reflective and collaborative opportunities.

from our research capable of offering insights into the emergence of science teacher leadership for social justice. The key contributions are used to organize our discussion.

5.1 | Teacher leaders integrating social justice and equity with their existing content and pedagogical knowledge

The initial key finding from this research relates to how teacher leaders felt most prepared to integrate a social justice and equity focus when it connected well with their existing disciplinary course foci and drew on their existing disciplinary specific content and pedagogical knowledge. This also led to, in the context of the collaborative nature of the CoP, teacher leaders being willing to share their content and pedagogically grounded social justice and equity focused integration strategies with other teachers in the department, as well as them offering ongoing support and collaboration. Such actions from teachers (i.e., willingly sharing teaching resources and strategies with other teachers and offering support and collaboration) resembled the kinds of actions other researchers have attributed to teacher leaders (Criswell et al., 2018; Park et al., 2024), especially as teacher leaders buttressed other teachers' learning by also offering different perspectives, sharing knowledge, and modeling practices (Collinson, 2012; Muijs & Harris, 2006; Park et al., 2024). In the context of this research, these teacher leadership actions were that much more important, since they involved teacher leadership actions that centered social justice and equity—a type of teacher leadership action not often detailed in the literature (Wenner & Campbell, 2017; York-Barr & Duke, 2004).

5.2 | Cultivating inclusive classrooms and the design of lessons as performances for teaching science for social justice

Our second key finding related to how performances connected to cultivating inclusive classrooms and the design of lessons were key to centering social justice and equity in science classrooms. Similar to this finding, researchers like Upegui et al. (2022), when incorporating social justice into biology classes, also identified how ensuring that students felt valued and respected—what we consider to be characteristics of inclusive classrooms—was key to creating environments conducive to students interrogating real-world social justice issues. In this current research connected to this finding, the combination of

designing social justice and equity focused lessons that featured diverse representation and identification with science or social transformation connected to strategies teachers drew on to foster inclusiveness created a space where students felt comfortable examining complex social justice issues in science classrooms. In addition, this key finding also resonates with what Heredia et al. (2023) point to as an activist teacher leader role, since they described this type of teacher leader role as one that involved creating inclusive environments to minimize harm to marginalized students, while centering social justice and equity aims in science classrooms.

5.3 | The PLP and action inquiry as structures for teaching science for social justice

As detailed in Table 4, perhaps the most important influence on science teacher leadership focused on teaching science for social justice were structures, specifically the PLP and action inquiry, that fostered peer and administrative support, as well as time, space, and a focus on reflective and collaborative opportunities. The structure of the PLP that focused on action inquiry provided a framework or infrastructure that fostered teachers' engagement in addressing and responding to student needs by adapting and improving their approaches to teaching science for social justice—characteristic of the type of infrastructure detailed as important in numerous other studies of teacher leadership (Esposito & Smith, 2006; Jacobs & Crowell, 2018; Miedijensky & Sasson, 2022; Muijs & Harris, 2006; Ryan et al., 2017; Somekh & Zeichner, 2009). The structure afforded by the PLP, along with the commitment of science teachers to teach social justice, fostered collaboration among science teachers. Not only did this create the conditions for shared professional practice, it also created time, space, and latitude for teachers to adapt curricular and instructional approaches that more seamlessly connected to their content areas, something important for connecting more authentic versions of who they were as teachers. As well, connected to structures and entangled with how important the PLP was as a negotiated administrative sanctioned school process, teachers identified the importance of having strong administrative support when faced with initial challenges and resistance encountered in introducing social justice topics in their science classrooms. Others (e.g., Cassata & Allensworth, 2021; Cooper et al., 2016; Ryan et al., 2017; Sebastian et al., 2016) have identified the benefits that can come from administrators creating supportive cultures, grounded in freedom and trust. Specifically, this kind of administrative support

empowers teachers to take risks and innovate their teaching (Balyer et al., 2017) and in the case of this research taking risks and innovating teaching was inscribed in the PLP and how it was implemented by the administration and the CoP in this study. In addition to administrative support, support from peers in the CoP was also an essential feature of how teacher leadership connected to teaching science for social justice unfolded in the department. Both types of support fostered teachers' perseverance in the face of resistance—resistance inherent in the development of new approaches to teaching and learning and the socio-political resistance that can come from parents with polarized ideological stances that are triggered by talk of social justice and equity.

6 | IMPLICATIONS AND CONCLUSION

In this research, the community of practice (i.e., the science department) played a crucial role in creating conditions for inclusive and socially just science teaching and learning during this year-long work. Creating supportive environments within the science department with the school administration was key to empowering and supporting emerging teacher leaders' commitment to teaching science that sought to center social justice. We believe the contribution of our research lies in our nuanced characterization of teacher leadership that seeks to support teaching science for social justice. This represents one context dependent manifestation in one science department, yet by using the CoPTLM we were able to map out the terrain of how science teacher leadership for social justice and equity unfolded in ways that go beyond just naming the tasks teacher leaders undertake (Campbell et al., 2019). The CoPTLM illustrates how this science department's initiative to teach science for social justice moved beyond work within teachers' classrooms since teachers co-created curriculum for their own and for others' classrooms, outside of their own. According to the CoPTLM teacher leaders develop their leadership identity by engaging in learning together, sharing expertise, and collaborating within communities to accomplish a meaningful pursuit, especially with aims that move beyond the walls of their classrooms. This study provides evidence that teacher competence, performance, and recognition are important factors for teacher leader identity development when teaching science for social justice. Teachers recognized themselves or peers as teacher leaders, however, some expressed some level of hesitation in identifying themselves as teacher leaders in relation to teaching science for social justice because they perceived their work in this area as only at the beginning stages of

development. This interaction of all components of the CoPTLM characterizes the emergence of teacher leaders and how the engagement in the pursuit of teaching science for social justice served as a driver for teacher leader development for teachers in the department. Further, our research also contributes to the dearth of studies focused on both disciplinary teacher leadership and social justice and equity, and is, we believe, that much more important since it does this as these two under-researched areas intersect.

In the end, we believe this research can set the stage for the characterizations of other ways that teacher leadership for teaching science for social justice can unfold and what it can look like in other contexts, as well as what seems most important in anchoring these other future context-dependent manifestations. Beyond this, future research might also explore teacher leadership for teaching science for social justice that is supported by similarly adopted or adapted PLP structures, like was used and found to be important in this current study, to engage other science departments or related communities of practice. Such research could seek to refine and improve structures like the PLP as they are tuned to different settings and socio-political contexts in the future. We acknowledge that the study was completed in a secondary science department but believe it can contribute to a broader audience. By exploring the intersection of science teacher leadership and social justice, our research can offer valuable insights for university teacher preparation programs, K-12 administrators, science department leaders and science educators. The study illustrates how educators can lead initiatives promoting social justice in science education, while also developing as science teacher leaders. Our research highlights a supportive administration, however, we acknowledge that the level of administrative support can vary across schools. This is a limitation that should be considered when working to support the development of science teacher leadership focused on teaching science for social justice in different settings or geographic locations with differing levels of administrative support.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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