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# Exploring Science Teacher Leaders' Identity Development within a Community of Practice

**Latanya Brandon**
*State University of New York at New Paltz, U.S.A.*

**Cindy Kern**
*Quinnipiac University, U.S.A.*

When it comes to implementing educational policy changes, teacher leaders have been identified as playing a critical role. Yet, despite more calls for increased teacher professionalism and leadership, we lack substantial empirical research on how these teacher leaders are developed and the role of collaborative relationships in their development. The purpose of this study is to describe and explain what science teacher participants experience in a community of practice for implementation of NGSS and support for their teacher leadership. This basic interpretive qualitative study, draws on ethnographic and case study methods of observation and interview to address the research question, *How do science teacher leaders' experiences within a community of teachers and leaders influence their identity development?*

***Keywords:*** Science teacher leader, identity, professional community

## Introduction

Statewide adoption of Next Generation Science Standards (NGSS; NGSS Lead States, 2013) calls for significant changes in the instructional practices of science teachers. Science teachers are tasked with creating opportunities for students to develop a deep understanding of core ideas by grappling with crosscutting concepts and engaging in science and engineering practices (National Research Council [NRC], 2012). Shifting the focus of science instruction from teaching to learning is complicated by a myriad of factors (National Academies of Sciences, Engineering & Medicine [NASEM], 2015); factors that include teacher dispositions, knowledge, and experience, as well as curriculum, professional development (PD), and available resources. For the instructional goals of science education to be realized, teachers will need targeted, coherent support and teacher leaders will likely play a significant role in this work (Cooper et al., 2016; Lai & Cheung, 2015).

Some states – such as in the Northeast, for example – have a long history of positioning teachers as professionals (Angus, 2001) and, as such, teachers are central to educational changes there (James et al., 2016; Koss & Paciga, 2023; NASEM, 2015; Saka et al., 2009). Specifically related to implementing educational policy changes, teacher leaders have been identified as a critical component (Cooper et al., 2016; Fairman & Mackenzie, 2015; Lai & Cheung, 2015). Taken together, these indicators warrant greater attention to science teacher leaders for their critical role in NGSS implementation. Despite a call for increased teacher professionalism and leadership (Whitworth & Chiu, 2015), we lack substantial empirical research on how these teacher leaders are developed and supported (Luft et al., 2016; NASEM, 2015; Wenner & Campbell, 2017). A more nuanced understanding of teacher leadership development could inform efforts to achieve the instructional goals captured by NGSS. The purpose of this study is to describe and explain what science teacher participants experience in a community of practice for implementation of NGSS and support for their teacher leadership.

This basic interpretive qualitative study draws on ethnographic and case study methods of observation. This study's methodology offers a unique contribution to our understanding of science teacher leadership identity. Past studies have helped to conceptualize teacher leadership, identify its effects and the different factors surrounding the work (Wenner & Campbell, 2017). Our interest involves the in-the-moment experiences of teachers leading discipline-specific instructional change. This examination shines a spotlight on teachers as they are experiencing NGSS implementation by providing a snapshot of their leadership journey to deepen our understanding of the impact of these policy changes on science teachers at the forefront of instructional shifts. The study involves a community of science educators with seven teacher leaders at its core. This community is often led by its teacher members and offers a particular context for science teacher leadership. Our interpretivist approach provides a detailed description of their lived experiences as science teacher leaders among science educators during a period of reform. To provide a more detailed and emic perspective on the transition to science teacher leader, this paper will focus on the experiences of three of the seven participants. These three were selected for the depth of their experience within the community and with teacher leadership. We aim to address the research question, how do science teacher leaders' experiences within a community of teachers and leaders influence their identity development.

## Literature Review

We know that professional learning communities can be designed in a myriad of ways to address the broad range of pedagogical, content, or technical competencies science teachers must develop along their professional continuum (Blonder & Vescio, 2022). For example, Feiman-Nesmer (2001) emphasizes the importance of developing tools to study teaching in the preparation and future development of pre-service teachers. This study of teaching occurred within school communities and in partnership with mentor teachers. For teachers farther along the professional continuum, a cohort model for PD has been helpful for expanding their knowledge and skills (Criswell et al., 2018; Gunning et al., 2020). Other PD models follow a community of practice model (Akerson et al., 2009; Eshchar-Netz & Vedder-Weiss, 2021; Lotter et al., 2014) that centers on members engaging in a collective process of learning (Wenger, 2000). PD for teacher leaders involves more complexity due, in part, to the nature of teacher leadership (Luft et al., 2016). For example, teachers can adopt leadership roles throughout their teaching careers (Luft et al., 2016). Rather than examining the impact of PD, we sought to learn more about what becoming a science teacher leader means to science teachers involved in reform work during a period of transition. This study will add another, more emic perspective to the knowledge base by exploring the experiences of science teachers as they are leading during NGSS implementation.

Identity, multi-faceted and fluid, prompts us to think about the interrelatedness of science teachers, their community of practice, and their schools. The concept of interrelatedness is relevant to science teachers facing significant shifts in their instruction. As Wong and Luft (2015) have pointed out, science teachers' beliefs about instruction are related to their persistence in the profession. Teachers' experiences with science learning shape their beliefs about science teaching. Ultimately, a combination of beliefs, experiences, and perceptions all contribute to a science teacher's professional identity (Akerson et al., 2014; Avraamidou, 2014, 2016, 2017; Forbes & Davis, 2012; Moore, 2008; Saka et al., 2013; Settlage et al., 2009), whereas less is known about the professional identity of a science teacher leader (Gul et al.,

2022; Hanuscin et al., 2014; Hanuscin et al., 2017). Scholars have demonstrated how students become science teachers, how PD impacts science teacher development, and how science teacher leaders may be developed all using identity frameworks (Avraamidou, 2016; Danielsson & Warwick, 2014; Hanuscin et al., 2014; Hanuscin et al., 2017; Moore, 2008). To better understand science teacher leaders' social identity as they transition from science teacher to science teacher leader, we adopt Gee's (2000) identity framework and the concept of collective agency. This theoretical framework guides our examination of the discourse and interactions among the science educators in a particular community. Consistent with a more emic perspective on science teacher leader identity development, this paper will focus on the experiences of three of the seven teacher leaders involved in the study given their experience with both leadership and the community.

## Theoretical Framework

This research study stemmed from our interest in tracing the influence of group participation on science teachers' development of their teacher leader identity. We define teacher leaders using the definition set forth by Wenner and Campbell (2017) as "teachers who maintain K-12 classroom-based teaching responsibilities while also taking on leadership responsibilities outside of the classroom" (p. 140). To explore their identity development within the context of this community of practice, we draw from Gee's Identity Framework (2000) and Bandura's work in Social Cognitive Theory (2002), specifically collective agency.

### Gee's Identity Framework

Gee (2000) argues that the aspects of identity tied to performance in a specific context could provide insight into understanding recognition as a social and political process. We are interested in three science teacher leaders' identity in relation to other science teachers' identity. This relational identity (Gee, 2018) is formed socially and can be interpreted in four ways (Gee, 2000). A *natural identity* is interpreted as a state of being that is meaningful in social interactions. This form of identity gains its power through the work of the other three forms. An *institutional identity* is interpreted as a position or role within an institution and its power is authorized by the institution. One's *discursive identity* is interpreted as interpersonal characteristics and its power is ascribed or projected through social interactions. Lastly, an *affinity identity* is interpreted as experiences shared within a group and it gains power through shared practices. These interpretations of identity are interrelated, dynamic, and contextualized and as such, offer a means for understanding how the science teachers in this study construct their teacher leader identities.

This study examines the interplay of these forms of identity within the community of practice. The science teacher leaders generate shared practices and structures for interpersonal communication. They are also affected by their ascribed roles and interactions within the community. These four identity forms, studied in combination, provide a framework for understanding the transition from science teacher to science teacher leader in the context of a single community. The transition would involve a realization of their leadership capacity since teacher "leadership is learned by doing leadership" (Lieberman et al., 2016, p. 122). Thus, we recognize that agency is critical for understanding this transition.

## Bandura's Social Cognitive Theory: Collective Agency

Our definition of a teacher leader prompts us to consider teacher agency as an inherent component of their identity as both classroom science teacher and leader. Bandura (2002) argues that "to be an agent is to influence intentionally one's functioning and life circumstance" (p. 270) and we turn to Bandura's Social Cognitive Theory (2001) to gain insight into how science teacher leaders are intentionally influencing science instruction. Bandura offers three modes of agency: personal, proxy, and collective, as necessary for achieving desired effects. He describes *personal agency* as securing desired outcomes individually, *proxy agency* as securing desired outcomes through others acting on their behalf and *collective agency* as securing desired outcomes by acting in concert with one another on shared beliefs. Collective agency involves intentions, knowledge, and skill as well as working with others to achieve what cannot be accomplished alone. We extend this line of thinking to science teachers' leadership. Prior research has shown teachers to be agents of change (Palmer et al., 2014; Szczesiul & Huizenga, 2015) and that their agency is mediated by elements in their settings (Bridwell-Mitchell, 2015; Lasky, 2005; Richmond, 2017). Collective agency provides a framework for understanding the science teachers' leadership. Specifically, we focus on science teachers taking responsibility for classroom implementation of NGSS as a proxy for collective agency. We hypothesize that participation in the community of practice is a form of collective agency for engaging in practices that promote changes in their science classrooms and operating as teacher leaders within their institutions.

# Methods

This study draws from a larger case and elucidates the experiences of three members of the community of science teacher leaders. The original larger study was designed to describe and explore the effects of a collaborative group on the development of a science teacher leader identity. Qualitative methodology was chosen to "capture complex action, perception, and interpretation" (Stake, 2007, as cited in Merriam, 2009, p. 44) occurring among members of the community. Various methods, such as an observational case study protocol and ethnographic field notes, were employed to focus on a unique community of teachers working on NGSS and instructional practices. We adopted an interpretivist approach for the study to better understand the science teacher leaders' perspective on leading for instructional change. Our focus for this study shifted to learning more about how the science teacher leaders view themselves with respect to their leadership identity. As researchers, we seek to uncover their meaning and generalize their experience to theory.

## The Context

The community of science educators chosen for the study meets voluntarily throughout the course of the academic school year. Participants in the community do not receive compensation for attendance nor is their participation evaluated. The informal, revelatory nature of the community makes this group ideal as a single case for examining identity development (Yin, 2003). The group was first developed under the direction of the second author as a project to provide instructional support immediately following statewide adoption of NGSS. The project was designed in accordance with principles of effective PD (Loucks-Horsley et al., 2009) and followed a community of practice (Lave & Wenger, 1991; Wenger, 2000) model. While the project formally ended prior to this study, a community was formed and continues to meet twice a month throughout the academic school year on a university campus. At the time of the study,

the group had been conducting regular meetings for over three years and the piloting of state assessments aligned to NGSS were also underway. The community's emphasis was on classroom implementation of NGSS and on supporting teacher leaders doing this work. Both authors are members of the community such that the primary author adopts the role of researcher-participant, and the second author serves as group leader-participant based on her organizational role in the community.

The community consists of just over 60 science educators. Approximately 97% are classroom teachers with professional roles outside of the classroom, a strong indication that this is a community of teacher leaders in accordance with the definition set forth in Wenner and Campbell's (2017) review of teacher leadership. Their professional roles include science coordinator, department chair, and curriculum developer to name a few examples related to instructional leadership. On average, the teacher leaders in this community have 12 years of teaching experience and have spent nine years at their current schools. Participants who have attended more than 10 workshops were the teachers who talked more frequently about teacher leadership compared to newer members. Three participants, Kayla, Hillary, and Judy, were appropriate for this study as all had attended more than 10 workshops and talked about their leadership practices. Thus, all three are situated as experienced teachers, midway along the professional continuum (Blonder & Vescio, 2022).

## Participants

### *Kayla's Experience*

Kayla is a white, female high school physics teacher with 19 years of science teaching experience. She has been a member of the community for one and a half years at the time of the study. She describes the community as a great atmosphere:

> I love the people. I love that it's actually useful, actually has an application right in my classroom and it is one of my only opportunities to get any professional development on NGSS as well. It's a good climate. (Kayla, personal communication, n.d.)

### *Hillary's Experience*

Hillary is a white, female middle school science teacher, biology concentration, with 12 years of science teaching experience. She has been a member of the community for the full three years. She describes the community as an extension of her work:

> It's a cultivated work group. Often, when I talk about the group, it's from a standpoint of NGSS. I talked to them [teachers] about the fact that you can come to these things. They're free. (Hillary, personal communication, n.d.)

### *Judy's Experience*

Judy is also a white, female high school biology science teacher with five years of science teaching experience. She has been a member of the community for the full three years. She describes the community as a resource:

> …there's a lot of resources and a lot of variation in experiences there that make it a really unique experience. And depending on what you're going through…you run the gamut

> from… "I don't understand how to do my teacher evaluation end-of-year conference" to "show my growth using NGSS when my administrator doesn't even understand it", you know, to "what research is there that supports that modeling helps my students learn". (Judy, personal communication, n.d.)

Judy values her time in the community working with other teachers who are teaching her subject.

**Data collection and analysis**

There were three methods of data collection: observations, artifacts of meetings, and interviews. Naturalistic observations of two group meetings were conducted. Field notes were the primary source of data for observations and were used to capture social interactions, norms, activities, and rituals. These notes include descriptions of the participants, the physical arrangement of the setting, core activities engaged in by the group, their speech patterns, and interactions. The meetings were video recorded to supplement field notes. A panoramic view captured rich non-verbal cues within the community. Related documents were also collected to supplement field notes. The third tool, semi-structured interviews, was used to capture participants' perceptions of social interactions, norms, activities, relationships, and roles. For example, participants were asked questions, such as what has it been like to work in this community and how do you work with someone new to the community, to learn about their experiences within the community. Participants were also asked about their leadership with questions such as, "Are you a teacher leader?" and "Tell us more about that." Of the six teacher leader participants interviewed, this paper will focus on the experiences of three teacher leaders from the community to allow for in-depth exploration of the research question (Miles & Huberman, 1984; Yin, 2003).

In the first round of data reduction, field notes were enhanced with additional detail provided by viewing the videotapes of the group meetings. Individual interviews were transcribed and read. During a second round of analysis, the data were read and re-read for patterns and themes; analytical memos were written about emergent themes. Three participants were selected from the larger data for their rich experiences with science teacher leader identity development.

For this study, coding proceeded both inductively and deductively, using phrases from multiple readings of the data as well as concepts from the theoretical frameworks of sociocognitive theory (Bandura, 2001) and identity (Gee, 2000). We followed Saldaña's (2016) description of 'themeing the data' (p. 198) to integrate the results of coding into memos and develop themes. The codebook along with the emergent themes can be found in Appendix A. The results of this analysis were compared to an open-ended focus group interview for the purpose of member-checking and provide the findings for this paper.

## Research Findings

Findings that address our research question, *How do science teacher leaders' experiences within a community of science educators influence their identity development*? were triangulated across three data sources. Based on our observations, the shared practices and routines that created and sustained the community also supports Judy, Kayla, and Hillary's shared belief that they are teacher leaders. Each community meeting provides information and practice with some aspect of NGSS-aligned instruction. Community members often lead or become involved in

leading community meetings. In this section, we report two themes from our analysis of the data; first that community allegiance means an identity as a science teacher leader and second that a culture of professional learning within the community supported collective agency among the science teacher leaders. We elaborate on these themes by providing a thick and rich description of the data.

**Theme 1: Community Allegiance Means an Identity as a Science Teacher Leader**

Table 1 shows a summary of the four interpretations of Judy, Kayla, and Hillary's relational identity as a science teacher leader. This section provides detailed findings related to affinity and discursive identities that appeared within the community. According to Gee (2000), an affinity identity has allegiance to a set of common practices and the shared nature of the practices meets the needs of each member. We noted a pattern that participants who have attended more than 10 workshops were the teachers who talked more frequently about a teacher leader practice such as modeling community workshop activities for colleagues. Thus, Judy, Kayla, and Hillary were chosen as participants for this study as all had attended more than 10 workshops and discussed their classroom and leadership practices when talking about the community and NGSS instruction. Here, we examined how they identify with the community of science teacher leaders in both affinity and discursive forms.

**Table 1**
*Four Forms of Science Teacher Leaders' Identity*

| Science teacher leaders | Within the community | | Outside the community | |
|---|---|---|---|---|
| | Affinity Identity | Discursive Identity | Institutional Identity | Nature Identity |
| Judy | Strong | Strong | Emergent | Fluid |
| Kayla | Present | Present | Imposed | Fluid |
| Hillary | Strong | Strong | Imposed and strengthened | Fluid |

***Affinity Identity***

Both Judy and Kayla joined the community to learn more about NGSS during the initial phases of statewide adoption. Each discussed their transition toward teacher leadership for NGSS implementation. As an initial member, Judy describes her early impressions of the community, "I felt as though they were a really strong group, and I was really going to learn a lot from them," (Judy, personal communication, n.d.). Similarly, Kayla describes her attraction to the community, "[B]eing able to address problems…it's very nice to… be in that atmosphere, to have that collegial atmosphere is wonderful," (Kayla, personal communication, n.d.).

After three years of participating, Judy talks about how her role within the group shifted toward leadership, "…and now I'm feeling more like a leader and a strong part of the group. I feel like my role has shifted. Before I didn't really know anything, and now I am a leader in the group," (Judy, personal communication, n.d.). The connection between Judy seeing herself as a teacher leader and Judy belonging to a community of teacher leaders is evident in her perspective on what the community means to her. Judy initially joined the community as an experienced teacher with the goal of professional growth around NGSS implementation. Over the course of three years, she engaged in a steady, though turbulent process of shifting her instructional

practices toward practices common among community members. During the process of her professional learning, a critical moment occurred as she began to develop both her affinity and discursive identities as a teacher leader for NGSS implementation. Judy began sharing her work within the community and we will explore how sharing progressed to leading through the development of Judy's discursive identity below and through collective agency among the community in Theme 2. We note from her above statement that Judy's identity as a teacher leader is linked to her involvement with the community of teacher leaders.

After one and a half years of participating, Kayla expresses a similar sense of belonging to and identifying with this community of teacher leaders. However, Kayla has not yet taken on leadership roles within the community itself:

> I'm a participant sometimes. Most of the time I take more than I give since I've been going there... But like I said I think I'm finally at a point where I can successfully implement or when I successfully implement more of these strategies, I'll have a little more to offer. (Kayla, personal communication, n.d.)

This community of teacher leaders maintains a focus on NGSS implementation. Kayla talks about the different NGSS-aligned strategies she has learned and implemented in her classroom. She attributes the knowledge and skills she has gained to her participation in the community. While Kayla is confident, she indicates that she wants to continue her PD before leading a session within the community. In the above quote, she does not describe herself as a leader within the community in the same way Judy does. Kayla talks about leading colleagues in her school prior to statewide adoption of NGSS and being looked toward for guidance on NGSS.

Hillary joined the group at a time in her career when she was looking to connect with other science educators. Hillary describes her role within the community as both participant and leader:

> My role in the group is as a person who's looking to make their practice better as a person who likes to lead workshops. So sometimes I'm a leader, sometimes I'm a practitioner, sometimes I'm at this point that I am any role that they need me to be and I'm comfortable in all those roles because I've been allowed to do all those roles. (Hillary, personal communication, n.d.)

Hillary's role within the community is fluid and with the same fluidity, she describes the community of science teachers and teacher leaders, "We spent a good year and a half growing to the mass that we are together. We grew together professionally, but also grew in size," (Hillary, personal communication, n.d.).

Both Hillary and Judy often describe the community in terms of "we", indicating their affinity among other science educators and also positioning themselves as leaders within the community. Hillary states, "I liked that we have new people hopefully that want to present because I'm learning about how other teachers are doing the same practices I am in their classroom," (Hillary, personal communication, n.d.). In this reference, Hillary refers to the community as "we" an indication of her community allegiance among science teacher leaders. Hillary, in particular, expresses a deep sense of belonging and identity with the community. She also references community practices as shared and invites other teachers to "present" or go

public with their work. Similar to Kayla, Hillary identifies as a teacher leader connected with the community, yet similar to Judy, Hillary is also a teacher leader within it.

***Discursive Identity***

Continuing with Gee's theoretical framework involving four ways of interpreting identity, the discursive form involves recognition as a science teacher leader through dialogue and interaction with other science educators. This form was intertwined with the science teacher leaders' affinity with the community and their institutional positions.

Both Judy and Hillary have engaged with the community since it began, and Judy provides a stronger example of how the community provides support for her becoming a science teacher leader. Through continued participation in the community, Judy developed a niche for her leadership. She is a teacher leader in two areas, performance assessments and standards-based grading, "I always talk about assessments, and assessing, summative and formative, and how that happens over the course of a unit or a year," (Judy, personal communication, n.d.). She also describes teacher leadership outside of the community, more specifically she talks about the informal nature of her institutional teacher leader identity:

> I definitely am somebody that people come to in the science department with hey "I want to do more of this in my NGSS" or "I want to try to implement this more". In our department meetings, it's like "J, is this NGSS-aligned". (Judy, personal communication, n.d.)

Alternatively, Hillary's niche involves student engagement in science and engineering practices, particularly Science and Engineering Practice (SEP) 6: Constructing Scientific Explanations. She enjoys the learning opportunities she receives when leading workshops and presenting for NGSS implementation within the community. In particular, being a classroom teacher is an important aspect of Hillary's discursive identity. She states,

> you get to a point sometimes and, [in] like a district or something, where you are The PD person but then you're no longer learning because you're always running the PD. I'm not that here at all and I value that role [of a practitioner] more than I value the role of leading. (Hillary, personal communication, n.d.)

Rather than becoming a teacher leader within the community, Hillary's experience offers insight into what community participation means for someone who already has a proscribed teacher leader identity. The community offers Hillary more opportunities to be both leader and learner such that Hillary embraces her teacher leader identity both within and outside of the community.

> It took some time for it to cultivate to the level that it's at. I think everybody's always learning and growing until they get shut down. This group helped me feel more comfortable being vulnerable and managing those situations. I can still learn and kind of lead PD at the same time, I am my most vulnerable here because I feel my most safe here. (Hillary, personal communication, n.d.)

Hillary attributes developing a stronger sense of herself as a teacher leader to her participation with the community.

Although Kayla had more experience teaching, she had less experience leading among colleagues than Hillary and less experience with NGSS implementation than both Hillary and Judy. Her sustained participation within the community bolstered her confidence around NGSS implementation:

> …in developing that sort of deeper understanding…and really how to put something together that I think will be good and I think will be aligned was entirely because of these workshops…I would say that at work I am more willing to [lead], there's a great deal of frustration due to a lack of understanding of what's expected of us as science teachers now. So, I am happy to [lead] and I have offered, you know to try and help teachers sort of understand what's expected or maybe give them an idea for a lesson… (Kayla, personal communication, n.d.)

Kayla makes a distinction that her leadership is recognized by her school administrators and a small number of her school-based colleagues, yet her leadership within the community has not been fully realized. While all three possess affinity and discursive identities as science teacher leaders, these identities are stronger for Judy and Hillary within the group (Table 1).

Both Hillary and Kayla view their membership within the community as additive to their teacher leadership identities whereas Judy views her membership within the community as central to her teacher leadership identity. All three identify as teacher leaders with expertise in a specific aspect of teaching. Their shared experiences with NGSS-aligned instruction among community members has contributed to and reinforced their ascribed teacher leader identities. We found that their science teacher leader identities develop with targeted support from the community. Targeted support happens within the community as the science teachers relate to other science educators and adopt a position as teacher leader.

## Theme 2: A Culture of Professional Learning Within The Community Supported

### Collective Agency Among The Science Teacher Leaders.

This section will provide findings related to collective agency around science teacher leaders' NGSS-aligned instruction. Collective agency involves intentions, knowledge, and skill as well as working with others to achieve what cannot be accomplished alone. Community practices were shared in dynamic transactions, such as workshop sessions, that involved people acting conjointly on a shared belief (Bandura, 2001). The findings reported here address what science teacher leadership means to these three teachers. We also report how the community supported Judy, Kayla, and Hillary's teacher leadership through collective agency.

Figure 1 (see below) illustrates how the science teacher leaders are working at the core of the community. Those fluent with NGSS instruction model their instructional practices, explain and reinforce NGSS-related language, and serve as resources for other science teachers' learning. Both Hillary and Judy have enacted leadership within the community, while all three have enacted leadership outside of the community. Our observations within the community reveal some of the transactions between the science teacher leaders and their peers. We observed the development of a discourse identity for science teacher leaders during community meetings. Workshop participants were immersed in pedagogical practices and language associated with NGSS-aligned instruction ("grade-level progressions", "SEPs", "core idea", "investigation", "sensemaking"). Such language was used fluently by the workshop leader and community

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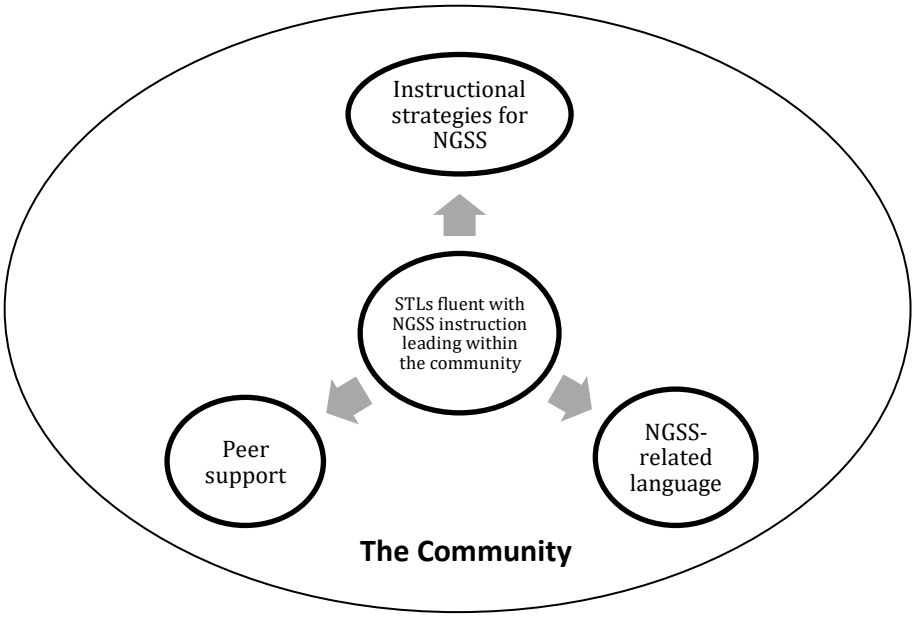
members who regularly attended. The language was adopted by the newcomers and evidenced in word or phrase substitutions during conversations.

**Figure 1**
*Science Teacher Leadership Within The Community*




***Collective Agency***

The practices that created and sustained group membership such as establishing and adhering to norms and publicly learning from errors, also contributed to Judy, Kayla, and Hillary's shared belief that teacher leaders can effectively lead colleagues toward NGSS-aligned instruction. All three refer to the community when talking about modeling NGSS-aligned instruction. According to Judy,

> …being in a community with similar goals in terms of implementing the standard and implementing practices, willingness to try them in their classroom. It's cathartic being with those people once to twice a month when you're fighting the fight every day. (Judy, personal communication, n.d.)

Kayla expresses a similar sentiment: "[W]hen I take it back to my classroom, or if I go with the problem and say you know I've tried this phenomenon, and it bombed, and they can identify immediately why that was," (Kayla, personal communication, n.d.) while Hillary shares, "[I]t's good teaching and strategies based around NGSS because there's still a need, that's our platform, but it's not, it's…it's not just that," (Hillary, personal communication, n.d.).

All three science teachers express a belief that learning is not fixed, and they position themselves and colleagues as learners. They share a commitment to helping students learn through a variety of instructional strategies. The public vulnerability of leading within this community distinguishes these science teachers as teacher leaders. The science teacher leaders make the point that their leadership stems from their learning. For example, Judy states, "[P]artly

because I was around them so much that I started feeling, like, at a more accomplished level, whether it would be implementing the strategies, or the successes in my own classroom," (Judy, personal communication, n.d.). Kayla thinks "…that [community work] furthers the goal of improving my practice, and you know, ideally, eventually, I'll be able to help other people improve theirs, once I get my competence with this," (Kayla, personal communication, n.d.). Hillary emphasizes that she needs other teachers' experiences because, "I'm learning from the things that I'm presenting because other teachers are doing them and telling me," (Hillary, personal communication, n.d.). What's striking here is not that these teachers have joined a community to further their own knowledge and skills, rather it is the shared action of making their professional learning experience public based on the belief that such action will benefit more students broadly.

All three teachers talked about the mistakes they made in their classrooms as they tried strategies for NGSS-aligned instruction and how sharing those mistakes with the group helped them improve their practices. Judy talks more about how the community supported her becoming a teacher leader, "…so being a part of this group catapulted me from being somebody who wasn't very confident in my skills of implementing the next generation of science standards to feeling almost like an expert in my region," (Judy, personal communication, n.d.).
Hillary joined the community as a teacher leader, and similar to Judy, talks about how the community has supported her leadership identity:

> I know inside that I have something to offer other teachers. I know that and I also know they have something to offer me, and I can facilitate that even if they don't believe it. So in a way, it's [participation in the community] made me more self-reflective. (Hillary, personal communication, n.d.)

Kayla had led PD workshops prior to joining the community. Despite her prior experience, Kayla does not feel ready to lead other teachers through NGSS implementation. She feels "confident… but, … within my school, one of the science teachers, and I love them all, but nobody knows anything about this and there's resistance…" (Kayla, personal communication, n.d.).

Kayla's ascribed identity as a teacher leader within her school community has created dissonance between her experiences leading as a teacher outside the community and her experiences being led by teacher leaders within the community. She expressed strong beliefs that teachers could effectively lead instructional change and cited changes in her own instruction based on community members' leadership as an example. Despite the influence of the community on her own instructional practices, Kayla has not yet practiced teacher leadership within the community.

In contrast, Judy proudly talks about her experiences with leadership as sharing her work publicly within the community and later at conferences,

> …I had multiple people that were at the presentation coming up to me and be like…I like how you did that, and I need to learn more about how you did that…those kinds of things. I didn't realize they were cutting edge practices. It was just me taking what I have learned and just doing it in my classroom. (Judy, personal communication, n.d.)

The work Judy presented at the conferences emerged from iterative cycles of reflection and practice that occurred between Judy's classroom and the community of teacher leaders.

> It's a little bit of sharing practices from my classroom and it's a little bit of sharing you know the new thing in education, standards-based grading and how do you pair that with the next generation science standards because everyone is struggling with that as well. (Judy, personal communication, n.d.)

Although Hillary's primary leadership activity for NGSS implementation is leading PD, she also describes a cyclical relationship between her classroom practices and the community of teacher leaders:

> So here when I give a presentation, I'm not looking just to depart information. I'm looking for teachers to say, um, …it's learning because maybe not in that moment, but I've had teachers email me about my presentation. (Hillary, personal communication, n.d.)

Hillary describes NGSS as a "catalyst" that brings teachers and other educators into the community. However, she expresses a strong belief that the community has value as a resource beyond NGSS implementation given the structured interactions that occur among its science educators.

These teacher leaders are developing their teaching practices around the implementation of NGSS in their classrooms and are engaged in leading teachers through a similar process of development. None of the teacher leaders attempt to re-create the community within their respective settings, rather they engage in teacher leadership practices of sharing and modeling the NGSS-aligned teaching practices they experienced in the community and implemented in their respective classrooms. The professional learning they experienced within the community was displayed outside the community in ways that could support their colleagues' transition to NGSS-aligned instruction. Kayla spent less time with the group and expressed less enthusiasm about formally leading other teachers in NGSS implementation. In contrast, Judy and Hillary spent more time with the group and expressed great enthusiasm about leading other teachers. Despite differences in their confidence, the community practice of sharing their learning of NGSS implementation is a common teacher leadership practice between Judy, Kayla and Hillary. This common practice of making their professional learning public is one both described as critical to the community and also to their teacher leadership.

## Discussion

Identity and social cognitive theories have contributed to our understanding of a process for developing science teacher leader identities. Hanuscin, Sinha, and Hall's (2017) scholarship sets the stage for supporting science teacher leadership identities through PD by demonstrating the malleable nature of science teacher leadership. This study adds additional insight into its malleable nature and in the current study, Kayla and Hillary provide strong examples. Kayla is developing efficacy around NGSS implementation while Hillary expresses high self-efficacy and openly collaborates and shares her work. Bandura (2001) reminds us that collective efficacy emerges from the dynamic transactions of the group. Kayla describes high self-efficacy with NGSS implementation in her classroom following interactions with the community, yet the collective efficacy of the group involves supporting major shifts in science instruction beyond a single classroom. Hillary embodies that collective efficacy beyond one's own classroom. There

is an exchange of ideas and social positioning that occurs during interactions between Hillary and the community that benefits them both. The community is strengthened by the continued participation of all three teacher leaders selected for this paper and multiple dimensions of their identities are reified. In accordance with Social Cognitive Theory, personal agency and social structures are interdependent. Judy, Kayla, and Hillary's agency with promoting NGSS implementation is connected to their work with the community of other science teacher leaders. They participated in shared practices for NGSS implementation and developed collective efficacy around promoting NGSS implementation.

**Science Teacher Leadership and Collective Change**

Social Cognitive Theory explains human agency as both the product and producer of social systems (Bandura, 2001). In this way, Judy, Kayla, and Hillary serve as 'the product' or an outcome of the community, they have implemented instructional changes and community practices in their classrooms. They are also 'producers of social systems', i.e. teacher leaders, in their promotion of NGSS-aligned instruction and community practices among colleagues. All three express a shared belief that learning is a process and that community practices support learning, both student and teacher learning. The community accomplishes what neither Judy, Kayla, Hillary, nor an individual member of the group could accomplish working in isolation. They, collectively, are able to intentionally shift classroom instruction toward the vision for K-12 science education (National Research Council, 2012).

Our findings indicate that simply learning strategies to improve one's practice was insufficient to consistently lead other teachers in the new strategies. We found that the shared practice of making their professional learning of NGSS-aligned teaching strategies public was critical to their identity as science teacher leaders. Surprisingly, this finding differs slightly from the constructivist notion that teacher leadership is learning (Lieberman et al., 2016) and we add that science teacher leadership involves the public display of that learning. The collective agency of these science teacher leaders closely resembled constructivist leadership (Lambert, 2003). Constructivist leadership is "the reciprocal learning processes that engage community participants in the creation and enactment of a shared purpose" (Lambert, 2002, p.81). Our finding that a culture of professional learning within the community supported collective agency among the science teacher leaders is consistent with framing leadership as the creation and enactment of shared practices for classroom implementation of NGSS. We argue that the science teachers' affinity with the community of teacher leaders affirms the science teachers' identity as a teacher leader for NGSS classroom implementation which, in turn, equips the science teacher leader for their institutional identities as teacher leaders for science instruction.

**The Relational Nature of Science Teacher Leaders**

According to Gee (2000), a natural identity is recognized through the work of institutions, discourse, and affinity groups. All three science teacher leaders maintain secondary classrooms and lead colleagues through NGSS-aligned instructional strategies. Their science teacher leader identities were fluid and negotiated through their interactions across two contexts, one inside the community, and the other outside the community. We argue that a science teacher leader identity is relational (Gee, 2018). Hillary's experience best illustrates the nebulous nature of science teacher leadership. The identity of a science teacher leader involves the simultaneous enactment of the roles of teacher, leader, and learner. Hillary identifies as a science teacher leader, even as one role may overshadow another depending on the context. We see this identity

fluidity when she talks about her role within the community; as a practitioner, a leader, or whatever role fulfills the community's need. Those with a strong affinity to the community, Hillary, as well as Judy, seamlessly transition among the various roles of practitioner, learner, and leader to accomplish communal goals. Others with a more moderate affinity to the community, such as Kayla, readily adopt one or two roles, primarily practitioner and learner, as they develop and strengthen their teacher leader identity. Though each individual has leadership capacity, their leadership was communal. Classroom implementation of NGSS resulted from the collective work of science teachers within the community. The science teachers who constructed a teacher leader identity became a reference group (Siegel & Siegel, 1957) for other science teachers. These science teacher leaders drew upon the collective agency of the community to develop and reinforce their identities as teacher leaders for science instruction in relation to other science teachers.

These findings were also consistent with Richmond's (2017) work on the impact of context on the development of identity and agency. Her work (Richmond, 2017) involved the professional identity and agency in early career science teachers; however, this paper focuses on the teacher leader identities of three mid-career science teachers. While none possessed a formal leadership title in their schools/districts, all three were recognized as leaders for NGSS implementation by administrators and colleagues. We offer that Kayla's institutional identity as a leader for science instruction contributed to her initial participation with the community and the subsequent, ongoing development of her discursive and affinity identities as a leader for NGSS implementation. We propose that Hillary experienced the same identity negotiation as Kayla and that the timing of the study captured Hillary's experience at a later point in her development. In contrast, Judy developed her discursive and affinity identities within the community that later contributed to the development of her institutional identity. The context of the community offered all three recognition as a teacher leader and a co-constructed workspace to act as agents for instructional change among colleagues.

## Conclusion

Findings from this study indicate strong connections between a leadership identity and collective agency that science teachers rely upon to shift their own instructional practices and also to influence the instructional practices of others. The teacher leaders exercised collective agency around NGSS implementation when sharing practices among the members of the community. Teachers from within the community leveraged their professional learning to lead colleagues through workshops and presentations on NGSS-aligned instructional strategies thereby connecting their leadership to the collective agency experienced in the community. Qanay et al. (2019) emphasize the idea that teacher leadership is closely related to teacher learning. Similar to Qanay et. al's (2019) work, this study offers some insight into how these science teacher leaders developed their identities without formal leadership positions. It appears that Hillary, Kayla and Judy developed their teacher leader identities as they worked among colleagues. More than a role or job title, all experienced their leadership, (i.e., promoting NGSS classroom implementation), as entwined with their science teaching goals, (i.e., helping students learn science). Yet, the social structure of their teacher leadership differs from the classroom environment when the target audience for leadership involves colleagues.

Additionally, our focus on the science teacher leaders' experience has illuminated a significant role for collaborative relationships in the development of a science teacher leader

identity for mid-career teachers. We draw from literature of career stages for teachers (Behrstock-Sherratt et al., 2014; Blonder & Vescio, 2022) and categorize Judy, Kayla, and Hillary as mid-career given that they possess more than five years of teaching experience. The dynamic interactions that occurred within the community hints at a mechanism for supporting teacher agency in policy implementation such as NGSS-aligned instruction. Additional studies are needed to elucidate key factors for maintaining collaborative models for teacher learning and leadership along the professional continuum.

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# Appendix A

## The Codebook for Science Teacher Leader Identity and Leadership

| Name | Description | # of Ref | Theory |
|---|---|---|---|
| Theme 1: Community allegiance ("We") means identity as a science teacher leader | | | |
| Community culture (combine C work + C norm) | rituals, norms, and activities repeated within the community | 44 | Collective agency; Affinity ID |
| C work | Activities occurring within the community. | 23 | Collective agency |
| C norm | Habitual gestures, nvc, speech patterns occurring repeatedly in the community (habits of "regulars") | 19 | Affinity ID |
| Like-minded | Common beliefs/practices/speech patterns | 27 | Affinity ID; Discursive ID |
| Peer relationships | Interactions with T and/or admin | 7 | Institutional ID (ext); Collective agency (int) |
| L recog | Recognition as a leader | 38 | Affinity ID (int); Institutional ID (ext) |
| L conf | Confidence as a leader | 12 | Efficacy; Collective agency |
| L act | Leadership action or practice | 26 | Collective agency |
| Self | Self-recognition | 8 | Affinity ID; Discursive ID |
| Other | Distinguishes between the community and outsiders (educators) | 16 | Affinity ID |
| Theme 2: A culture of professional learning w/in the community supported collective agency among science teacher leaders. | | | |
| T work | Activities and strategies related to teaching science | 19 | Efficacy |
| Prof LRN Combine (PKnwl + Exprt) | Activities and strategies related to inc CK/PCK | 26 | Collective efficacy-agency |
| PKnwl | Procedural knowledge about science teaching and learning | 7 | Efficacy |
| Exprt | Having specialized knowledge and/or skills | 4 | Collective agency |
| Leadership | Leadership definition or description | 10 | Institutional ID (ext); Discursive ID (int) |
| Ss view | Focus on needs/interests of students | 20 | Discursive ID |
| T view | Focus on needs/expectations of teachers | 11 | Discursive ID; Collective agency |