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The Reformation of Identity: What is Present After a Science Teacher Leadership Program

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This qualitative study investigates the development of science teacher leaders during and after professional development. It examines the impactful experiences during a teacher leadership program that allowed them to explore their leadership identity and how this identity manifests in their schools' post-program. The participants are 14 chemistry and physics teacher leaders from schools in the Southeastern U.S. who attended a five-year Noyce teacher leadership program. They are emergent leaders who entered the program with limited leadership exposure or expertise. Social learning theory provides the lens to examine during and post-program interviews with science teacher leaders. Three themes emerge from the interviews: 1) Redefining leadership, 2) Responsibility for others, and 3) Collaborative community that developed the science teacher leadership identity during and after the program. The findings from this study have theoretical and practical implications for teacher leaders, schools, and leadership development programs.

Keywords: Science teacher leaders, professional identity, teacher leadership, and development of teacher leaders

Introduction

The role of science teacher leaders has become increasingly significant in driving national science reforms and supporting educators (National Research Council, 2014 & 2017; Sheppard & Wieman, 2020; U.S. Department of Education, 2016; White House, 2012). Science teacher leaders are K-12 classroom teachers who lead within and beyond their classroom to influence colleagues, improve instructional practices, increase student achievement, and advocate for science (Cheung et al., 2018; Luft et al., 2016; Katzenmeyer & Moeller, 2009; Wenner & Campbell, 2017; Whitworth et al., 2022; York-Barr & Duke, 2004). As demand for their expertise increases, understanding the process of professional identity growth within developmental teacher leadership programs for these leaders is crucial because their identity is connected to their focus and participation as a leader (Campbell et al., 2022; Hsieh, 2010; Whitworth et al., 2022). Emergent science teacher leaders represent a valuable demographic for development within teacher leadership programs because they enter programs with limited leadership experience and competence (Yow et al., 2021). Focusing on the unique developmental factors that shape their professional identity maximizes the potential of these individuals and helps expand the pool of competent science teacher leaders.

In a teacher leadership program (TLP), science teachers establish an identity of a leader, distinct from their identity as a teacher (Criswell et al., 2018; Hunzicker, 2017; Hutchinson, 2019; Sinha & Hanuscin, 2017). To maximize their effectiveness, science teachers must integrate teaching and leadership into a unified professional identity (Komives et al., 2005; Wenner & Campbell, 2018). A teacher leader's professional identity is constantly reforming based on

"participation and reification by which experiences and social interpretations inform each other" (Wenger, 1998, p.151). Uncertainties, however, remain about which specific experiences within TLPs foster exploration of their leadership identity and what aspects of this identity are present after program completion. According to Wenger identity formation is a constant negotiation, meaning a teacher leader's identity may deepen, regress, or remain static without ongoing support from the program. Previous research focuses on identity development of science teacher leaders during TLPs (Barth et al., 2023; Criswell et al., 2018) and the continued support of existing science teacher leaders (Reid et al., 2022).

This study, conducted from 2011 to 2018, is highly relevant as it explores the perceptions of 14 science teachers about their experiences both during the TLP and afterward in their schools. Interviews, conducted by a team of university professors, graduate students, and external evaluators, provide a novel insight into how teacher leadership developed within a program continues post-program. The study focuses on emergent science teacher leaders who are becoming leaders in their schools through program development. Additionally, it contributes to the broader understanding of science teacher leadership development, a particularly relevant topic as teacher leaders were called upon to navigate the unprecedented challenges of the COVID-19 pandemic (Campbell, 2020; Hollweck & Doucet, 2020). However, concerns persist regarding a potential decline in teacher leadership as schools return to more traditional practices (Ghamrawi et al., 2024).

The research questions guiding this study are:

1. How did experiences during a teacher leadership program influence the exploration of identity for science teacher leaders?

2. How does a teacher leadership identity, developed during a teacher leadership program, manifest after the program concludes?

The following examines how the TLP influenced the professional identity of emerging science teacher leaders during and after the program. The first section provides background information on the professional identity of science teacher leaders and an overview of the TLP. The second section introduces a conceptual framework, integrating elements from various theories. The third section describes the methods and explains how the conceptual framework was applied to analyze the data. The fourth section explores the experiences of the TLP from the perspective of the participating science teacher leaders. Lastly, the fifth section investigates how these experiences influenced their leadership identity during and after the program.

Background Information

A Description of a Teacher's Professional Identity

Identity is an interplay of individuality and the practices of a specific community that forms through social experiences that allow an individual to reflect on the possibility of assuming it (Markus & Nurius, 1986; Wenger, 1998). By experimenting with identity, an individual can revise their self-conception (Ibarra, 1999). Individuals reveal their identity through self-talk, views of others, and practices (Gul et al., 2022; Fealy et al., 2018; Olitsky, 2019). According to Wenger, practices are actions carried out by an individual, which are shaped

by historical influences and the social environment where they occur. They have a structured nature and carry significance within a given community (Campbell et al., 2022). The ability to enact practices and make meaning of social interactions in a community shape one's identity (Carlone, 2012; Lave & Wenger, 1991). Communities influence identity by fostering trust, enhancing confidence, offering role models, cultivating a sense of belonging, and encouraging participation in social experiences (Adler & Heckscher, 2005; Carrasco & Miller, 2006). The degree to which individuals are connected and feel a sense of belonging in the community determines their level of engagement and learning of community experiences (Wenger, 2000).

A Description of a Science Teacher Leadership Identity

Becoming a science teacher leader requires a shift in professional identity because the expectations, roles, and actions of a teacher leader differ from those of a classroom teacher (Campbell et al., 2022; Carver, 2016; Frost, 2012; Sinha & Hanuscin, 2017; Wenner & Campbell, 2018; Whitworth et al., 2022). Classroom teachers guide the knowledge of their students through instruction; a science teacher leader would inform and mentor other teachers in and outside their school about the best practices to assist the understanding of students. Science teacher leaders use interpersonal relationships, collaboration, science knowledge, and contextual awareness to influence colleagues to carry out leadership with or without a positional title (Nappi, 2014; Trabona et al., 2019). The transformation of science teachers into science teacher leaders requires an awareness of self and context, competence in science and leadership, performance and recognition as a collaborative leader, and a purposeful commitment to a more significant cause (Carlone & Johnson, 2007; Komives et al., 2005).

According to Komives et al. (2005), the integration of the leadership identity with personal beliefs and values represents a crucial stage in the identity development of emergent leaders because they initially have limited leadership training. They explain that at this juncture, leadership becomes an integral component of an individual's self-identity. The identity should be steadfast, empowered, and adaptable to meet challenges (Wenner & Campbell, 2018). If the sub-identities of individuals are not successfully integrated, they may experience identity dissonance (Nentwich et al., 2013; Stephens, 2019; Warin et al., 2006). This dissonance manifests as a sense of tension between their roles as a leader and as a classroom teacher, prompting them to question "their values, ambitions, abilities, and self-worth" (Joseph et al., 2017, p. 100).

Description of a Teacher Leadership Program

Cultivating a leadership identity through TLPs is an effective strategy for retaining teachers in high-needs schools (Alemdar et al., 2018). A strong leadership identity enables teachers to drive reforms that improve teaching and student achievement (Aderet-German et al., 2021). A teacher's ability to change policies and practices in their schools empowers them and connects them to a greater sense of purpose, enhancing their retention (Komives et al., 2005; Muijs & Harris, 2003). TLPs support teachers in developing their leadership expertise by strengthening content knowledge, interpersonal skills, and leadership abilities (Criswell et al., 2018; Lotter et al., 2020). The development of these attributes enhances their capacity to lead effectively (Simpson, 2021). These programs often rely on federal funding, such as the National Science Foundation's Robert Noyce Teacher Scholarship (Noyce) program. Noyce provides critical resources like professional development and salary supplements for teachers in science, technology, engineering, and mathematics fields.

The TLP in this study is a Noyce program that operates outside the science teachers' schools. It is developed and facilitated by a project team of university faculty and graduate researchers. External evaluators are also involved, collecting data to assess the program. Over the course of five years, the science teachers collectively meet eight times during the academic year (~once per month) and participate in a week-long retreat each summer. The academic year meetings take place on Saturdays and typically last approximately six hours. These meetings allow the teachers to engage in approximately 80 hours of programmatic experience per year. Table 1 provides a detailed overview of the program experiences.

Table 1
Experiences in the Teacher Leadership Program

Program Experiences	Description of the Experience
Building shared vision	The science teachers collaborated to form a program goal.
Setting community goals	The science teachers developed collective and individual goals.
Professional vision	The science teachers learned how to observe interactions occurring outside their classrooms, interpret the observations by noting the important factors, and create a material illustration of the observation.
Pedagogical content knowledge	The science teachers discussed best practices.
Leadership styles survey	The science teachers completed a survey to assess their leadership.
Socratic pedagogy	The science teachers participated in a discussion about using the Socratic method to engage students in critical thinking.
Next Generation Science Standards	The science teachers discussed the standards and participated in science demonstrations aligned to the standards, enhancing PCK.
Conferences	The science teachers participated, presented and hosted science education conferences.
Panel discussion on the roles of teacher leaders	Local and state teacher leaders spoke to the science teacher leaders.
National science teacher leaders	The science teachers identified and hosted national science teacher leaders that they followed on social media.
Professional growth plans	The science teacher leaders identified their goals, strengths and challenges to becoming a teacher leader in their schools.

The science teachers move from a guided and scaffolded approach to an autonomous model throughout the five-year program. In the program's first two years, the science teachers complete a three-course teacher leadership certification program offered by a regional education center. The courses address various principles and models of broader general education

leadership while focusing on teacher leadership. They require science teachers to explore their beliefs and attitudes about teacher leadership. The science teachers also engage in other experiences designed to build their content knowledge and connect them with nationally recognized teacher leaders. As the science teachers transition into the latter stages of year two and beyond, they use this foundation to take ownership of their professional learning. For example, the science teachers host and participate in a local science education conference that focuses on sharing effective pedagogical practices. This experience allows the teachers to determine the content, select speakers, and showcase their professional knowledge and skills (Gess-Newsome, 2015). It also gives them the skills and confidence to present at state and national conferences (e.g., the National Science Teaching Association).

During the program's final years, the science teachers establish professional learning communities (PLCs) centered on the most relevant and impactful issues. For example, one PLC focuses on developing accessible curricular materials tailored for physics teachers who may be teaching outside their area of expertise (e.g., those with a primary focus in another science discipline). Another PLC explores innovative approaches to leveraging technology to enhance chemistry learning experiences. These PLCs and other program experiences emphasize collaboration and community-building to foster leadership skills among the participants. To effectively examine the TLP, the conceptual framework must account for the science teachers' ability to reflect on and interpret their experiences, enabling their development as leaders.

Conceptual Framework

Social learning theory explains the role of experiences in social contexts in shaping learning and identity development (Carlone, 2012; Wenger, 1998). This theory underpins the conceptual framework for this research as a science teacher leader emerges by interpreting and assigning meaning to their experiences within the social contexts in which they function (Campbell et al., 2022; Crotty & Roehrig, 2020; Sinha & Hanuscin, 2017). As science teachers navigate diverse and evolving social contexts, their professional identities transform (Farnsworth et al., 2016). To investigate professional identity as the science teachers move contexts (from the TLP to the school), elements from four theoretical frameworks based in social learning theory were integrated to form a conceptual framework: Provisional Selves (Ibarra, 1999), Leadership Identity Development (Komives et al., 2005), Communities of Practice and Social Learning Systems (Wenger, 2000), and Communities of Practice Teacher Leadership Model (Campbell et al., 2022).

Explanation for the Integration of the Theoretical Frameworks

Elements from four theoretical frameworks were integrated to address the major components of the study: emergent identity, leadership identity, and teacher leadership identity (see Table 2 below).

Table 2
Theoretical Frameworks Forming the Conceptual Framework

Theoretical Framework	Author	Description of the Theoretical Framework	Major Components of the Study	Rationale for Inclusion in the Conceptual Framework
Provisional Selves	Ibarra (1999)	A transient identity embraced by individuals as they engage and navigate unfamiliar roles.	Identity Experimentation with a New Role	This model describes the science teachers' exploration of their developing teacher leader identity while in the TLP.
Leadership Identity Development Model	Komives et al. (2005)	A leadership development model for emergent leaders with six phases of identity development.	Identity Development of Emergent Leaders	Awareness shapes the identity of emergent science teacher leaders by contributing to the development of confidence, leadership knowledge, interpersonal efficacy, and contextual understanding.
Communities of Practice and Social Learning Systems	Wenger (2000)	A framework that examines organizational design through the perspective of social learning, emphasizing the interaction between a sense of belonging and participation in a community of practice.	Identity Development in an Organization	The interaction between a sense of belonging and participation in a community of practice influences how and the degree that the science teachers learn, engage, and practice their competence in science teacher leadership.
Communities of Practice Teacher Leadership Model	Campbell et al. (2022)	A framework that explores the evolution of a teacher leader identity across various communities of practice over time.	Teacher Leadership Identity Development	This framework serves as the foundational component because it describes the longitudinal development of teacher leader identity within the TLP and the school.

Description of the Conceptual Framework

The conceptual framework, Identity Development Model for Emergent Science Teacher Leaders, synthesizes elements from identity development in different social contexts of organizations, leadership, and teacher leadership to describe the development of emergent

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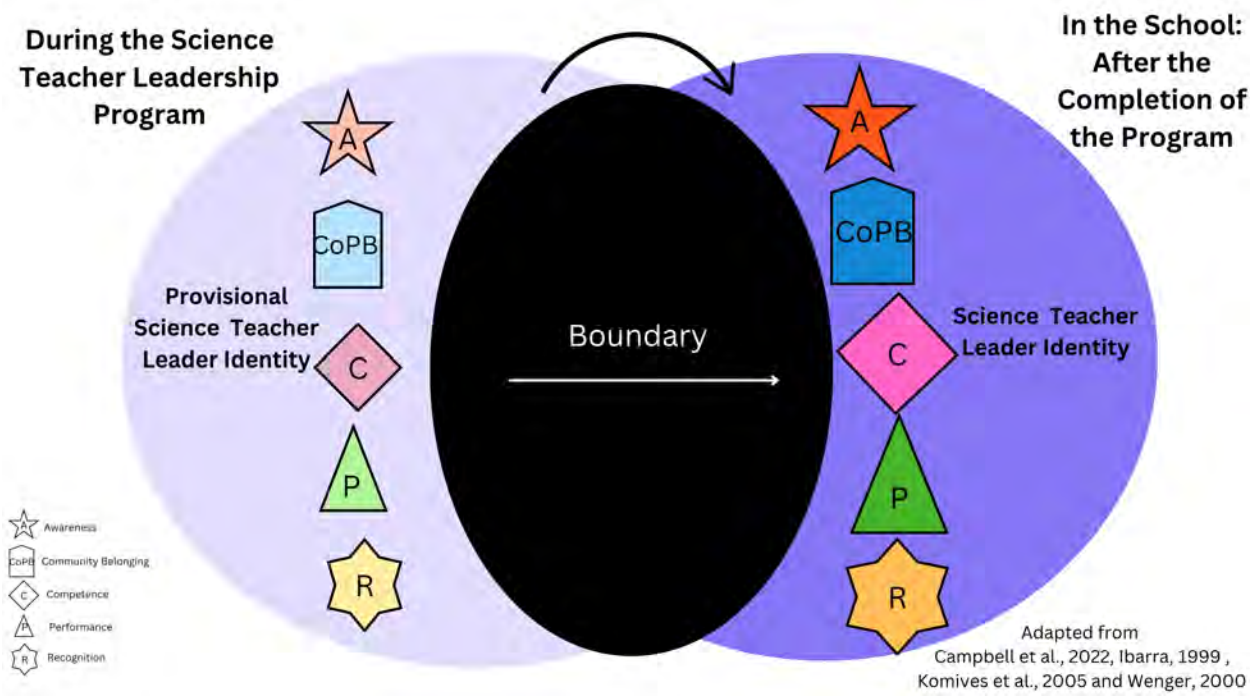
science teacher leaders. The conceptual framework describes a **provisional identity** (Ibarra, 1999), which is a transient identity embraced by individuals as they engage, explore, and navigate unfamiliar roles being formed in a TLP. The identity forms in one context and crosses the **boundary** between the external teacher leadership program and reforms in a second context, the school post-program (Campbell et al., 2022). Identity development occurs through 1) **awareness:** individual recognizes self and context in a different way ("A", in Figure 1: Komives et al., 2005), 2) **community belonging**: the interconnectedness of individuals through experiences, relationships, artifacts, and collective understanding ("CoPB", in Figure 1:Wenger, 2000), 3) **competence:** in depth knowledge and understanding of leadership and science pedagogical content knowledge ("C", in Figure 1: Campbell et al., 2022); 4) **performance**: public engagement and display of teacher leadership practices ("P" in Figure 1: Campbell et al., 2022); and 5) **recognition:** realization by self and others that they are a teacher leader ("R" in Figure 1: Campbell et al., 2022).

Figure 1
Identity Development Model for Emergent Science Teacher Leaders



Methods

A basic interpretive qualitative design was employed as the research method to gain a descriptive understanding of the science teachers' perceptions regarding the TLP's experiences. These experiences contributed to exploring their teacher leadership identity during the program and how it manifested after the program. Merriam and Tisdale (2016) noted that this research design seeks to understand how individuals interpret and make sense of their experiences. The research design's emphasis on personal experiences aligns with the study's conceptual framework, examining identity development through an individual's social experiences. This alignment ensured the coherence of the research and guided the data analysis of the interviews conducted with the science teacher leaders.

Authors' Positionality

The authors have experience as public school teachers. Throughout a 15-year career, Author 1 taught biology and chemistry and also served as a science department head at the secondary level. Author 2 spent seven years teaching high school chemistry before transitioning to a role as a chemistry educator at the college level. Additionally, Author 2 developed and facilitated the TLP examined in this study.

Participants

This study focused on the perspectives of 14 out of 16 science teachers recruited from urban and suburban schools serving diverse student populations in a central metropolitan area in the Southeastern U.S. (see Table 3 below). One teacher declined to participate, and another exited the profession post-program due to family obligations. The participants were chemistry and physics teachers with 5 to 17 years of teaching experience at the start of the TLP. Addressing the shortage of qualified chemistry and physics teachers was critical (Feder, 2022). One year after completing the TLP, participants were invited to participate in this project's data collection. Through individual science teacher leader interviews, the teachers reflected on their leadership experiences during and after the TLP.

Table 3
Attributes of the 14 Science Teacher Leaders

Cohort	Name	Main Subject Area	Years of Teaching Experience at the beginning of the TLP	Degrees at the beginning of the TLP
1	Ashley	chemistry	10	B.S. life science education
1	Henry	physics	17	B.S., M.S. aerospace engineering
1	John	physics	10	B.S. science education
1	Natalie	chemistry	6	B.S. biochemistry M.A.T chemistry education
1	Patty	chemistry	8	B.A. chemistry M.S. forensic science
1	Tess	chemistry	5	B.S. chemistry M.S. forensic science
2	Aimee	chemistry	5	B.S. chemical engineering Ph.D. chemical engineering, chemistry
2	Barrett	physics	5	B.S. physics
2	Cassandra	chemistry	5	B.S., M.S. chemistry
2	Elaine	physics	12	B.S. physics
2	Lee	physics	8	B.S. chemistry M.Ed. science education
2	Mark	physics	8	B.S., Ph.D. chemistry
2	Marty	chemistry	5	B.S., Ph.D. chemistry
2	Melanie	chemistry	5	B.S. chemistry

Data Sources

Data collected during and after the TLP offered comprehensive insight into the identity of the science teacher leaders (see Table 4 below). The provisional identities explored by the science teacher leaders during the program were captured through the 2015 and 2016 focus group interviews for cohort 1 and 2 and the TLP-related questions from the 2018 individual science teacher leader interviews. The findings section combined the 2015 and 2016 focus group interviews from Cohorts 1 and 2 to present the perspectives of all science teacher leaders who underwent the same program training and were asked identical interview questions. Two external evaluators summarized the focus group interviews. Each evaluator provided a report that included the interview's purpose, a summary of critical points, the questions asked, anonymous responses from the science teachers, and evaluators' observations.

Table 4
Data Sources Connected to the Research Questions

Research Question	Year	Type of Data	Function of Data
1. How did experiences during a teacher leadership program influence the exploration of identity for science teacher leaders?	2015 & 2016	Focus Group Interviews: Cohort 1 and Cohort 2	Science Teachers' Identity and Critical Experiences during the TLP
	2015 & 2016	External Evaluator Reports: Cohort 1 and Cohort 2	Triangulation
	2018	Individual Science Teacher Leader Interviews	Science Teachers' Identity and Critical Experiences during the TLP (Program-Related Questions)
2. How does a teacher leadership identity, developed during a teacher leadership program, manifest after the program concludes?	2018	Individual Science Teacher Leader Interviews	Science Teacher Leaders' Identity post-program (School-Related Questions)
1 and 2	2011-2017	TLP Artifact: Instructional Materials	Triangulation Context of the TLP
1 and 2	2018	Principal Investigator Interview	Context of the TLP

The 2018 individual science teacher leader interviews provided insights into the science teachers' leadership identity within their schools by examining the teachers' responses about their post-program experiences. Lastly, external evaluator reports, instructional materials and principal investigators interview were used to triangulate the data, enhancing the reliability and validity of the research (Santos et al., 2020).

Procedure for Data Analysis

The authors employed a thematic analysis to explore the science teachers' identity development throughout the TLP and within their schools, allowing for the interpretation of patterns and relationships within the data (Saldaña, 2021). A postdoctoral researcher, a graduate student, and two undergraduates conducted the coding process. The graduate student met weekly with a research professor to discuss the codes. Multiple researchers' involvement enhanced the analysis's trustworthiness (Lincoln & Guba, 1985). Initial training sessions ensured consistent code application, leading to the refinement of the codebook. Once trained, the researchers coded independently, achieving an inter-rater reliability of 80% on the transcripts, thereby maintaining the study's trustworthiness. Any ambiguous data were discussed among the researchers until a consensus was reached (Armstrong et al., 1997). The researchers entered all codes into NVivo-14 qualitative analysis software for further examination (Lumivero, 2023).

First and second cycle coding revealed the experiences that shaped the science teachers' leadership identity during the program and as it emerged afterward (Saldaña, 2021). Deductive first cycle coding used elements from the conceptual framework: awareness, community belonging, competence, performance, and recognition (see Figure 1 above). The elements were assigned to sentences or paragraphs to capture the meaning of the science teachers' interviews. After the first cycle coding, the data were categorized through descriptive sub-coding, adding more detail to each element (Miles et al., 2020). The sub-codes were inductively identified to denote how the science teachers perceived their understanding, behavior, or self-identification as a teacher, a classroom focus, or leader, a focus beyond the classroom.

The second cycle coding process involved examining patterns by reorganizing the data into two categories based on the conceptual framework's contexts: TLP and school (Saldaña, 2021). Data from the 2015 and 2016 focus group interviews and those related to the TLP from the 2018 individual science teacher leader interviews were categorized under TLP, providing insight into provisional identity. Data from the 2018 individual science teacher leader interviews related to the teachers' post-program experiences were categorized under schools. The school category was then divided into teacher leader and teacher subcategories using the study's definition of science teacher leaders. Data reflecting leadership within the school or broader community and collaboration with colleagues were placed under the science teacher leader category. Meanwhile, data related to classroom instruction were categorized under the science teacher category.

A matrix table was constructed to illustrate the intersection of direct quotes from the science teacher leaders (Miles et al., 2020). This table, with columns labeled with the elements and sub-codes and rows representing the identity: provisional identity (TLP), teacher identity (school), and science teacher leader identity (school), facilitated the development of themes by initially identifying the patterns within the provisional identity category and comparing them with the patterns observed in the school setting (see Appendix A).

Findings

This study examined the impact of a TLP on the teacher leadership identity of science teachers during and after the program. Three themes emerged describing the experiences that influenced the exploration of the science teacher leaders' identity during the TLP and manifested after the program: 1) Redefining leadership, a partnership dynamic devoid of formal structure or authority; 2) Responsibility for others, the obligation to foster the professional development of colleagues; and 3) Collaborative community, supportive interactions fostering awareness, personal connections, diverse viewpoints, mutual engagement, and leadership growth (see Figure 2 below). The findings followed the conceptual framework, showing how the teachers explored their teacher leadership identity during the TLP and the presence of this identity in their schools after the completion of the program.

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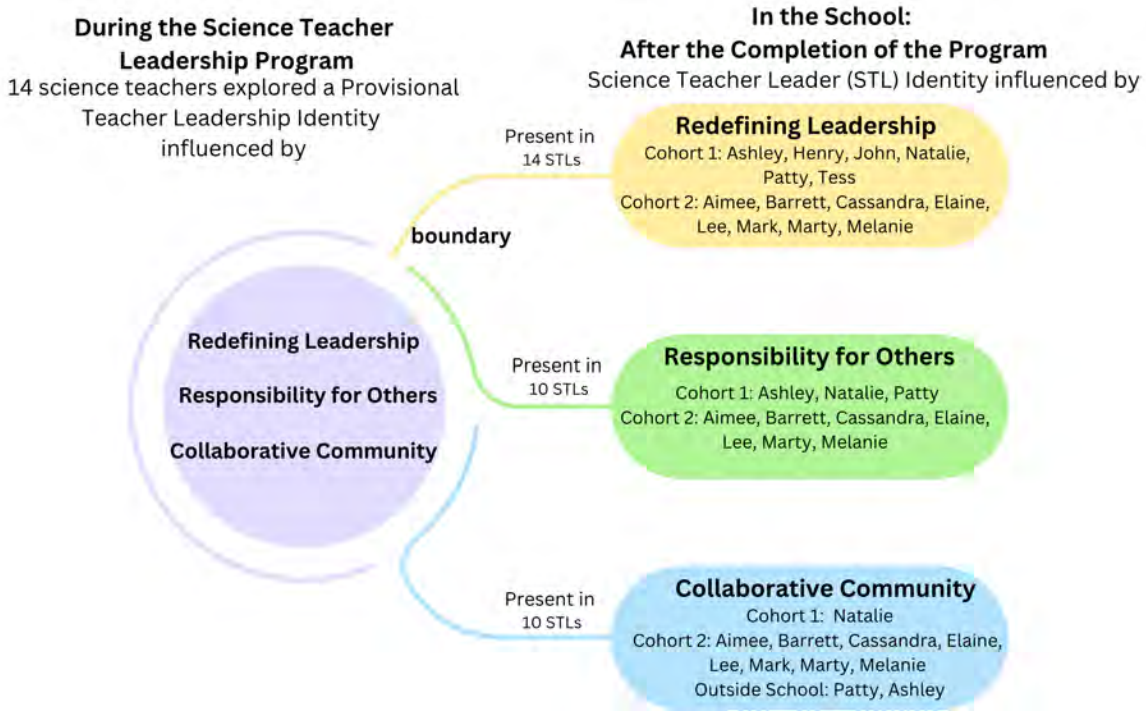
Figure 2

The Themes Prompting Teacher Leadership Identity Exploration and their Presence Post-program



Teacher Leadership Program: Exploring Science Teacher Leadership During the Program

Redefining Leadership in the TLP

Redefining leadership meant adopting a collaborative approach rather than a hierarchical one. Initially, the science teachers viewed leadership as solely administrative (Focus Group, Cohort 1, 2015) and didn't see themselves as school leaders (Individual Science Teacher Leader Interview, Mark, 2018). Through the TLP, they became aware of redefining leadership through leadership certification courses that taught them "how to be an effective leader but didn't necessarily give them positions or titles" (Focus Group, Cohort 2, 2016). Redefining leadership empowered them to engage in meaningful collaboration, fostering a sense of "impact" in their professional roles (Focus Group, Cohort 1, 2015).

The science teachers experimented with their leadership identity during the program's professional learning community (PLC), conference presentations, and opportunities outside the classroom. This new understanding of informal leadership helped them experiment with teacher leadership in the program's PLC. A Cohort 1 teacher described the PLC as a space for passionate collaboration and shared growth, where they developed leadership skills by working in small groups (Focus Group, Cohort 1, 2015). This collective decision-making experience reinforced that leadership extends beyond the classroom, by sharing and collaborating with other teachers (Focus Group, Cohort 2, 2015).

Tess identified sharing information at conferences as a catalyst for her experimentation with teacher leadership. She said, "the experiences and opportunities I had and the people I got to talk changed the way I saw myself" (Individual Science Teacher Leader Interview, Tess, 2018).

Lee gained an awareness of his impact on the educational system through opportunities that allowed him to share information outside his classroom. He said, “I think that's helped me to see that you can be a classroom teacher and still have influence and grow your influence” (Individual Science Teacher Leader Interview, Lee, 2018). Lee recognized that being a classroom teacher does not limit one’s ability to impact others, and that influence can continue to develop over time. Developing influence allowed the teachers to see themselves as leaders. A Cohort 2 teacher said, “I can have an influence beyond just my classroom…I’m starting to be seen as a leader” (Focus Group, Cohort 2, 2015).

There were drawbacks associated with opportunities that occurred when experimenting with redefined leadership in different contexts. A Cohort 2 teacher said, “It’s actually easier to help people you don’t know versus trying to influence those that you do [especially] when trying to practice leading” (Focus Group, Cohort 2, 2016). Barrett spoke about the challenges of redefined leadership in familiar contexts. He said, “[While in the program] I worked with so many people that were apathetic in my own school. However, I need to help them by being in that building more” (Individual Science Teacher Leader Interview, Barrett, 2018).

Responsibility for Others in the TLP

A responsibility for others represents an obligation for the science teacher leaders to foster the professional development of colleagues. This responsibility appeared in the TLP through the desire to develop more well-trained science teachers, who need proper training in pedagogical content knowledge and leadership (Focus Group, Cohort 2, 2016). A Cohort 2 teacher wanted to “help colleagues grow” (Focus Group, Cohort 2, 2016). Program discussions helped them recognize their duty to develop others (PI interview, 2018). Marty mentioned that being called "superstars" by facilitators “motivated them to improve teaching and develop peers” as leaders (Individual Science Teacher Leader Interview, Marty, 2018). Principal investigators stressed empowering the wider school community (PI interview, 2018), and this became “ingrained” as part of a teacher leader’s role (Individual Science Teacher Leader Interview, Ashley, 2018).

One Cohort 1 teacher described this responsibility as developing fellow teachers and becoming more invested in what was happening across classrooms (Focus Group, Cohort 1, 2015). One teacher expressed that students in other classrooms were now part of their responsibility (Focus Group, Cohort 2, 2015). However, not all teachers embraced this role easily. One felt limited by classroom demands, saying, “I feel like I can't do all those things I want to do” (Focus Group, Cohort 1, 2015).

Collaborative Community in the TLP

The collaborative communities in the TLP fostered personal connections, diverse perspectives, mutual support, and leadership growth. These interactions exposed science teachers to new opinions, encouraged reliance on others, and fostered vulnerability. In 2018 individual science teacher leader interviews, all teachers emphasized the importance of the TLP’s collaborative environment in shaping their leadership development. The TLP provided opportunities for collaboration through leadership discussions, conference presentations, and participation in PLCs, which strengthened their commitment to improving teaching and solidified their professional identity. A Cohort 2 teacher described the group as “highly intelligent... [and] all wanting to be better teachers” (Focus Group, Cohort 2, 2015). Beyond their expertise, these teachers valued learning from others' perspectives while openly sharing their

educational philosophies. Melanie described the group as being "like-minded" (Individual Science Teacher Leader Interview, Melanie, 2018).

This collaborative atmosphere also played a key role in leadership identity development. Teachers noted that their growth as leaders was driven by the support and collaboration within the TLP's group (Focus Group, Cohort 2, 2016). Role models and collective encouragement inspired them to experiment with leadership, as John reflected: "I kept thinking about [leadership]... [colleagues] kept inspiring us to do those things" (Individual Science Teacher Leader Interview, John, 2018). This community-driven support elevated their leadership skills and strengthened their identity as leaders.

School: Manifesting Science Teacher Leadership After the Completion of the Program

Redefining Leadership in the School

Evident in the analysis of all the teachers' 2018 post-program experiences (N=14) was the presence of redefining leadership, a partnership based on collaboration. All the science teachers expressed this type of leadership when asked to describe their performance as a teacher leader post-program. Henry, John, Tess, Patty, and Ashley expressed sharing teaching or content knowledge with colleagues, even though they had limited personal relationships with their school colleagues.

Aimee explained her teacher leadership role in the school. She said, "I am a leader of the chemistry group. We do not have official leadership positions for academic disciplines. When somebody wants to know something about chemistry, I'm the go-to person" (Individual Science Teacher Leader Interview, Aimee, 2018). Aimee recognized herself as a de facto leader (the go-to person), sharing her knowledge of chemistry. Also, her performance as a teacher leader was recognized by colleagues because they sought her guidance, despite the absence of a positional title. Natalie spoke about her influence on the school post-program. She realized her ability "to influence students, colleagues, and others in the community to get better with their craft" (Individual Science Teacher Leader Interview, Natalie, 2018). Melanie described working with other teachers as an "interaction she loved" because she had a "bigger influence" on them because she was still in the classroom teaching alongside them (Individual Science Teacher Leader Interview, Melanie, 2018).

Redefining leadership also produced a sense of classroom contentment post-program. Cassandra said, "I am growing and growing does not have to be a vertical move. I can grow where I'm at. I can make an impact without having a title. I'm very content now as a classroom teacher. I see myself as a teacher leader" (Individual Science Teacher Leader Interview, Cassandra, 2018). Cassandra's comment acknowledged that growth does not entail moving into a principal or district office position. A teacher can make a difference without holding a formal title. Like Aimee, Cassandra recognized herself as a leader without a title.

Post-program some of the teacher leaders had greater influence outside the school. Elaine's teacher leadership opportunities centered on her work as an AP Physics teacher, providing professional development at the state and national levels. Elaine said, "I felt like I was seen as a leader outside my school. The teachers around me never cared to use me or ask for advice" (Individual Science Teacher Leader Interview, Elaine, 2018).

Responsibility for Others in the School

Post-program, the concept of responsibility for others influenced teacher leaders in varying ways, as evident in 10 of the 2018 individual science teacher leader interviews. Natalie's,

Aimee's and Patty's perspective of responsibility for others represents the 10 teachers who also hold this view. Natalie viewed a teacher leader as someone who "coaches others to improve, helping everyone understand" the system (Individual Science Teacher Leader Interview, Natalie, 2018). Her approach went beyond collaboration, as she sought to elevate others beyond their current level. Aimee echoed this sentiment, emphasizing the importance of an "us attitude" over a "me attitude" in her role as a science teacher leader (Individual Science Teacher Leader Interview, Aimee, 2018). Patty stated that she wanted to make the system "better than what it was" when she entered so she wanted to "lead so that it's easy for others to follow" (Individual Science Leader Interview, Patty, 2018).

For four science teacher leaders, responsibility for others was challenging. Mark remained a teacher leader but found balancing leadership and teaching difficult, feeling guilty when he couldn't meet his students' needs (Individual Science Teacher Leader Interview, Mark, 2018). Henry and John preferred to share materials with colleagues while "working and developing students" (Individual Science Teacher Leader Interview, Henry, 2018). After completing the program, Tess left her school to avoid the pressure of being accountable for others, expressing discomfort with the overwhelming responsibility (Individual Science Teacher Leader Interview, Tess, 2018).

Collaborative Community in the School

The science teacher leaders benefited from a collaborative community in their schools, marked by strong relationships, diverse perspectives, and mutual support, which continued to foster their leadership after the TLP. Lee, representing ten science teacher leaders with positive school collaborations, said, "[Relationships are] pretty positive. I feel there are a lot of people I can talk to and joke around with. We are all very collaborative, even beyond our department. There is a lot of communication in the school, sharing of methods, a lot of support" (Individual Science Teacher Leader Interview, Lee, 2018). Lee was recognized as a resource for colleagues across departments, further contributing to the supportive atmosphere.

In contrast, five science teachers who lacked a collaborative community were less engaged as leaders in their schools. Tess transferred schools, limiting her relationships with colleagues. Henry described close "working relationships" with his physics colleagues but noted a lack of personal connections outside his department, limiting his leadership reach (Individual Science Teacher Leader Interview, Henry, 2018). John had a similar experience, observing that his interactions with colleagues became less "positive" and he felt he was "losing influence" after the TLP ended, as the regular community engagement it provided faded (Individual Science Teacher Leader Interview, John, 2018). Patty and Ashley transferred schools after the program and had not established collaborative communities in their schools. They experienced limited leadership inside the school. However, they did maintain collaborative communities outside the school that provided them with teacher leadership opportunities.

The findings suggest that the TLP helped teachers redefine leadership in more collaborative, informal ways while providing opportunities for them to practice and expand their leadership influence. These leadership roles often came with both a deepened sense of responsibility and various challenges in implementing leadership within familiar school contexts.

Discussion

This manuscript examines science teachers' experiences who participated in a TLP, both during and after the program's conclusion. The analysis is grounded in social learning theory to determine how the participants make meaning of their teacher leadership experiences. The study focuses on how science teacher leaders explore their leadership identity during the TLP and how it manifests in their school contexts post-program. Elements of the leadership identity cultivated during the TLP remain evident in their school environments after the program ends. From the perspectives of the science teacher leaders, three key elements shape their leadership identity during and after the program: 1) redefining leadership—a partnership-based approach to leadership that operates without formal structure or authority, 2) responsibility for others—a sense of obligation to support the professional growth of colleagues, and 3) collaborative community—fostering connections through mutual engagement, diverse perspectives, personal relationships, and shared leadership growth. This section examines each theme with both the program and school contexts.

Redefined Leadership in the TLP and School

The redefined approach to leadership, which emphasizes collaboration and leaders without titles, transitioned from the Teacher Leadership Program (TLP) into the school environment, maintaining its significance and effectiveness. Redefined leadership empowers science teacher leaders to influence and impact colleagues—an essential element of teacher leadership (Cheung et al., 2018; Katzenmeyer & Moeller, 2009). Within the TLP, the science teachers felt a sense of belonging and influential by sharing with colleagues. Through the TLP's professional learning community (PLC) and outside the classroom leadership opportunities (e.g., conference presentations) they gained an awareness of leadership as a collaborative and informal process. Empowerment allows them to collaborate and develop leadership skills beyond the classroom despite not holding formal leadership titles.

At the school level, these science teachers continued engaging with both small and large groups within and beyond their schools, performing as collaborators. Even Henry and John, who had limited opportunities for collaboration, assumed a redefined leadership role by working informally with other physics teachers in their schools. Redefined leadership is significant because it fosters competence and recognition by supporting an individual's sense of value and professional growth (Miles & Markgren, 2023). The redefinition of leadership, with its strong emphasis on collaboration, also contributed to teachers' contentment with classroom teaching, potentially reducing the likelihood of them leaving the profession. Teachers who engage in instructional leadership based on collaboration have a greater tendency to remain as classroom teachers (Lazcano et al., 2022). For teachers like Henry and John, their competence as science teachers and working with colleagues in their content area may have contributed to their decision to remain in the classroom.

Additionally, redefined leadership allowed Aimee and Cassandra to recognize themselves as leaders, signifying the integration of leadership into their professional identities (Komives et al., 2005). Wenner and Campbell (2018) emphasized that teacher leaders must integrate their identities as teachers and leaders to function effectively in schools. Through collaboration and sharing with colleagues informally, the science teacher leaders were able to integrate this aspect of leadership into their identities.

Responsibility for Others in the TLP and School

Responsibility for others extends beyond simple collaboration to development with colleagues, giving science teacher leadership a broader and more profound significance. Nurturing the growth and development of colleagues leads to social responsibility (Sunderman et al., 2023). As Komives et al. (2005) highlighted, an aspect of leadership identity development in emergent leaders is a sense of greater purpose, which includes fostering the development of others. When a larger purpose in their work drives individuals, they tend to form stronger connections and community belonging (Pratt et al., 2020). A sense of responsibility for others in one's work brings a deep sense of fulfillment and satisfaction (Wiktorowicz et al., 2022). The concept is particularly relevant to exploring a science teacher leader identity, as it emphasizes the role of others in performing as a leader and enriching leadership positions.

The impact of this responsibility for others varied among emerging science teacher leaders. Marty and Ashley emphasized that leadership within teaching extends beyond sharing ideas to feeling invested in colleagues' teaching practices and student outcomes. In the school environment, Natalie and Aimee embraced this investment in their peers, creating a united front to improve the educational system. These teachers' collective mindset focuses on the school's benefit and emphasizes collaboration over competition. In contrast, Tess did not fully integrate this aspect of leadership into her identity after completing the program. The difference in the support she received from her colleagues during the TLP compared to her experience at school may have influenced her perception of teacher leadership. Research suggests that individuals who feel disconnected from their community are more likely to resist changes to their identity, which can create a sense of dissonance (Joseph et al., 2017). Tess experimented with teacher leadership when interacting with program peers. Since identity is an ongoing negotiation, she may continue to develop this self-perception after the program.

The Collaborative Community in the TLP and School

Being part of a collaborative community, where members share mutual support and assistance, is a necessity and a fundamental aspect of the human condition (Adler & Heckscher, 2005). The science teachers in the TLP formed such a community, a supportive and like-minded group that expanded their networks through various teacher leadership opportunities. They attributed their growth as leaders to this community, underlining the crucial role of collaboration and inspiration from their peers to identity formation. The collective encouragement and peer learning in this environment not only helped them solidify their leadership identities during the program but also fostered a deep sense of belonging and support, making each member feel included and valued.

Interactions within the TLP also heightened the science teachers' awareness of their capacity to influence others as teacher leaders. Influence, as defined by Hoy and Smith (2007), involves persuading change in another person's thinking or actions. Science teacher leadership functions through this influence, allowing teachers to mentor, collaborate, and advocate for their colleagues and students. Unlike authority or manipulation, influence in teacher leadership depends on understanding the needs and motivations of others. Science teacher leaders apply this awareness to affect their peers' behaviors and attitudes positively. Both Lee and Natalie recognized their positive influence on their colleagues through their informal leadership roles.

Some science teachers observed a noticeable contrast between their dedicated TLP peers and certain indifferent colleagues within their school environments. This disparity created tension and led to different responses in leadership approaches. For instance, Elaine sought out

leadership roles and earned recognition beyond her school, expecting her school colleagues to seek her guidance. On the other hand, Barrett realized he needed to take the initiative to engage with and support his colleagues. A shared commitment to continuous improvement fostered relationship-building, as science teachers were naturally drawn to those who shared their values and beliefs (Lawrence & Shah, 2020). While Elaine found this shared commitment in individuals outside her school, Barrett saw the potential to nurture it among his colleagues.

For science teacher leaders, it is crucial to recognize the challenges of influencing colleagues who may wait to embrace their leadership identity. Rather than restricting their leadership development to environments outside of their schools, they may need to adapt their skills, build relationships, set clear expectations, demonstrate passion, and remain open to gain credibility and influence (Hogg et al., 2012). This adaptability is critical to successfully navigating the complexities of teacher leadership within the school setting.

Conclusion and Implications

The examination of science teachers' experiences during and after their participation in a TLP reveals the exploration and manifestation of their leadership identity. Their experiences underscore three key elements that shape their identity during the program and persist beyond its conclusion: the adoption of partnership-based leadership approaches, the embrace of a sense of responsibility to support the growth of others, and the fostering of collaboration with colleagues. These findings have significant implications for science teacher leaders, school administrators, and the design of teacher leadership professional development programs, offering insights into effectively nurturing sustainable leadership practices.

Science Teacher Leaders

Science teacher leaders must navigate the transition between the TLP and school environments by adapting their leadership skills to their school culture. They should be mindful of how their competence and recognition from the TLP may shift their self-perception and actions. Maintaining leadership identity within the school requires fostering community belonging and engagement. Additionally, staying connected with TLP peers and networks is crucial for reinforcing their leadership identity.

School Administrators

School administrators should support science teacher leaders during their transition from the TLP by providing structures like time and space to nurture their leadership roles. They should recognize the importance of leadership redefinition and its impact on teachers' job satisfaction. Participating in TLP experiences can help administrators understand the benefits of redefined leadership. Schools should also document teacher leadership actions through self- and peer recognition, which can help gauge the impact of these leaders.

Teacher Leadership Professional Development Programs

TLP providers should build mechanisms for maintaining networks after program completion, emphasizing the role of peer connections in sustaining leadership identity, particularly for those struggling to build community in their schools. Individualized support should be offered based on participants' experiences within the TLP to assess its impact.

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Appendix A

Coding Matrix

	Awareness-leader	**Competence-teacher**	**Performance-leader**	**Recognition-leader**	**Community Belonging-leader**
Provisional Science Teacher Identity (Teacher Leadership Program)	The leadership piece … I really found it valuable too. Some of the activities that we did, and just the thinking perspective and understanding how some of the decisions are made that were affecting me …[I] sort of have a better understanding of how those things came about. I really think the leadership piece was an important part, too. (Focus Group, Cohort 1, 2015)	We're doing some technology and trying to tie that into chemistry lessons and improve lessons in that manner. It's worked pretty well." (Focus Group, Cohort, 1, 2015)	As a teacher leader I'm willing to try and share new approaches, new teaching techniques with people in my school, especially since I just changed schools. (Focus Group, Cohort 2, 2015)	I can have an influence beyond just my classroom…I'm starting to be seen as a leader (Focus Group, Cohort 2, 2015	[My PLC colleagues] give you a chance to have other opinions to validate, giving you other things to try and other perspectives to look at. It gives you a fresh set of eyes. I don't see it the way they see it. I need another way to look at it. (Focus Group, Cohort, 1, 2015)

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	Awareness-leadership	**Competence-teacher**	**Performance-leader**	**Recognition-leader**	**Community Belonging-leader**
Science Teacher Identity (School)		[The impact of the program] would be in terms of my teaching, it has made me better about sequencing content so that students really understand. (Individual interview, Ashley, 2018)			
Science Teacher Leader Identity (School)	A teacher leader is in a position where they can support other teachers in their professional, whatever it is professionally. They don't necessarily have to be an administrator; they can be a teacher. (Individual interview, Henry, 2018).		I work as a teacher leader in a countywide program. Every single school is required to incorporate many different discipline professionals. I put media and TV together in a professional development meeting that includes doing outside activities with students. (Individual interview, Barrett, 2018)	You know, people, people see me differently than they used to. In the past I had sought out a title of leadership, you know, basically getting department head and being appointed a leader. And in this case, I feel like it was more, I was selected as a leader by my peers because they saw qualities in me that they felt would be beneficial for our program. (Individual interview, Natalie, 2018)	When you start somewhere new, it takes a while to develop trust, and it takes a while to develop friendship. I have that. She was a physical science teacher in a middle school for 17 years. She's a wonderful teacher that I collaborate with (Individual interview, Aimee, 2018)