



International Journal of Leadership in Education

Theory and Practice

ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/tedl20>

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To cite this article: Joshua W. Reid, Allison B. Hardee, Brett A. Criswell, Melody Elrod, Steven B. Berryhill Jr. & Gregory T. Rushton (2022): Empowering teacher leaders: the role of research in changing teacher leaders' sense of themselves as professionals, International Journal of Leadership in Education, DOI: [10.1080/13603124.2022.2045629](https://doi.org/10.1080/13603124.2022.2045629)

To link to this article: <https://doi.org/10.1080/13603124.2022.2045629>



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Published online: 11 Mar 2022.



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RESEARCH

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Empowering teacher leaders: the role of research in changing teacher leaders' sense of themselves as professionals

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ABSTRACT

Teacher leaders often have to navigate implicit leadership structures within their schools and often move between communities as part of their roles. This study explores how a Noyce Master Teaching Fellow program fostered a sense of empowerment within teacher leaders. The program provided opportunities for the teacher leaders to become legitimate participants in a research community in addition to supporting the transfer of new meanings, practices, and identities to their teaching community of practice. Drawing upon frameworks of border crossing and communities of practice, we highlight mechanisms by which teacher leaders become empowered and cross the boundaries between research and teaching. We identified four mechanisms of empowerment: (1) identification of shared boundary objects, (2) coordination of professional visions, (3) experimentation with provisional selves, and (4) expansion of professional networks. Additionally, our analysis revealed ways in which validation, legitimacy, and sense of belonging are fostered through engagement in a research community. The findings from this study have both theoretical and practical implications for leadership development and teacher leader scholars.

Teacher leadership in K-12 schools has been associated with a number of positive outcomes for teachers and students: increased teacher retention, student learning, and instructional reform (Wenner & Campbell, 2017; York-Barr & Duke, 2004), and a sense of validation as professionals for teachers who take on teacher leader roles (Smylie, 1995; Smylie et al., 2002). Enacting leadership practices within K-12 schools, however, requires teacher leaders to navigate extant and often top-down leadership structures in established school cultures. Current models of teacher leadership advocate for a shift away from hierarchical, formalized leadership roles (the typical norm in school cultures) to more distributed leadership roles that empower teachers to lead while maintaining their positions as educators (Harris, 2003; York-Barr & Duke, 2004). Many studies have sought to define teacher leadership roles and practices (i.e. Lai & Cheung, 2015; Muijs & Harris, 2003; Smylie, 1995; York-Barr & Duke, 2004) and challenges surrounding teacher

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leadership (i.e. Cooper et al., 2016; Weiner, 2011; York-Barr & Duke, 2004). Less understood is how teacher leaders become empowered to make change within their classrooms (as teachers) and their educational systems (as teacher leaders), a task that can seem daunting.

Teacher empowerment is often used to describe the extent to which teachers are given a voice in decision-making processes related to teaching and learning in their schools (Lin, 2014; Rice & Schneider, 1994). Short (1994) defined teacher empowerment as ‘a process whereby school participants develop the competence to take charge of their own growth and resolve their own problems’ (p. 38). Considering both perspectives, empowerment of teachers involves providing opportunities for teachers to engage in power structures, develop autonomy, and foster a sense of responsibility in their schools (Lightfoot, 1986). The concept of teacher empowerment arose from reform and school improvement efforts (Pounder, 1998), and has since been shown to be positively related to teachers’ job satisfaction (Bogler & Nir, 2012; Rice & Schneider, 1994; Thomas & Velthouse, 1990), school and student achievement (Lyons et al., 2013; Marks & Louis, 1997), and professional validation (Maeroff, 1988). Moreover, teacher leaders have reported feeling more empowered than non-leader teachers and this is considered to be related to the increased opportunities to engage in decision-making in their schools (Rinehart & Short, 1991).

An effective path to empowerment for teacher leaders is through engaging in research activities and using research insights to inform their contributions to school decision-making. Engaging in research and using research-informed contributions in their schools can lead to the incorporation of research into their professional identity (Cochran-Smith & Lytle, 1999; Dempsey, 1992; Zeichner, 2003). Teacher leaders are in a prime position to not only benefit from research (i.e. *consuming* knowledge), but they can also use research to transform teaching, learning, and school systems through *mobilizing* and *producing* knowledge (Dimmock, 2016; Gunter & Ribbons, 2003). However, teacher research is often designed and implemented within a school system or a teacher’s classroom; little is known about how teacher research skills and projects developed external to the school and classroom facilitate their work and empower them.

Running parallel to academic considerations regarding teacher leadership, the National Science Foundation (NSF) funded Robert Noyce Teacher Scholarship Program (<https://www.nsfnoyce.org/>) promotes the development of Master Teaching Fellows, teachers in a program for developing teacher leaders (National Science Foundation, 2017). Noyce programs across the United States under the Master Teaching Fellowship (MTF) track utilize different methods to empower science, technology, engineering, and mathematics (STEM) teachers in their teaching and leadership, including STEM education courses, mentorship, and professional development activities chosen by individual administering universities (National Science Foundation, 2017). In this study, we explored how an NSF Robert Noyce Scholarship Program positioned Master Teaching Fellows (hereafter Fellows) as empowered leaders within their schools by encouraging their participation in a research community of practice (CoP). In this Noyce program, teacher leaders were provided with opportunities to engage in a research community of practice to bolster their teacher leadership and professional identities as teacher leaders. We used semi-structured interviews to study the impact of a Noyce teacher leadership program, *Mountaintop Teacher Leadership Program* (program

pseudonym), on the development of teacher leaders. The focus of this paper will be on the program structure, particularly related to how it fostered a sense of empowerment within the teacher leaders and supported the development of researcher identities in conjunction with teacher and teacher leader identities. We examine the way these identities, and associated practices and meanings, were transferred back to the teaching CoP rather than how this transfer influenced the teaching CoP more broadly. The specific research questions for this study were:

RQ1: What were the conditions in the Noyce CoP that affected their experiences within their teaching CoP?

RQ2: In what ways did crossing the boundaries between teaching and research CoPs affect the Fellows' identities as teacher leaders and their validation, credibility, and sense of belonging within their teaching CoP?

RQ3: How did the Fellows transfer what they learned in the research CoP to their teaching CoP?

Literature review

The focus of this study is how the experiences of the Master Teaching Fellows (henceforth, *Fellows*) as education researchers within the Mountaintop program fostered a sense of empowerment as teacher leaders within their K-12 schools. To ground this study in the appropriate literature, we have surveyed existing research related to teacher leadership in general, the role of teacher research in the professional activities and identities of teachers, and specific constructs that allowed us to understand the factors involved in the empowerment of teachers and teacher leaders.

Teacher leadership and teacher research

Though the definition of teacher leadership has been contested over the last two decades (Wenner & Campbell, 2017; York-Barr & Duke, 2004), a broad characteristic of teacher leadership is that it involves K-12 teachers who maintain both teaching and leadership responsibilities in and out of the classroom (Wenner & Campbell, 2017). The responsibilities of teacher leaders can vary across schools. For example, in some schools, teacher leaders are provided formal roles such as Department chair, while in other situations teacher leaders are afforded more informal roles such as de facto leader of a curriculum redesign effort. Across this spectrum of leadership roles, there are various ways the activities of teacher leaders have been categorized. For instance, the Teacher Leadership Institute (Teacher Leadership Institute, 2018) has distinguished between three types of teacher leadership: instructional, association, and policy leadership. By comparison, the Teacher Leadership Exploratory Consortium (Teacher Leadership Exploratory Consortium, 2011) has identified seven domains into which the work of teacher leaders can be delineated: fostering a collaborative culture, accessing and using research, promoting professional learning, facilitating improvements in instruction, promoting the use of assessments and data, improving outreach and collaboration, and advocating for student learning and the profession. The TLI types have research

embedded in two of the three labels; the TLEC domains have research as its own area. The literature on teacher leadership has largely not investigated the mechanisms through which empowerment takes place when engaged in these leadership activities related to research.

In parallel to the activity categorizations outlined above, several scholars have focused on the essence of what makes a teacher leader. Dempsey (1992) outlined four metaphors for teacher leadership: (1) fully functioning person, (2) reflective practitioner, (3) learning partner, and (4) scholar. These metaphors suggest that teacher leaders construct a nexus of identities to inform their practice in leadership. These multiple identities provide the context for teacher leaders to develop skills, knowledge, and competency to be effective in their roles. For this paper, we focused on one of these metaphors (scholar), which was conceptualized by Dempsey (1992) as *consumers* of academic knowledge. Criswell et al. (2018) moved beyond Dempsey's (1992) view and supported the notion that teacher leaders as scholars can be *producers* of knowledge, which aligns with other scholarship about teachers as researchers (i.e. Cochran-Smith & Lytle, 1999). It has been shown that positioning teachers, and particularly teacher leaders, as researchers and producers of knowledge helps foster competency in their practices and promotes the professionalization of teaching (Cochran-Smith & Lytle, 1999). Furthermore, engaging teachers in research (i.e. teacher or action research) has been suggested as a mechanism to provide agency and validation to teachers (Zeichner, 2003).

Teacher research has been promoted as an extension of, or alternative to, traditional teacher professional development (Borg, 2015; Zeichner, 2003). This alternative presents opportunities for teachers to engage in self-reflective processes about their own practices (Zeichner, 2003), and personalize their professional development (Borg, 2015). In the current study, we adopted the stance taken by Borg (2015) and defined teacher research as a feasible, self-reflective tool that teachers can use to bring about change within their schools and classrooms. While this stance of research is data driven, the goal is often to focus on improving practice within the classroom or school system as compared to broader and more global impacts (Zeichner, 2003). This conceptualization of teacher research aligns with the mission of teacher leaders as reported by Smylie et al. (2002) and Criswell et al. (2018).

Zeichner (2003) found that when engaged in research in their schools that was teacher-driven, collaborative, and intellectually rigorous, educators took a more analytical approach to teaching, became more student-centered, and felt empowered to make change with policy-based decisions in their schools. This research is often conducted within the teachers' schools and classrooms. Related to the issue of the support system for teacher researchers being external to the school system is the question of what happens when these teacher leaders attempt to transfer the ideas for and findings from their research efforts into the school systems. As Terhart (2013) has noted,

Although educational researchers, school reformers and educational developers assume that teachers and schools await their programmes, proposals and new practices with baited breath, we should accept the fact that a considerable majority of teachers and schools in fact simply want to hear nothing of reform, innovation, new forms of teaching and so on. (pp. 486 – 487)

It is not clear how empowerment is affected when the development of the teacher research skills and design of the teacher research projects are undertaken as part of involvement in groups *external* to the school system. The Fellows in our study were part of just such an external entity (the Noyce Mountaintop project) that facilitated their work as *teacher leaders as researchers*.

Terhart's (2013) statement suggests that there will be pushback to the attempts made by teacher leaders to bring research insights from their external entities back into the school system. Day (2013) alluded to the competencies required for teacher educators as researchers to bridge the divide between higher education and K-12 schools. Quoting Walker (1996), Day suggests these include, '... the competence to cross borders, cultures and dialects, the learning and translating of multiple languages (the political, the everyday, the academic) and the courage to transgress when faced with social injustices' (p. 19). Day (2013) then goes on to connect this skillset to the notion of border crossings from Finley (2005). In a parallel manner, teacher leaders being supported in their research by an external entity must function as border crossers by, for instance, connecting the language of research to the language of practice for their peers and finding ways to attain buy-in from peers and administrators. Effectively doing so could be empowering for these teacher leaders; struggling or failing to do so could lead to decreases in their professional satisfaction. To date, we know little about how teacher leaders enact such change within their schools or how their peers' and administrators' responses to such changes affect the identities of the teacher leaders.

Teacher leader identity

Wenner and Campbell (2018) conceptualized a teacher's leadership identity to be based on three characteristics: competency, performance, and recognition. A teacher must possess the skills needed to lead, be willing to perform leadership tasks, and be seen as a leader by others in order to be considered a teacher leader. This identity structure was first presented by Carlone and Johnson (2007) with regard to science teachers' identities stating, 'One cannot pull off being a particular kind of person (enacting a particular identity) unless one makes visible to (performs for) others one's competence in relevant practices, and, in response, others recognize one's performance as credible' (p. 1190). Thus, teacher leader identity is shaped not only by one's ability to skillfully act in the role as leader, but also through the acknowledgment of their leadership by others in their community.

To be viewed as a leader by oneself and others, then, a teacher must have the opportunity to develop and enact skills related to that position. According to socialization theories, acquiring new roles involves acquiring new behaviors, beliefs, and values related to that new role (Staton & Hunt, 1992), as well as seeing one's future self in the new role (Markus & Nurius, 1986). For teachers, learning to integrate research into their practice requires them to also see themselves or future selves as a teacher and researcher. Markus and Nurius (1986) referred to this *vision* of one's future self as 'possible selves', while Ibarra (1999) referred to *enacting* these possible selves as 'provisional selves'. Teachers' images of their future selves are interpreted as either desirable or undesirable based on whether these new images synergize with or come into conflict with current identities and contexts (Ibarra, 1999). What is not clear is what happens if/when these

images synergize in one context (e.g. the focus of an external professional development program aligns with what is valued in a school) and generate conflict in another context (e.g. the focus of a group of teachers on researching their practices opposes the use of traditional practices in a school).

Empowerment of teacher leaders

The notion of teacher empowerment first arose in the late 1980s as a response to implementing reform initiatives in schools and school improvement efforts. Since that time, scholars have studied teacher empowerment from multiple perspectives and evidence suggests teacher empowerment to be a crucial factor in school effectiveness (Wall & Rinehart, 1998). Several studies have identified positive correlations between empowerment of teachers and their job satisfaction (Bogler & Nir, 2012; Rinehart & Short, 1993), organizational and professional commitment (Bogler & Somech, 2004), and school and student achievement (Lyons et al., 2013; Marks & Louis, 1997). These relationships provide the impetus to better understand the mechanisms behind empowerment of teacher leaders.

Teacher leadership has been proposed as a way to decentralize power and authority from hierarchical structures to more distributed leadership structures by empowering teachers to become more involved in school-based decision-making (Katzenmeyer & Moller, 2001). When comparing teachers and teacher leaders' perceptions of Rinehart and Short (1991, 1993) found that teacher leaders perceived themselves as having more empowerment compared to teachers not viewed as leaders. These authors suggested this difference was associated with teacher leaders having more decision-making authority and agency than their colleagues (Rinehart & Short, 1991). However, teacher empowerment is not a unidimensional construct, and many factors can influence whether a teacher leader feels empowered (Rice & Schneider, 1994). This includes factors such as types of decisions made, extent of involvement in decisions, and intrinsic motivation related to the decision (Duke & Gansneder, 1990; Rice & Schneider, 1994). Duke and Gansneder (1990) referred to a typology of decisions that teachers could be involved in including the *technical* and *managerial* decisions. Technical decisions are those more closely and directly related to classroom teaching and learning (i.e. instructional leadership), whereas managerial decisions are those more closely affecting larger school-based operations (i.e. policy leadership; Duke & Gansneder, 1990).

Formal teacher leader roles are traditionally embedded within the extant hierarchical leadership structures within the schools; therefore, individuals occupying them are seen as legitimate leaders based on power and authority (Hatch et al., 2005). In this sense, formal leadership positions might be more aligned to managerial-based decisions. Alternatively, informal leadership is often classroom-oriented and responsibilities can include planning, communicating goals, and supervision of students and teachers (Ash & Persall, 2000). This is more aligned with Duke and Gansneder's (1990) notion of technical decisions. Unlike formal leadership roles, teachers in informal roles must navigate the existing leadership structures in their schools, and their ability to enact change comes from their expertise and being seen as legitimate by their colleagues (Hatch et al., 2005). Whether formal or informal, teacher leaders must be positioned in such a way to be seen as legitimate leaders to feel empowered to enact change in their

educational contexts (Turner et al., 2018). Drydyk (2013) suggested that empowerment is an outcome from a 'process of change' (p. 251) in the agency, well-being, freedom, and power given to an individual by themselves and others (i.e. positioning). Three antecedents to empowerment are identified in the literature: validity, legitimacy (credibility), and a sense of belonging to the empowering community (Dee et al., 2003; Drydyk, 2013).

Teacher validation refers to the acts which provide credibility to the teacher by their colleagues and others (Hatch et al., 2005; Whitaker & Moses, 1990). That is, actions, not the person, are validated. When these actions are seen as valid to the community (i.e. they follow the norms and values of the community), then the individual can be given the status of being legitimate (i.e. credible). Legitimacy refers to a sense of one's worthiness for a particular role (i.e. teacher leader) based on whether one's peers and colleagues have validated their actions in that role (Johnson et al., 2006). That is, a person is seen as legitimate if they are acting according to the norms, values, beliefs, and practices held by the community. A sense of belonging to a higher-status community of practice could raise one's self efficacy in a lower-status one (Lev-On, 2015), but it is not clear that this would result in greater empowerment in that lower-status community.

Theoretical framework

This study is framed within the sociocultural perspectives of situated learning (Lave & Wenger, 1991), mechanisms for learning via boundary crossing (Akkerman & Bakker, 2011), and professional vision (Goodwin, 1994). The notion of boundary crossing was central to this study as the Fellows were simultaneously participating at the intersection of two communities of practice: the Noyce program and their schools. This theoretical foundation suggests that learning occurs via two different pathways: (1) as novices move from the periphery to more central roles in a single community of practice, and (2) as individuals move across the boundaries of different communities of practice (Figure 1). These learning processes include both formal (i.e. school and courses) and informal (i.e. apprenticeship) mechanisms.

In this study, we were interested in understanding how teacher leaders crossed the boundaries between a research-focused community of practice (the Noyce Mountaintop project) and a teaching-focused community of practice (their schools). Wenger (1998) discussed the concept of boundaries of communities of practice to distinguish one community from another. These boundaries exist as discontinuities in practices, meanings, and identities across communities. Although boundaries represent discontinuities between two or more communities, the movement or crossing of these boundaries can also generate spaces where innovative learning can occur (Wenger, 1998, p. 234). For the Fellows, their participation in the Noyce program positioned them to be teacher leaders as researchers in their schools, and their work across the research-teaching boundary had the potential to empower them to influence teaching within their educational systems, a key component of teacher leadership. In this study, we focus on the experiences fellows had within the research community and when crossing the boundary between teaching and research communities. While we acknowledge that this boundary crossing should support change within their educational systems, studying these changes was beyond the scope of this manuscript.

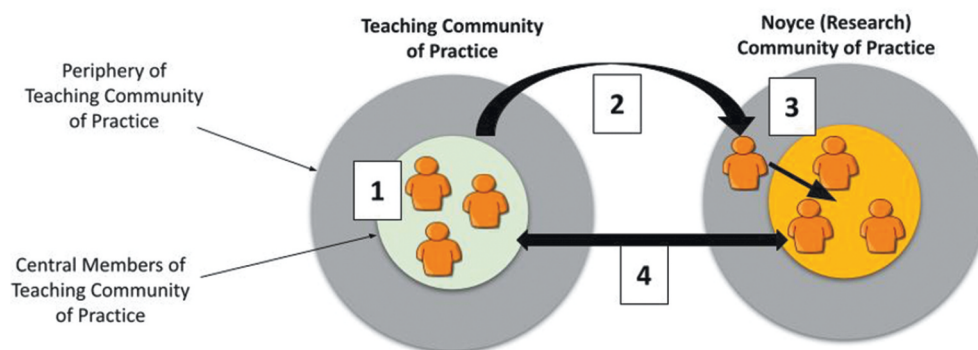


Figure 1. Conceptual framework of teacher leadership development and learning. (1) Teacher leaders in this project were already central members of their teaching community of practice (i.e. their school). (2) Learning can occur when crossing between one community of practice to another. Teacher leaders enter the Noyce (research) community of practice as peripheral members. That is, they move from a central position in their teaching community of practice to a less central position in the research community of practice. (3) Through participation in the research community of practice (i.e. legitimate peripheral participation), teacher leaders become active, central members of the research community of practice. (4) As a teacher leader becomes more central in the research community of practice, they are able to expand their professional vision and experiment with new identities (provisional selves). Through these processes, teacher leaders can identify shared boundary objects between the two communities and foster coordination between them.

Learning within a community of practice

Lave and Wenger (1991) described learning as legitimate peripheral participation or the movement from a peripheral member of a community of practice (henceforth CoP/s) to a more central, active participant. They also suggested that learning involves identity formation and meaning making related to the shared practices and knowledge of the community. According to Lave and Wenger (1991), identity development can occur through legitimately participating in the periphery of a community. Within this legitimate peripheral participation, novices can learn about the culture and norms of the community including

who is involved; what they do; what everyday life is like; how masters talk, walk, work and generally conduct their lives; how people who are not part of the community of practice interact with it; what others are doing; and what learners need to learn to be full practitioners.. (p. 95)

Legitimate peripheral participation in CoPs provides opportunities for teacher leaders to sample different roles and norms, which creates a space to experiment with provisional selves (Ibarra, 1999). When that experimentation produces outcomes that are viewed positively by both those ‘trying on’ the provisional selves and those whose work in the CoP is affected by these selves, then the identities associated with the selves are reinforced and the individuals can feel a stronger sense of belonging in the community. However, when there are negative outcomes associated with the experimentation around the provisional selves, this can create conflict between the individuals experimenting with the selves and the other members of the CoP – as well as bringing into question the identities associated with the provisional selves. The latter situation might be likely to

arise, for instance, when a provisional self is tested successfully in one CoP (e.g. the Noyce Mountaintop project) and then transferred into a second CoP (e.g. the school) where it might not be perceived as being congruent with the practices and meanings already in place in the latter CoP. Our data analysis explored these considerations.

The Fellows were already central participants in their school communities of practice at the time they became part of the MTL program. Their participation in the research CoP represented by the MTL program began as legitimate peripheral participants relative to the established education researchers with whom they collaborated – although their involvement in previous professional learning programs run by the MTL program team strengthened their peripheral position. According to Wenger (1998), movement from a legitimate peripheral participant to an active contributor to the community of practice is facilitated by various activities including (but not limited to): apprenticeships and mentoring experiences, induction programs, formal professional development programs, professional learning communities, and formal research collaborations. As the strength of their participation in and contributions to a new CoP increase, the members' sense of identity as belonging to that CoP also strengthens (Wenger, 1998). This can encourage members to transfer practices, meanings, and identities that they see as productive to other CoPs in which they had been participants. In the case of the Fellows, this would entail engaging in boundary crossings to bring the knowledge accrued in the MTL program – specifically about conducting educational research and using it to inform best teaching practices – back to their school CoPs.

Learning at the boundaries of communities of practice

Interactions between multiple CoPs and the movement of an individual between CoPs manifests opportunities for learning and developing identities within and between CoPs. Furthermore, teacher leaders work with multiple educational stakeholders and thus need to develop a competence with boundary crossing to ensure successful collaborations with the various stakeholders. For the Fellows, two communities of practice were prominent: research and teaching. Learning across boundaries is mediated by boundary crossers: someone who moves between different communities of practice (Wenger, 1998; Wenger-Trayner et al., 2015). Boundary crossers become filters for information to move between two or more communities of practice (Grima & Josserand, 2011) and assist with the transfer of different practices between communities (Frade et al., 2009). For instance, the Fellows engaged in a research community of practice and had the opportunity to bring those research practices back to their teaching community of practice. The transfer of practices can be facilitated by experimentation with provisional selves in the CoP from which the practices are being transferred – something the Fellows were able to do in the MTL program. It can also be facilitated by the existence of a boundary object that can provide a physical or conceptual link between the CoPs across which transfer is occurring (Star, 2010).

Akkerman and Bakker defined boundaries between communities of practice as socio-cultural differences that lead to discontinuities in practices (p. 139). In our case, there are differences in the purposes of research and teaching and discontinuities in the practices used (research and teaching practices do not always align). The authors argue that these discontinuities are foundational to learning/development. They form the distinctions

between two different communities of practice and in turn, define what constitutes expertise within a community. The movement from one community to another can require the renegotiation of meanings and reformulation of identities; therefore, crossing the boundaries necessitates transitioning into a new community and domain while trying to establish continuity between the two distinctly discontinuous communities. This movement might also present challenges and changes in context and what counts as expertise and professionalism.

According to Akkerman and Bakker (2011), there are four dialogical learning mechanisms (p. 150) of boundary crossing: identification, coordination, reflection, and transformation. Identification refers to the distinguishing of practices and roles in one community from another community. During this process, boundaries are redefined or reconstructed through drawing distinctions between the communities and their practices, as well as through legitimizing the coexistence of different communities. Coordination involves analyzing the practices of two or more communities to identify areas of cooperation and collaboration. With more use of research practices, teacher leaders could find synergistic ways that research and teaching might be related. Reflection includes becoming aware of ones' own understanding of a particular issue and seeing oneself through the perspective of others in a different community (i.e. perspective taking). Transformation refers to changes in practices and can generate new hybrid practices between the communities.

Akkerman and Bakker (2011) note that many of the studies they reviewed which illustrated coordination focused on examining the role of *boundary objects* in the CoP (p. 143). They define boundary objects as 'artifacts [that] can fulfill a specific function in bridging intersecting practices' (p. 134), a definition they attribute to Star and Griesemer (1989). It is important to note that Star herself, in more recent work (2010), has emphasized the fact that boundary objects do not need to possess *materiality* in the sense of having 'thing-ness' to them, but in the sense of being 'something people . . . act toward and with' (p. 603). As an example, she suggests that something as abstract as a *theory* can thus serve as a boundary object. The most critical aspect of a boundary object is that it creates an overlap in the meanings and practices of two intersecting CoPs, and thus can support transfer of those meanings and practices across the CoPs. This is contingent on the boundary object having appropriate characteristics, such as being tied to conventions of practice and embodying shared standards of the linked CoPs (Star, 2010, p. 611).

While Akkerman and Bakker (2011) paper provides a framework for exploring learning across boundaries, there are issues that need to be further explored. For instance, it is likely that there are system factors operating in the two CoPs that control the extent to which these mechanisms can be actuated by specific boundary crossings, but those have yet to be identified.

Professional vision as a means of supporting learning mechanisms

Goodwin (1994) introduced professional vision to represent the capacity to (a) highlight key aspects of practice within a profession, (b) code the ontology and meaning of those practices, and (c) produce artifacts that reify the profession's ways of understanding and enacting those practices. There has been limited scholarship connecting professional

vision with communities of practice (e.g. Brimdyr, 2002; Grasseni, 2007). We conceptualize professional vision as a socially-derived ability to ‘see’ the activities and meanings within and across communities of practice in ways that can support the learning mechanisms described above. Teacher leaders serve as bridges or liaisons between multiple educational stakeholders. Therefore, the development of teacher leaders includes an expansion of their professional vision to include both communities. Teacher leaders developing a professional vision involves identifying boundary objects that would allow for the transfer of ideas and practices from their teaching community of practice with their research or Noyce community of practice. For instance, highlighting key aspects of practice can allow a person operating in two intersecting communities of practice to make the distinctions that are part of the mechanism of identification. We also assert that developing as a teacher leader – in particular, as a teacher leader as researcher – enhances one’s professional vision in ways that can augment the application of Akkerman and Baker’s learning mechanisms.

Method

The study described in this paper is part of a larger research project involving eight Noyce programs across the U.S. The goal of the larger project is to understand how the experiences within the Noyce programs intersect with the professional identity and contextual factors that influence the professional trajectories of the Fellows (i.e. Hutchinson et al., [under review](#); Reeder et al., [under review](#)). The larger project used a convergent-parallel mixed-methods approach in which both qualitative and quantitative data were collected via interviews and surveys, respectively (Patton, 2015). For this manuscript, we focused only on the qualitative interview responses of select participants. The present study looks at one group of participants and their associated data by focusing on just one of the Noyce programs: Mountaintop Teacher Leadership (MTL) Program (pseudonym). This study was approved by the MTSU Internal Review Board (MTSU 19–2091).

Participants and context

The MTL Program served three cohorts totaling 23 STEM teachers working in high needs schools, predominantly teaching middle and high school science courses, across a few districts within and surrounding a metropolitan area in the western United States. During year 1 of the project, team members worked in conjunction with the principal investigator of the MTL program to contact each of the Fellows and seek their participation in the project’s data collection. Out of the 23 potential participants from the MTL Program, 19 individuals (18 female, 1 male) agreed to participate and signed consent forms. All Fellows who were a part of the MTL program had earned at least a master’s degree either in education or a scientific field and had some teaching experience (many with more than 5 years) before entering the program. Of those interviewed, at least 9 had worked in other industries, from nuclear physics and environmental biology to financial consulting, before acquiring their teaching license. The MTL program ended in 2018 and each participant in this study had completed the program.

The MTL program was a STEM teacher professional development program administered by faculty at a local university as part of the Noyce Master Teacher Fellowship. The principal investigators for the grant emphasized a goal of the project to reconceptualize the intertwining roles of K-12 teachers and the community of professionals in STEM education research. As such, the goals of the program centered on helping teachers develop not only in their teaching but also in their leadership skills by engaging them in the critical investigation of pedagogical practices through research, creating space for the formation of a scholarly community with other teachers as well as university faculty and students, and supporting K-12 teacher participation in nation-wide discussions on STEM education and educational research.

Each of the three cohorts of the program, composed of experienced K-12 STEM teachers with a master's degree working in high-needs school districts, participated in professional development and research activities for five years. These activities included taking STEM education courses, conducting research in their classrooms, meeting biweekly with other fellows to discuss their research and other topics in science education, writing papers on their research to be submitted to academic journals, and presenting their research at national educational research conferences. The program was built on a relational leadership model that allowed the Fellows to engage as equal participants in the creation of their own learning experiences, meaning that MTL was predominantly led by the teachers themselves, who decided the research and topics that were explored. Finally, the MTL program was designed to support current teacher leaders rather than develop them (Yow et al., under review). The teachers enrolled in this program had already been involved in previous professional development programs with each other and the project principal investigators, thus suggesting that forming their own community of practice was expedited.

Data sources

Data for this study were collected over a period of three years (2018–2020). In year 1, we conducted individual interviews with the 19 participating Fellows as well as the principal investigator of the project. Interview with the principal investigator served to gain an insight into the structure of the MTL program and leadership goals of the program for teacher leaders. In year 2, follow-up interviews were conducted with six of the original 19 Fellows. These six were chosen based on their comprehensive representation of themes discovered across the 19 interviews completed in year 1 as well as for their variety of professional trajectories. In year 3, we contacted each of the original 19 Fellows for a final round of follow-up interviews, of which 9 responded and were interviewed. The individual interviews were semi-structured, with protocols consisting of 8–14 main questions and several probe questions. In the first year interviews, there were four versions of the main questions associated with the four different professional trajectories identified by the project team: stayer (Fellow is still in the same school as at the start of the project), mover (Fellow has moved to another school, but is still in the classroom), shifter (Fellow is still in education, but has shifted out of the classroom, either into an administrative position or into higher education), and leaver (Fellow has left the field of education altogether). These versions all maintained the same basic sequence and topic focus but changed the language of certain questions as necessary to match the Fellow's professional

trajectory. Years 2 and 3 interviews followed a similar protocol except the research team modified and added questions that specifically probed into the Fellows experiences with research both during and beyond the program. The protocols are found in Appendices A. – C.

Interviews lasted from 45–60 minutes. They were conducted by members of the project team who had gone through the protocol with its developers (lead researchers on the project) and were completed via Zoom. The interviews were audio recorded and the audio recordings were professionally transcribed verbatim. Each participant was given a pseudonym to protect anonymity and these pseudonyms are used throughout this manuscript.

Analysis process

The data was analyzed using a deductive thematic approach (Pearse, 2019). The larger project team developed a codebook to use across all of the interviews and programs being studied. The codes were developed *a priori* based on critical ideas about teacher leadership, and the influences of professional identity and contextual factors in the literature. The codes were, however, refined through application to sample interviews across the program sites – a process that involved input from all individuals involved in codebook development and usage. The final codebook included six domains of codes: (1) Professional Perception/Philosophy, (2) Professional Identity, (3) Program Features, (4) System Features, (5) Professional Trajectory, and (6) Teacher Leadership. Each domain had two or three specific codes within it. For instance, Professional Perception/Philosophy had the two codes ‘Views’ and ‘Expectations’ under it and Professional Identity had the three codes ‘Becoming/Being’, ‘Acting’, and ‘Re-acting/Responding’ under it. There were a total of fifteen codes across the six domains.

Once the larger project codebook had been established, our research team (studying the MTL program) had discussions of issues related to the codebook and its definitions, specific to the MTL program data. This resulted in further refinement of the codes. Once the codebook was finalized, two or three coders worked together and conducted separate coding and comparisons until inter-rater reliability values of 80% or better were achieved on several transcripts. At this point, individuals often conducted independent coding, although coders would still check on ambiguous pieces of data.

To expedite the identification of patterns and themes in the data, *summary tables* were prepared for the entire set of coded transcripts for a particular Noyce program. The summary tables had a column for each fellow participant and rows for identifying key insights and associated data across each of the six domains. There were also rows for (1) Tentative Cause-Effect Relationship, (2) Moving Toward Patterns/Themes, and (3) Missing Data (items that might need to be addressed in years 2 and 3 data collections). These summary tables were critical for recognizing many of the findings that will be presented in this paper. In selecting the data for presenting, we tried to represent the patterns and themes we had identified by drawing on data from the broadest set of participants; due to space limitations, the data we share came from six of the participants.

Results

In the presentation of our results, we have sought to highlight the experiences that aligned with the Fellows' development as teacher leaders, teacher researchers, and the intertwining of these two roles through research as a component of leadership. Specifically, we examined the various ways that Fellows were engaged in the research community of practice, how these experiences transferred into their teaching community of practice, and how these experiences empowered the Fellows as teacher leaders. To do so we have organized our findings by aligning the data and our analyses of it with each of our research questions.

Research Question 1: What were the conditions in the Noyce CoP that affected their experiences within their teaching CoP?

During the analysis of year 1 interviews, research experiences were a core component of the MTL program that became salient across multiple interviews. The intentional design of the program provided participants with opportunities to engage in research, an element that was not heavily featured in the other programs studied as part of the larger project. These opportunities manifested in many ways including working in teams to develop and implement research projects conducted in their schools (or partnering with an educational researcher on a science curriculum/professional development project), presenting and publishing outcomes from their research, and networking at research conferences. In an interview with the principal investigators of the MTL program (PI; conducted fall 2018), they explained that the MTL program was structured using a 'relational leadership model' that supported the Fellows' agency in directing their own research experiences and operating as essential, contributing members in a research community of practice. One of the teacher leaders, Nadine, explains her experience within this relational model:

I always felt like my opinion and my voice is valued and that it mattered . . . they [education researchers] were all very welcoming and open and valued what I had to say and made me feel like part of the group. (Nadine, Year 2)

The educational researchers directing the program understood the value of teachers' professional experiences and constructed an open format to meetings and research activities with the intention of having the teachers themselves guide conversations and research foci. This created space for teachers to use their knowledge of and expertise in K-12 classrooms as the foundation for their agency as leaders and researchers within the MTL and larger educational research community.

The Fellows' research experiences were intentionally grounded in their work as teachers. In fact, one of the MTL program PI's main goals when engaging these teacher leaders directly in research was to help the Fellows

"learn how to support claims with evidence. . . to be able to say this lesson worked and I know that because of this, it worked for this, but it didn't work for that. We wanted systematic evaluation of their instruction and of any claims that they were going to make in the classroom" (PI Interview, fall 2018).

This was exemplified in Hunter's research experience:

My cohort really grappled with, "What do we mean by inquiry-based instruction?" That was a guiding question that we kept coming back to . . . We did some lesson studies. We spent some time in each other's classrooms. We gave some feedback on what we were seeing, what could be improved upon or how it connected to some of our learning goals. And then, I think in combination with that we started creating workshops for other teachers at conferences around inquiry-based learning. In doing that it helped me realize like, "Wow, am I doing all of these things in the lessons that I'm creating for students?" (Hunter, Year 1)

Supporting claims about best teaching practices based on evidence from research is an epistemological commitment made explicit in the MTL program. If that commitment is shared by intersecting CoPs – such as the schools within which the Fellows' operated – then that epistemological commitment can serve as a boundary object.

There was also an expectation that all research projects would culminate in presenting and defending their research at science education research conferences, and, ideally, publishing their findings in academic journals. Many of the participants mentioned participating in multiple conferences and disseminating research through presentations and publications:

One [key experience from the program] is that community where we could come and talk about our challenges in education, things we wanted to learn and try. . . . The other aspect was the research and presenting. Doing workshops, poster presentations, talks, and you know, collecting and analyzing data, all of those things helped me feel like a professional. (Jessie, Year 1)

Fellows were expected to delve into a full experience of scholarship, conducting research and then sharing results in published articles and academic conference presentations. When attending conferences, the Fellows did not simply consume talks by research professionals: they also actively engaged as producers of research. The positioning of the Fellows as active members in a research community of practice and as border crossers between this community and their teaching community of practice led to a sense of empowerment and professionalism for the Fellows. Specifically, we can see this in Jessie's quote above when she stated it ' . . . helped me feel like a professional'; that is, research provided a sense of professional validation.

Research Question 2: In what ways did crossing the boundaries between teaching and research CoPs affect the Fellows' identities as teacher leaders and their validation, credibility, and sense of belonging within their teaching CoP?

We identified three mechanisms by which the Fellows became empowered teacher leaders while engaging in the MTL program. Engaging in research provided opportunities for the teacher leaders to (1) increase their sense of belonging among teacher leaders and educational researchers, (2) develop a sense of professionalism through experimenting with new identities, and (3) be seen as a credible teacher leader by their peers and colleagues.

Empowerment through a sense of belonging

Meeting fellow passionate teachers, engaging in authentic research, and networking at research conferences were important for participants to see themselves within a community of practice that values both teaching and research. The Fellows felt energized due to the shared values and enthusiasm for professional growth. Because of the program's community-driven design, the teacher leaders were not only put in contact with other K-12 teacher leaders but also university-level educational researchers. These connections formed through their meetings at the university and at science education conferences where Fellows were seen as equal contributors to the field. This sense of reciprocal interactions with researchers was touched on by a few of the Fellows:

I think going off to some of those first conferences and presenting research or running a workshop and having conversations with college professors while I was doing it and being seen as a peer and in that respect, it really, the confidence building I think was a huge personal gain of feeling, like I belonged to the table, to have those conversations. . . . You know, instead of, I should be kind of on the outside looking in. (Hunter, Year 1)

. . . doing workshops, poster presentations, talks, and you know, collecting and analyzing data, all of those things helped me feel like a professional. I guess it helps me bridge from K-12 education into higher ed, and gives me a sense of belonging I think in both worlds. (Jessie, Year 1)

Their networks were expanded by presenting at conferences where they were able to interact with educational researchers as peers, bringing them into an even larger and enriching community that enlivened their commitment to research and leadership in science education. For Hunter, teachers often feel like outsiders regarding research and conferences ('on the outside looking in'); however, the MTL program supported him in becoming an insider and strengthened beliefs in themselves as true professionals. Jessie summarized during their Year 2 interview, ' . . . feeling like I'm actually part of that community was really empowering to me versus feeling like I was an outsider'. This was a similar sentiment to Hunter ('on the outside looking in'). That is, Jessie was made to feel like a legitimate, peripheral participant in the research CoP. As we saw with many of the Fellows, this networking with researchers empowered them and validated their belonging to a scholarly community, contributing to greater enactment of their teacher leadership.

Because of their experiences with research, the teacher leaders had the knowledge and skills to engage in the larger educational research dialogue from which they previously felt prohibited. Further analysis of the interviews revealed that this was made possible because of the nature of the relationships formed between the researchers and teachers in these settings. While the dynamic relationship between these two parties is often contested and considered hierarchical (Carter & Doyle, 1995; Gore & Gitlin, 2004), the participants described their relationships with researchers to be more horizontal rather than vertical. This was evident in the participants' descriptions of their experiences at the science education research conferences. Morgan stated:

I think just the ability to go to conferences and see what that world is all about and present at conferences and what that takes, just the collaboration process and the revision process . . . [it] has pulled the veil away a little bit, you know. It's not these people high up on a hill. It's like I can present and I have things to say, and it's important that I get my work out there. (Morgan, Year 2)

Morgan alludes to the separation she previously felt between her work as a K-12 educator and that of educational researchers, with the latter operating in a mythic realm of prestige and knowledge 'high up on a hill'. This detached verticality was reduced for her and the other Fellows through the opportunities they were given in the MTL program to function as researchers such as collaborative projects, academic writing, presenting at conferences, and networking with other experienced researchers. For Morgan, the MTL program 'pulled the veil away' allowing her insider access to the practices of the research community. These experiences empowered the Fellows to see themselves on equal footing with those already established in the research community. These interactions with others were important for the Fellows to develop a sense of belonging which provided opportunities for professional growth and retention in education:

... in my own classroom, I always felt very isolated. I did not feel like I was pushed to grow in any real way. And so the [Mountaintop Teacher Leadership] program really invited me to grow through doing the classroom research, collaborating, presenting at conferences. ... I think I would have left education altogether if I hadn't had that because it [teaching] just is so intense. (Jessie, Year 2)

Empowerment through professional validation

Engaging in the research and expanding their networks were important professional validation opportunities for Fellows within their communities. Having the unique opportunity to learn about teaching practices through a systematic research approach had a profound impact on the Fellows' actions in their classrooms. Fellow Jessie, for example, explains how her research experiences impacted her ability to strategically make pedagogical decisions:

I think one of the big things I realized is that as teachers, we are constantly researching our classroom, we're constantly collecting data and making decisions about it. ... having a researcher's mindset allows you to interpret data in a way that's much less knee jerk reaction to whatever is coming in at you. So giving yourself time to collect the data, deciding what to do with it, and then making instructional decisions based on that. So I think that the research process itself and really thinking about, what data am I collecting? Why am I collecting it? What am I going to do with it? What does it mean? Having those things in the back of my mind really affected my ability to be an effective teacher. (Jessie, Year 2)

Jessie notes the shift in perspective that formal research initiated for her with regards to the pedagogical choices she was making in her classroom. That is research helped Jessie expand their professional vision by highlighting research practices (i.e. collecting data on student learning) and giving them meaning in their teaching practice. As a teacher, before participating in the program, she already regularly collected data and adjusted her instruction based on that data, without having the knowledge or formal structure of a research framework. The MTL program gave her the tools to systemize her process and organize her instructional decision-making to justify her choices. In this case, the boundary object of justifying her instructional decisions (shared with justifying claims in research) supported the development of a stronger professional vision. This is inferred from her statement of no longer having 'knee jerk' reactions but rather making informed

decisions. Having this justification empowered Jessie and the other Fellows in their roles as teachers because they had rigorous evidence to support their actions in the classroom.

One of the crucial characteristics of these research opportunities that impacted the teachers' efficacy both as teachers and researchers was their active engagement in the process. Teachers were not simply consuming research on evidence-based practices but producing it themselves, aligning with Criswell et al. (2018) notion of productive scholar. Here, Hunter talks about a big takeaway from her experiences in research through the MTL program:

I think one [outcome of producing research] really was just to give me a little bit of extra confidence in my professional role of being able to do some of the research . . . we were really trying to push ourselves to improve our practice together. . . . There's some really great practices or some great research that you connect to those practices, but it wasn't about unlocking this key master door, but it was really about just trying to figure it out ourselves and realize that we were making a difference. And there were some great things that we were doing, and we had some really good ideas that we could work with. So I feel like there was just a lot of efficacy that was built through that, a lot of feeling like this is something I can do. I can continue to become another greater teacher and stronger educator. (Hunter, Year 2)

Hunter's metaphor about 'unlocking this key master door' highlights a goal of the MTL program to prepare teacher leaders to be scholars. That is, the program wanted the Fellows to learn the process and practices of research, integrate it into their own identities, and use this new development as a way to make change in their school systems. Morgan noted that conducting research and subsequently sharing her findings through publications and presentations bolstered her self-efficacy and supported her self-conceptualization as a professional in teaching and leading. Hunter also had a similar experiences and feelings of professionalism:

I think that it has professionalized teaching for me. . . . I feel like my participation with this group where I've actually done research and I do PD [professional development] and I do coaching has made me feel like more of a professional which I think is important. (Morgan, Year 2)

You know, it's funny, what I said before about like professionalism as a teacher, I don't think I could verbalize that until I started writing this book because it just so happened I was reading research from Richard Sagor . . . and he has a lot to say about that. So it just kind of put the words to what I've been feeling for a long time. (Morgan, Year 2)

I feel like that's been the biggest piece that's made me a stronger educator. So when I think about, you know, taking my research and shifting it into what that means for me as a teacher, that was one of the biggest pieces for me. (Hunter, Year 2)

Because Fellows were given agency in choosing the research conducted in their classrooms, the Fellows were able to test educational topics and practices that were directly relevant to them and, as a result, gain justification for their pedagogical choices and perceive themselves as contributors to the research field. This, then, granted them both the knowledge and confidence to lead other teachers in implementing effective practices whether through informal conversations with colleagues or more formal roles of teacher leadership such as leading professional development:

... we would lead some professional development and workshops while we were in stream-line and realizing that those structures that I put into my class to help my students learn, that I could use the same exact structures when I was helping adults learn in this workshop ... (Hunter, Year 1)

Hunter describes how her research is used to inform her teaching (i.e. 'made me a stronger educator'). In particular, the participant takes ownership of her research when she referred to it as 'taking my research'. Hunter was able to not only subsume the identity of researcher but also created a nexus between it and her teacher and leadership identities. In this way, Hunter experienced a change in herself as a professional by experimenting with researcher as a component of her identity and redefined her teaching identity to include research. This process aligns with what Akkerman and Bakker (2011) referred to as a transformation learning mechanism. That is, Hunter recognized a shared problem space and worked to use the knowledge and skills learned in the research community of practice within the teaching community of practice (hybridization) – 'taking my research and shifting it into what that means for me as a teacher' (Hunter, Year 2). This transformational learning experience fostered feelings of being a 'stronger educator' (Hunter, Year 2).

One implicit theme to note across previous quotes is the desire these Fellows had to be validated as professionals in their craft. By participating in research, not only did the Fellows find support for their professionalism as educators, but some of them also developed a broader vision regarding the misalignment between teachers' experiences as professionals and the view of teaching as a profession. For Morgan, delving into existing research while writing the action research book with other Fellows validated her personal experience of lacking appreciation for teaching as a profession. Morgan 'had these feelings of teachers not being seen as professionals and leadership opportunities not being there, but I feel like doing the research and writing this solidified that for me' (Year 3). Before reading academic writings on the topic, Morgan did not have the language to describe her plight. Finding research on the topic of teacher professionalism not only justified Morgan's individual experience of not being seen as a professional but also expanded her vocabulary and vision regarding this phenomenon. This allowed Morgan to talk about her personal dilemma with clarity and participate in a larger conversation on this issue surrounding the teaching community, all while growing in her certainty of her professionalism as a teacher.

Empowerment through credibility

Conducting research and participating in the MTL program not only changed the way Fellows perceived themselves and their actions as teachers and leaders, but it also influenced their legitimacy in these roles from the view of those in their educational and leadership communities. Acquiring experiences in research skills, particularly those centered on sharing findings and pragmatically connecting them to pedagogical practices, bolstered their confidence and ability to lead effectively while simultaneously contributing to their social capital among fellow teachers and teacher leaders.

Felice was empowered to engage more fully in certain leadership opportunities based on credibility she earned through participation in the MTL program. Felice and a teacher leader colleague now lead Noyce-related programs for prospective and early-career

teachers that focus on support and mentorship for novice educators and, hopefully, future teacher leaders. Felice began her work with these programs as a Fellow in MTL and, with the support of the program PIs, has since taken charge. This evolution of leadership has influenced how Felice is seen as a leader by other Fellows:

Just through having them defer to either myself or [my leadership partner] . . . we're the ones with this vision. They look to us to take the lead, to lead the meetings, to kind of delegate the work that needs to be done for this grant. Looking at the scholar program or the induction program, we're the contact people. We're the ones developing the professional development, the activities, the curriculum, kind of driving this ship . . . I really appreciate it, [the MTL PIs] trusting us with this. (Felice, Year 2)

Felice points to two types of relationships that have affirmed her credibility as a leader. Felice mentions the trust the PIs of the MTL program have given her and her leadership partner in positioning them as the heads of these programs. The MTL PIs did not simply give them a new leadership title. They empowered Felice and her colleague to design the programs using their own vision, believing in their ability to skillfully plan and implement best practices. Felice also mentions the positioning that occurs through other leaders looking to her and her partner as initiators. That is, gaining credibility with their colleagues made their colleagues feel comfortable putting Felice in charge (i.e. ' . . . driving the ship . . . '). Their work in making the program their own, and the value of having the support of the MTL PIs, has proven that they are legitimate leaders to others in their leadership community.

Many of the Fellows have also gained credibility outside of the MTL program by using the learning mechanism of coordination to transfer skills they gained from the program into their work in their respective educational systems. For Hunter, completing the MTL program has shaped her approach to her formal leadership position as the STEM pathway designer of her district, in turn impacting her credibility with those in schools and the district office:

When there's things that people are working on or questions that people have, I don't think that they hesitate to reach out, to work with me on different things. . . . I think I'm trusted by teachers and administrators alike, as well as central leadership to be thoughtful about the work that we're moving forward. (Hunter, Year 2)

One of Hunter's main tasks as a district science coordinator is to provide support to science teachers in their instructional methods and planning whether through individual help or professional development workshops. In all the work she does with fellow teachers, Hunter emphasized the necessity of grounding the structure and content in research, having experienced the value of making these connections herself. This thoughtfulness and careful designing of materials for teachers has given many of them practical tools for effective, research-driven teaching and leading 'the best professional development they've ever been a part of' (as some have told Hunter) which has led them, and administrators, to consider Hunter trustworthy. Thus, because of Hunter's research experience and the knowledge she brings to her role, she is seen as a credible teacher leader on whom others can depend.

Research Question 3: How did the Fellows transfer what they learned in the research community of practice to their teaching community of practice?

The MTL participants explored a variety of topics through research. Many of these projects manifested as action research in which the project ideas were conceived from practical issues in the teachers' classrooms, but others grew beyond the classroom focus to include district-level questions and teacher development projects. Nadine discussed a project that she led where she explored the utility and fidelity of standing desks in her classroom on student performance. She stated:

... we wrote a grant for standing desks and we wanted to look at engagement and how, if students were standing, did that reduce certain behaviors and increase other behaviors? So, we came up with an observation protocol. We would have another teacher come in and if all the desks were up, they would track how many students left their group to go do something productive or to go do something unproductive or, you know, was there extra movement in the class, things like that. (Nadine, Year 2)

Nadine's experience highlights the positive impact these research projects had on numerous facets of the Fellows' professional identities. At its core, systematically studying the impact of standing desks was beneficial for Nadine's teaching and classroom management. Engaging in action research also empowered Nadine in her instructional leadership while expanding her research skills. For example, research grant writing is not a typical activity of teachers, yet Nadine wrote and secured funding to make an impact in her classroom.

Another example comes from a small group of Fellows that were writing a book when we interviewed them to share their research experiences with others in the wider educational community. These Fellows have secured a publisher for this book that will discuss how they were impacted by the research component of the MTL program and will provide guidance for teachers and teacher leaders on how to implement action research as a means of supporting their teaching practices and professional development. When asked for more details on this project, Morgan said:

So we are writing a book actually for AAPT AIP publishing about doing action research in classrooms and how it affected us. ... Most of us had published articles from our research, and so since we weren't currently doing research anymore because we weren't part of [MTL] anymore, we decided maybe instead of writing a paper to write a book. ... We got a contract and we're in the process of writing it right now, so it's pretty exciting. (Morgan, Year 2)

Another group of Fellows are utilizing their skills as researchers to write a grant to extend the MTL program for other teachers. Fellow Felice stated:

We're in the process, I would say of implementing it, of getting, writing our own Noyce grant ... for a track three grant to build and sustain this program that we have this vision for. And so I think that was the intention of the [Mountaintop] program is to build these teacher leaders and to really allow us to take on and to build something that we believe in. (Felice, Year 2)

In this excerpt, Felice describes the initiative taken by these Fellows to extend the program using research-related skills they acquired through their participation in MTL. The participants were able to try these research tasks and take them on as part of their leadership identity through the program. This gave them the ability and efficacy to see themselves in research-supported leadership roles which they are now using to continue the program and 'build something that we believe in'. Much like the Fellows

writing about their action research experiences, these Fellows are using skills obtained through participation in their research CoP to help connect other educators in local teaching CoPs with transformative research experiences.

Some Fellows had opportunities to lead in a greater capacity through positions related to the MTL program. One of the largest outcomes of research conducted by multiple teachers through the MTL program was development of an active learning curriculum for physics teachers. Multiple Fellows who were interviewed (in the second-year interviews, these were Jessie, Morgan, and Nadine) have continued to work on this curriculum beyond the MTL program and are currently involved as leaders in developing it and supporting its propagation to schools across different districts and states. For Morgan, this curriculum group has given her another platform on which she has been seen as a researcher and leader:

... with my [curriculum] program, because I've done this research and had kind of successful outcomes and successful interventions, I am seen as a leader because I've put in the work and I've seen what parts of it work and how it works and tested different things in my classroom. ... I'm showing that this thing that they work on day in and day out has successful outcomes. So, I think that's really helped with my position and role within that group. (Morgan, Year 2)

As a teacher currently experimenting with and implementing the curriculum in her classroom, Morgan is using her skills as a researcher to support her involvement in the group as a leader. The curriculum developers and fellow teachers alike see Morgan's passion for and proficiency in researching and designing curricula around the research findings and, as a result, perceive Morgan to be a successful, credible leader within the group.

In certain cases, the transfer between the research and teaching communities was supported due to a boundary object (i.e. epistemological commitment to arguing with evidence). Recall that boundary objects serve as bridges between two communities (Akkerman & Bakker, 2011). However, in one case, the school at which the Fellow worked did not share that epistemological commitment, and therefore the boundary object linking the communities did not exist. As a result, tensions had arisen when the fellow tried to implement research in her school. This was described by Sara:

"There were some teachers here, five years ago, who were part of Noyce, part of MTL program. And so we had some research projects going. And they were talking about them with other teachers and kind of getting made fun of. They are like 'your stupid little research project' you know it basically wasn't respected because we are not 'researchers' [airquotes added by participant] really, we are teachers. So that caused a little bit of tension." (Sara, Year 3)

As an outcome of the boundary object not being shared, Sara observed how certain MTL fellows were 'othered' by members of the school CoP. This outsider feeling is in contrast to other participants (Hunter) where the boundary object was shared between the communities. Sara discussed the lack of support ('stupid little research project' and 'getting made fun of') from colleagues and how this hindered the transfer of practices (action research and research-based teaching) from one community to another. That is, research was not a practice that was valued within the teaching CoP nor was the epistemological commitment of supporting claims about best practice based on evidence

from research. Furthermore, Sara suggested that the Fellows' teacher-researcher identities were being challenged ('not "researchers"'), suggesting that this school CoP (1) undermined the opportunity to experiment with a provisional self (i.e. researcher) or (2) rejected the new provisional selves.

Discussion

Findings from this study demonstrate how teacher research can empower teacher leaders. Empowerment is often associated with more decision-making autonomy; yet, teacher leaders are often embedded within hierarchical leadership structures rather than distributed systems, limiting the voices of teachers. Compared to traditional action research enacted by teachers in their classrooms, the research system in this study occurred both internal and external to the school system in which the teacher leaders worked. We have little information about how engaging in research external to the school system can influence teacher leadership characteristics, including empowerment. In this study, we focused on how a Noyce program fostered the empowerment of teacher leaders by engaging them in a research community of practice.

In this manuscript, we have explored how engaging in a research community of practice influenced feelings of empowerment among a group of teacher leaders who participated in a NSF Robert Noyce Scholarship program. Using frameworks of communities of practice (Lave & Wenger, 1991) and boundary crossing (Akkerman & Bakker, 2011) we studied: (1) the conditions for boundary crossing to occur, (2) how these boundary crossing experiences fostered a sense of empowerment among the teacher leaders, and (3) what was transferred (coordination) across these boundaries.

Finding 1: conditions and mechanisms for boundary crossing

The structure of the MTL program provided authentic experiences that supported the Fellows' boundary crossing between the two communities of practice. These opportunities gave way for the teacher leaders to experiment with new identities (viz., teacher researcher). Five conditions were identified which allowed for boundary crossing to occur: functioning as a member of the external community, experimentation with provisional selves (viz. teacher researcher), coordination of shared boundary objects between the communities, expansion of their professional vision, and through an expansion of their professional networks. In this section we will discuss our findings related to the conditions for boundary crossing and the mechanisms by which these conditions supported such crossing.

Functioning as a member of the external community

In Drayton's (2020) blog post, the author discussed the action-validation-networking cycle in relation to teacher leaders staying within one community of practice. In the present study, we chose to focus on how teacher leaders engage and network between their teaching community and the research community, which was external to the schools. In particular, we examined how teacher leaders cross the boundaries between a teaching community and a research community. In the context of this study, teacher

leaders moved from a traditionally perceived lower status community (teaching) to a higher status community (research) and back again. Educational dialogue is often contested due to boundaries, and hierarchical nature, between teaching and research communities (Carter & Doyle, 1995; Gore & Gitlin, 2004). However, the participants in the present study did not feel disconnected from the research or from researchers. Instead, they described their relationships with researchers as horizontal rather than vertical (hierarchical).

Morgan alluded to the separation she previously felt between her work as a K-12 educator and that of educational researchers, with the latter operating in a mythic realm of prestige and knowledge 'high up on a hill'. This detached verticality was reduced for her and the other Fellows through the opportunities they were given in the MTL program to function as researchers such as collaborative projects, academic writing, presenting at conferences, and networking with other experienced researchers. These experiences empowered the Fellows to see themselves on equal footing with those already established in the research community, that is to experiment with new identities.

Experimentation with provisional selves

The Fellows were expected to plan, conduct, and publish their research findings in academic journals, providing them with professional skills to aid them in their leadership development. Engaging in these practices provided opportunities for the teacher leaders to see themselves as a teacher researcher (i.e. possible selves; Markus & Nurius, 1986). Once the teacher leaders saw researcher as a possible self, the structure of the program allowed the participants to experiment with research as a provisional sub-component of their teacher leadership identity (i.e. provisional selves; Ibarra, 1999). Through this experimentation, teacher leaders came to see research as a critical component of their professional identity, allowing them to successfully integrate research as a synergistic aspect of their teaching and leadership. Engagement in the research CoP provided support systems for the Fellows to experiment with new identities. The teacher leaders in this study were provided opportunities to meaningfully engage as producers of knowledge rather than acting only as consumers. Positioning teachers and teacher leaders as producers of knowledge, rather than consumers of knowledge, is often a novel approach to engaging teachers in research (Cochran-Smith & Lytle, 1999). However, studies have demonstrated that positioning teacher leaders as producers of knowledge can foster their competency (credibility) in their teaching and leadership roles and helps to promote teaching as a profession (Cochran-Smith & Lytle, 1999).

Although the program has ended for them, many of the teacher leaders are still engaged in practices they learned, including research. This further suggests that the teacher leaders subsumed their provisional research self (i.e. Ibarra, 1999). For some, this looks like collecting data in their classrooms and reading educational research to inform their own pedagogy. For others, this involves demonstrating the importance of evidence-based practices in their pedagogy and leadership activities, including helping teachers see the value of engaging in research through formal and informal leadership roles. In other words, during the program the teacher leaders had opportunities to consider and experiment with possible and provisional selves, which included research

as part of their leadership roles. The enactment of teacher-researcher selves provided them with the necessary tools to solidify the aspects of research that best aligned with their individual teacher leadership goals and identities.

Finding 2: empowerment through teacher research

Teacher research can empower teacher leaders by positioning them to be validated, credible, and agentic leaders in their educational and school systems. In this study, our participants revealed how conducting research and sharing their findings through publications and presentations improved their credibility and sense of belonging and supported their self-conceptualization as a professional in both teaching and leading.

Engaging in authentic research and networking at research conferences as part of the MTL program were key to Fellows viewing themselves as part of a larger community and feeling that their voices were heard. In their connections through research and in-depth discussions on science education topics with fellow MTL participants, the teacher leaders were invigorated by mutual enthusiasm for growth in their teaching and leadership, something that was missing for many of them in their school environments where they did not feel challenged by their peers or administrators, as was the case for Jesse. The Fellows' engagement within the research community allowed them to expand their networks to include educational researchers as peers (i.e. horizontal vs vertical networking). This fostered a sense of belonging for the Fellows within the research community. As we saw with many of the Fellows, this empowerment through belonging to a scholarly community contributed to greater enactment of their teacher leadership.

The Fellows saw engaging in research, as part of their activities in the MTL community, to be important for validating themselves as professionals within their school communities. Getting to learn about teaching practices through the systematic approach of research, something that many teachers are not given the tools or opportunity to do (Cochran-Smith & Lytle, 1999), firstly impacted their actions in the classroom by showing them how to strategically make pedagogical decisions. As both Hunter and Morgan expressed in their interviews, conducting research and subsequently sharing their findings through publications and presentations bolstered their self-efficacy and supported their self-conceptualization as a professional in both teaching and leading. Because Fellows were given agency in choosing the research conducted, they were able to test educational topics and practices that were directly relevant to them and, as a result, gain justification for their pedagogical decisions. This, then, granted them both the knowledge and competence to lead other teachers in implementing effective practices, whether through informal conversations with colleagues or more formal activities of teacher leadership, such as conducting professional development.

Finally, the Fellows in this study articulated that their experiences in the MTL program, and thus the research community, had expanded or enhanced their professional vision. In particular their activities as education researchers changed the way they saw and described the practices within their work as teachers. A significant example of this was when Jessie discussed how the development of a 'researcher's mind-set' allowed her to 'interpret data in a way that's much less knee jerk reaction to whatever is coming in at you'. Further, this new perspective on how to analyze and make sense of data supported her in making better 'instructional decisions based on that [more thoughtful

process of interpretation]’. Additionally, Jessie indicated that the expansion of her professional vision also impacted her professional identity, as the ‘collecting and analyzing of data’ helped her to ‘feel like a professional’. Jessie also suggested that the skills that she developed as an education researcher, and therefore the expanded professional vision she developed, provided a ‘bridge’ between the school and Noyce/research CoPs. We speculate that, in doing so, this enhanced professional vision influenced her ability to *coordinate* practices (e.g. inquiry) and meanings (e.g. interpretation of data) across the CoP boundaries.

Finding 3: coordination across community boundaries

Shared boundary objects promote coordination across communities

The Noyce program was designed in a way that an epistemological commitment to *arguing from evidence* became a boundary object that was shared across the Noyce CoP and at least some of the teaching CoPs. This epistemologically-oriented boundary object promoted *coordination* and supported the transfer of practices (e.g. evidence-based teaching supported by research) between the two communities. We hypothesize that such a boundary object could support empowerment of teacher leaders through the transfer of credibility and validation across the communities of practice (in this case, from the Noyce CoP to the teaching ones). This transfer would require certain conditions to exist, such as were in place for some of the Fellows in this study. These conditions include functioning as a legitimate participant in the external community, experimenting with new identities (provisional selves), and identification of shared boundary objects. The boundary object (in this case, the commitment to arguing from evidence) would need to be highly valued in a similar way by the intersecting CoPs (which was true for the Noyce and some of the school CoPs). Practices that are associated with that boundary object and reflect what is valued about it (in this case, research practices and the teaching practices they support) could be transferred from the CoP where they are more commonly used (Noyce CoP) to one(s) where they are not used or are less commonly used (school CoPs). Individuals who are proficient in those practices and who had been seen as credible and validated in the CoP in which those practices are more commonly used would be seen as credible and validated in the CoP in which those practices had not been used or less commonly used, *by virtue of the boundary object and its associated value mediating that transfer of credibility and validation*.

Professional vision and coordination across communities

Akkerman and Bakker (2011) suggest that coordination necessitates a communicative connection between diverse practices or perspectives. Aligning the professional vision of the intersecting communities would provide just such a communicative connection. One way this alignment could happen is for the way of seeing and talking about practice in one CoP to be brought back and distributed across another CoP. Jessie indicated that she was bringing back her way of seeing data to her school CoP when she described interpreting data with a researcher’s mind-set. We do not have data on the extent to which she distributed this way of seeing to other participants in her school CoP.

However, if, as under the conditions described above, there is a boundary object with a high associated value that could mediate the transfer of new ways of seeing and talking about practices, it seems like alignment of the professional vision would be facilitated. This, again, could carry with it a linked increase in the credibility and validation of the individuals sharing this new way of seeing and talking about practice. Conversely, if there is not a shared boundary object with a high associated value, an individual trying to promote this recast professional vision could start to be viewed as an ‘other’ – i.e. the change in professional vision also produces a [detrimental] change in professional identity. This happened in the case of another fellow, Sara who stated that when bringing research-based practices into her school, teacher researchers were ‘kind of getting made fun of’ and not respected as researchers. In this case, research was a provisional self that was undermined within the school CoP, a function of a lack of a shared boundary object and a contesting of a recast professional vision.

Expanding networks and spheres of influence

The development of teacher leaders has been conceptualized as a cyclical process of action, validation, and networking (Drayton, 2020). That is, teacher leaders identify and propose a solution to a problem (*action*), share findings to relevant stakeholders (*validation of action*), and use professional networks to receive feedback and build collaborations around shared interests (*networking*; Drayton, 2020). The notion of boundary crossing highlights the transfer of practices from one community of practice (i.e. research) to another (i.e. teaching; Akkerman & Bakker, 2011). The boundary crossing for the fellows began with participation within the research community of practice, shifted to developing research-based knowledge, and, finally, to applying that knowledge in their teaching community of practice. That is, unlike the cycle proposed by Drayton (2020) for developing teacher leaders, our study demonstrated that when supporting current teacher leaders in boundary crossing between research and teaching, the Fellows engaged in a different cycle. The fellows became members of a new community and expanded their professional networks (*networking*), developed competence in new skills and practices (*validation and credibility*), and then applied their new skills and practices within their teaching community (*action*).

This cycle, networking-validation-action, differs from Drayton’s (2020) model. Within his model, Drayton discussed teacher leaders operating within a single community of practice (i.e. teaching community). In our study, the Fellows were engaged in research practices in a community that was external to their teaching community. From this, we speculate that when moving between CoPs, networking might play a larger role in validating individuals within the new community. This validation would be necessary for changes to occur back in the original CoP. However, more research is needed to understand how and why these cycles differ and whether the differences are due to engaging across CoPs rather than within a single CoP.

Limitations and delimitations

In this study we chose to focus on how fellows of a Noyce program were empowered by crossing boundaries between a research community of practice and a teaching community of practice. The study was undergirded by the idea that through empowering teacher

leaders through research, meaningful changes could be supported within their school settings. However, elucidating the mechanisms by which the fellows influenced their school communities was beyond the scope of this study. Additionally, while there are many components to teacher-leadership, it is outside the scope of this study to consider them all. We have chosen to study a specific component, productive scholar (researcher), as a component of teacher leadership. Furthermore, our study has limitations regarding the sampling and data collection. Participants self-selected to participate in interviews in all three years. As such, a sampling bias might have been present if only the participants with positive experiences participated in the years 2–3 follow-up interviews. Finally, while we identified the boundary object of *arguing from evidence* as a condition for supporting the boundary crossing of the fellows, several other factors could have shaped this experience including shared values between research and teaching.

Conclusion and implications

Through studying the programmatic features of a Noyce program which emphasized research, we inquired into how these experiences empowered teacher leaders. The Mountaintop Teacher Leadership program encouraged participants to attend national and regional science education research conferences, develop research projects with their peers, and use research as a way to enhance their teaching and leadership skills. Teachers reported gains in their sense of belonging to a leadership community and felt that research helped validate them as professionals – in contrast to teaching oftentimes not being seen as a profession (Nenty et al., 2015; Shulman, 1986). In particular, these experiences did more than validate the individuals as professionals and teacher leaders. It provided them with a sense of validation for their profession as a whole (i.e. ‘Building something we can believe in’).

Additionally, we identified several conditions that were in place to support the Fellows in boundary crossing between the research and teaching communities. First, the importance of a shared boundary object was noted as a possible mechanism for transferring credibility across communities. Identifying boundary objects between two communities was necessary for the Fellows to see shared values, meanings, and problems across the two communities. For programs wanting to engage teachers or teacher leaders in research, this finding suggests to consider the value the school places on research. This is critical to consider given the status differentials between research and teaching communities and schools that do not value research might present barriers to the transfer between research and teaching. Second, Fellows were provided with opportunities to expand their professional vision to include components from the research community. This occurred through their interactions within the community, including the expansion of their professional networks to include these new stakeholders (third condition). The development or expansion of their professional vision allowed the Fellows to see boundary objects that they might not have recognized before. Finally, during their time in the program, the Fellows were provided with opportunities to engage in the research community and their associated practices. These provided Fellows with opportunities to consider and experiment with ‘researcher’ as a new component of their identity.

While this work contributes to the growing literature on teacher leadership, specifically related to empowerment through teacher research, there are several pathways forward for researchers. Future work could use these study findings to further inquire about how teacher leaders balance their multiple roles and how research could be seen as a critical component of teacher leadership. It was beyond the scope of this study to explore how the fellows enacted leadership practices within their schools after their participation in the MTL program. Future research should attend to how fellows interact within their school systems (i.e. with colleagues) and whether engaging in these research experiences position the fellows to be more effective at influencing their system.

Acknowledgments

This work was supported in part by National Science Foundation awards DUE-1758452 (B.A.C.) and DUE-1758342 (G.T.R.). The authors would also like to gratefully acknowledge the financial support from Middle Tennessee State University and our colleagues for providing valuable feedback on early drafts of this manuscript. The findings, conclusions, and opinions herein represent the views of the authors and do not necessarily represent the view of personnel affiliated with NSF.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the National Science Foundation [DUE-1758342,DUE-1758452].

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Appendix A – Year 1 Interview Protocol

A. Stayers

1. If I was writing a story about you, what 4–6 words would you want to make sure I included to describe you?
2. Tell me the story of how you got into teaching. Tell me what you see happening related to teaching in your future. What would you have to see happen for you to stay in the profession until your retirement?
3. What did you envision teaching being like before you got into your own classroom? What did you see yourself accomplishing? What do you see yourself accomplishing now?

4. What is it like to teach in your school? [Probe $\Rightarrow$ What are *students ... teachers ... administrators* like?] What's the relationship between the school and the local community? What interactions have you experienced with individuals/organizations in the community?
5. Describe your relationships with administrators ... and with colleagues. How have they changed over the years? What about your professional relationships with people/organizations outside of your school – how have these changed over the years? [Follow-up for both about whether the changes were rapid or gradual.]
6. Can you tell us some stories of the challenges you faced in your time as a teacher? [Get answer to this question before asking next question.] How did you respond to these challenges?
7. What lead you to apply to the Noyce MTF program?
8. Describe the key experiences from the program. [Probe: How have these experiences contributed to staying at your current position?]
9. What was the culture and community in the MTF program like? How has being a part of the program affected your professional network?
10. What were the biggest impacts the program had on you – both personally and professionally? How has it changed the way you do things – again, either personally or professionally?
11. What do you think defines someone as a teacher leader? [Get answer before asking follow-up.] Do you think STEM teachers approach leadership differently than other teachers?
12. In what ways do you see yourself as a teacher leader? [Give fellow time to answer first question.] In what ways do you think others see you as a teacher leader? How would you rate yourself as a teacher leader?
13. What are some of the activities in which you engage that you think represent teacher leadership? [Fellow provides answer] How do you decide the opportunities in which to engage? [Fellow provides answer] How do you determine if your leadership efforts are successful?
14. How would you describe the perfect job? What would that look like?

B. Movers

1. If I was writing a story about you, what 4–6 words would you want to make sure I included to describe you?
2. Tell me the story of how you got into teaching. Tell me what you see happening related to teaching in your future. What would you have to see happen for you to stay in the profession until your retirement? [Probe on how their move might have been related to professional satisfaction.] Did your identity change with moving?
3. What did you envision teaching being like before you got into your own classroom? What did you see yourself accomplishing? What do you see yourself accomplishing now?
4. What is it like to teach in your current school? What about the schools in which you had taught previously? [Probe $\Rightarrow$ How are *students ... teachers ... administrators* similar or different across schools?] What's the relationship between your current school and the local community? How is that relationship similar to or different from the ones that existed in previous schools?
5. Describe your relationships with administrators ... and with colleagues. How have they changed over the years? How did they change when you moved to your new school? [Probe whether the move was in order to produce such changes.] What about relationships with those outside of school? How have they changed over time and across contexts?
6. Consider the challenges you have faced in your current school and your previous school. How have the challenges been different? In what ways has your ability to respond been different?
7. What lead you to apply to the Noyce MTF program?
8. Describe the key experiences from the program. [Probe: How have these experiences impacted your trajectory and decision making?]
9. What was the culture and community in the MTF program like? How has being a part of the program affected your professional network?

10. What were the biggest impacts the program had on you – both personally and professionally? How has it changed the way you do things – again, either personally or professionally?
11. What do you think defines someone as a teacher leader? [Get answer before asking follow-up.] Do you think STEM teachers approach leadership differently than other teachers?
12. In what ways do you see yourself as a teacher leader? [Give fellow time to answer first question.] In what ways do you think others see you as a teacher leader? How would you rate yourself as a teacher leader?
13. What are some of the activities in which you engage that you think represent teacher leadership? [Fellow provides answer] How do you decide the opportunities in which to engage? [Fellow provides answer] How do you determine if your leadership efforts are successful?
14. How would you describe the perfect job? How closely aligned is your current position to that description?

C. Shifters

1. If I was writing a story about you, what 4–6 words would you want to make sure I included to describe you?
2. Tell me the story of how you got into teaching. Tell me what you see happening related to teaching in your future. What would you have to see happen for you to stay in the profession until your retirement? [Probe on how their move might have been related to professional satisfaction.]
3. What did you envision teaching being like before you got into your own classroom? What did you see yourself accomplishing? How did changing positions help you in better accomplishing what you wanted to in education?
4. What is/was it like to teach in your current school? What is it like to be in this administrative/coaching/etc position? What do you see as similar or different about the two roles? How has your relationship with students/teachers/administrators changed? What differences or similarities are there in the way that you interact with people in the community in your new role?
5. Describe your relationships with administrators . . . and with colleagues when you were in the classroom. How did they change when you moved into this new position? [Probe whether they were seeking new relationships in moving into their positions.] What about relationships outside of school? How have they changed across the different positions?
6. Consider the challenges you saw as a teacher. In your new position, in what ways do you view those challenges differently? And how might you respond differently?
7. What lead you to apply to the Noyce MTF program?
8. Describe the key experiences from the program. [Probe: How have these experiences impacted your trajectory and decision making?]
9. What was the culture and community in the MTF program like? How has being a part of the program affected your professional network?
10. What were the biggest impacts the program had on you – both personally and professionally? How has it changed the way you do things – again, either personally or professionally?
11. What do you think defines someone as a teacher leader? [Get answer before asking follow-up.] Do you think STEM teachers approach leadership differently than other teachers?
12. In what ways do you see yourself as a teacher leader? [Give fellow time to answer first question.] In what ways do you think others see you as a teacher leader? How would you rate yourself as a teacher leader?
13. What are some of the activities in which you engage that you think represent teacher leadership? [Fellow provides answer] How do you decide the opportunities in which to engage? [Fellow provides answer] How do you determine if your leadership efforts are successful?
14. How would you describe the perfect job? How closely aligned is your current position to that description?

D. Leavers

1. If I was writing a story about you, what 4–6 words would you want to make sure I included to describe you?
2. Tell me the story of how you got into teaching. How did that story change when you made the decision to leave teaching? What were things that might have been different in order to encourage you to stay in the profession?
3. What did you envision teaching being like before you got into your own classroom? What did you see yourself accomplishing? Was there something about the profession that didn't allow you to accomplish what you wanted to? [Yes/No, so probe for what it was]
4. What was it like to teach in your school? [Probe $\Rightarrow$ What are *students ... teachers ... administrators* like?] What is it like working in your new job? How are your interactions with colleagues or senior personnel similar to or different from when you were teaching? What differences or similarities are there in the way that you interact with people in the community in your new job?
5. Describe your relationships with administrators ... and colleagues when you were in the classroom. Did they play any role in your decision to leave the profession? If those relationships had been different, would you have stayed in the profession? How would they have had to be different for you to stay in the profession?
6. Consider the challenges you saw as a teacher. In what did these challenges contribute to your decision to leave the profession? Looking back on these challenges, how might you respond now?
7. What lead you to apply to the Noyce MTF program?
8. Describe the key experiences from the program. [Probe: How have these experiences impacted your trajectory and decision making?]
9. What was the culture and community in the MTF program like? How has being a part of the program affected your professional network?
10. What were the biggest impacts the program had on you – both personally and professionally? How has it changed the way you do things – again, either personally or professionally?
11. What do you think defines someone as a teacher leader? [Get answer before asking follow-up.] Do you think STEM teachers approach leadership differently than other teachers?
12. In what did you see yourself as a teacher leader? [Let fellow respond] How did others see you as a teacher leader? [Let fellow respond] If others had seen you as teacher leader, would you have stayed in the profession?
13. Did you engage in activities that you think represent teacher leadership? [Let fellow respond] What activities do you do know that represent leadership? [Fellow provides answer] How do you decide the opportunities in which to engage? [Fellow provides answer] How do you determine if your leadership efforts are successful?
15. How would you describe the perfect education job? Would you have stayed in teaching if a job like that existed?

Appendix B – Year 2 Interview Protocol

1. When we interviewed you last time, you said your position was _____. Is that still your position, or have you changed schools or job titles since the last interview? [if yes – probe for new position and ascertain move/shift/leave, along with the reasons for the change]
2. **[If they are in the same position]** Last year we asked you about what it is like to teach in your school and about your relationships with building administrators and colleagues. Has anything changed in the past year that might in turn change your answers? [probe for what, such as new principal, different district standards, changing relationships, etc.]
[If Year 1 interview did not clearly articulate relationships with students, teachers and administrators, probe for the satisfaction with these relationships.]

3. **[If they have moved to a different position or building]** What is it like to teach in your school? [Probe ⇒ What are *students ... teachers ... administrators* like?] What's the relationship between the school and the local community? What interactions have you experienced with individuals/organizations in the community?
4. Describe your relationships with building administrators ... and with colleagues. How have they changed over the years? What about your professional relationships with people/organizations outside of your school – how have these changed over the years? [Follow-up for both about whether the changes were rapid or gradual.]
5. How do your current location and previous location compare in terms of school culture and professional relationships?
6. **[For active Noyce projects]** What have been your key Noyce experiences across this past year? Have the culture and community of your Noyce cohort changed in the past year? If yes, in what ways? What are the biggest impacts the program has had on you – both personally and professionally? How has it changed the way you do things – again, either personally or professionally?
7. Last time we talked, you defined teacher leadership as _____. To what extent does that definition still represent your thinking about teacher leadership?
8. In what ways do you see yourself as a teacher leader? [Give fellow time to answer first question.] In what ways do you think others see you as a teacher leader? Is the nature of your role as a teacher leader clear to you and to others within your school? Has this leadership role changed at all in the past year?
9. What are some of the activities in which you have engaged in the past year that you think represent teacher leadership? [Fellow provides answer] How do you decide the opportunities in which to engage? [Fellow provides answer] How do you determine if your leadership efforts are successful?
10. [Other follow-up questions to clarify Year 1 interview statements – individualized per interviewee]
11. **[collecting peer/admin contact info]** I would like to gather more information about the context in which you work by interviewing one of your peers and one of your administrators. Can you provide me with a couple of names of people I could contact? If you recently changed schools or administrators, I'd appreciate having multiple names, from the old and new contexts. It is also helpful if you let these people know that I will be contacting them to set up a brief (20 minute) interview with them.

Appendix C – Year 3 Interview Protocol

1. First, when we last interviewed you, you had _____ position in **[time of last interview]** **[fill in per year 1 or 2 interview]**. Is that still your current position?
 - a. [if 'no'] What is your current position?
 - b. [if 'no'] Please briefly describe what led to this change.
2. We've asked you in the past to tell us 4–6 words to describe you, if I were writing a story about you. You've told us **[fill in per 2018–19 interview]**. At this point in time, would you want to change those in any way? [probe for explanation for any changes to new words]
3. What are the educational challenges that have arisen as a result of COVID-19? In what ways have you been able to respond to those challenges as a teacher and teacher leader?
 - a. In what ways did the Noyce program prepare/support you in responding to those challenges?
 - b. What process do you use for deciding how to respond to the challenges that confront you, either related to COVID-19 or to other challenges of teaching and teacher leadership?

- c. [if applicable] Is there a person or resource that you look to? Why this person or how did that come to be? How do Noyce programs make it so MTFs see each other as resources?
4. How have your relationships/interactions with colleagues and administrators changed as a result of the COVID-19? In what ways have your professional networks – including those related to Noyce – been impacted by COVID-19? [Make sure this is not interpreted only as *negatively* impacted – encourage the interviews to consider positive impacts, such as drawing on the networks more to meet the challenges.]
 - a. [possible probe] What was the modality of these interactions, and how did that change after March 2020? (online via e-mail, social media, zoom, still in person)
 - b. [possible probe] If the modality/frequency/persons changed during this time, who initiated these changes? Was this a more organic process or was a system in place?
5. What opportunities have arisen as a result of COVID-19 for you as a teacher or teacher leader that might not have existed under normal circumstances? How have those opportunities unfolded? In what ways did Noyce prepare/support you to take advantage of those opportunities?
6. In what ways has teacher leadership in general been affected within your school/district by COVID-19? What do you see happening with regards to those effects once things return to normal? [Make sure they understand this to mean, ‘Do they think lost opportunities will return or new opportunities will be lost?’]
7. Since the focus of the Teacher Leadership research project is teacher leadership, with each interview, we circle back to your definition of teacher leadership. The last time you were interviewed, you defined a teacher leader as **[fill in from year 1 or year 2 interview, as appropriate]**. Do you want to revise your definition now? (Explain)
8. Has the way others see you as a teacher leader changed since March 2020?
9. **What activities do you engage in now that reflect teacher leadership?** Have those activities changed since March 2020? <–*probe for change since March 2020*
 - a. In what ways do you support colleagues with STEM instruction and teaching, such as via mentoring them or providing resources, either formally or informally?
 - b. Have you had the opportunity to mentor preservice teachers since March 2020? Can you describe those mentoring opportunities? How have these opportunities changed compared to prior to March 2020?
 - c. Have you had a leadership role or do you participate in professional organizations such as your state’s Math/Science teacher association?
 - d. Do you participate in school improvement efforts such as school committees or community organization? [goal here: to get at policy leadership]
 - e. Do you participate in leadership activities beyond your school or district, such as at the state level?
 - f. (Probe for examples or instances of change with any of the questions above)
 - g. Out of all these activities we’ve just discussed, what do you think are the most impactful? In what ways are they impactful?
 - h. Can you compare how comfortable you are with formal versus informal leadership roles? Why? (Ask for specifics)
10. What does your ideal teaching-teacher leader position look like?
11. What tensions have you experienced between what you have/had learned or done in the Noyce program and what you are doing/have done within your school?
 - a. How might these tensions have been different if you had not participated in Noyce?
12. What have been some of the major stresses to your teacher leadership activities in 2020?
13. How, if at all, has the social unrest and upheaval of 2020 affected your thoughts on equity in education? How have disparities of access to resources and opportunities been exacerbated during this time? What do you see as the role of STEM teacher leaders to respond to the need for more inclusive teaching?

14. Tell me what you see happening related to teaching in your future. What would you have to see happen for you to stay in the profession until your retirement? How much have the events of 2020 influenced or changed how you view your future in education? [In what ways has your participation in the Noyce program affected your view toward remaining in the teaching profession?]

Appendix D: Codebook

CODE and subcode	Definition
PROFESSIONAL IDENTITY	Reference to the formation and realization of their role as a teacher leader.
Personal Situation	We have added this code to capture what will likely be conditions of the fellow's personal life that impact what they do as teachers or teacher leaders. They probably will be representative of affordances and constraints, but they will not be affordances and constraints of either the system or the Noyce program. As such, we didn't want to apply codes from those two domains to the data. The domain such data (see example in column E) fits under is the one most related to the fellow her/himself – thus the reason for putting it under this domain. However, since this data will not represent factors related to teacher leadership, we wanted to create this catch-all code, as it seems like this data will be valuable in terms of understanding the way the fellow operates in the school system or within Noyce.
Becoming/Being	This code should be applied to data that shows how the characteristics of the fellow (Qualities) or the nature of their interactions with colleagues/administrators (Positioning) help them develop/exhibit an identity as a teacher leader. This would include statements that indicate the fellows' belief in themselves as teacher leaders (Efficacy). It is really important that this code be reserved for how the fellows' or others' ideas and actions support their teacher leader identity, and not be used for data that describes the fellows doing the work of teacher leadership. Year 3 Interview questions 8. ('Has the way others see you as a teacher leader ... ?') and 9. ('What activities do you engage in now that reflect teacher leadership?') will likely contain data that should receive this code.
Qualities	Represents personal/professional characteristic that fellows attribute to themselves or they believe others attribute to them. These qualities do not have to specifically reference teacher leadership. It is important to code all qualities that the fellows list because (1) it will involve too much inferential thinking to determine which codes relate to their teacher leadership capacities and (2) it will make it easier to study the question, 'How well do their qualities – both personal and professional – align with their views of what a teacher leader is?'
Positioning	This code is represented by actions (including discursive actions such as someone saying something) or events that put a fellow in a specific social role – specifically in a leadership-related one. The following may be sources of the positioning: · Self · Peer · Administrators · Noyce Program · Document (e.g. fellows might reference a label identified in a policy document)
Efficacy	Separate from an act (e.g. in Agenting), Efficacy represents the demonstration of a belief by a fellow in her/his ability to do something in the leadership realm. Positioning is an action that empowers someone to function as a TL, Efficacy is a demonstration of the belief that one can act as a TL. This would include general statements about fellows seeing themselves becoming teacher leaders that implicitly suggest that they knew they were capable of handling that transition.
Balancing	This code will be used to identify excerpts in which the fellows talk about multiple identities, how these identities interact/relate, and how/when they might assume the different identities. In our construct map, we note for instance, that a fellows teacher and teacher leader identity might interact in different ways. For instance, the increased validation a fellow receives for her/his teacher leader work could strengthen her/his teacher identity – e.g. when practices that the fellow believed in now are more accepted by colleagues. Conversely, a fellows' teacher leader work could pull her/him away from the classroom and thus negatively interact with her/his teacher identity.

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CODE and subcode	Definition
Teacher-TL Synergy	This code should be used any time the interaction between the fellows teacher and teacher leader identities is positive. For instance, maybe being validated as a teacher leader makes a fellow feel better about the teaching profession in general, as well as her/his work in the classroom.
Teacher-TL Conflict	This code should be used any time the interaction between the fellows teacher and teacher leader identities is negative. For instance, having more TL responsibilities might pull fellows away from their classroom foci and make them feel like they are not being as good a teacher as they would like.
Acting	This code represents all ideas/actions that fellows describe that are related to their efforts as teacher leaders. This would include plans that they have that may not yet have been completed or even begun (Envisioning) as well as work that they have actually conducted that is representative of teacher leadership (Agenting). This should not include their response to challenges of carrying out their TL work as that would fall under Re-Acting /Responding. Year 3 Interview questions 8. ('Has the way others see you as a teacher leader . . . ?') and 9. ('What activities do you engage in now that reflect teacher leadership?') will likely contain data that should receive this code.
Envisioning	Fellow describing what it would look like for them to accomplish a leadership goal or to function in a leadership capacity; i.e. this is creating a plan. It is expected that this would precede data that is coded for Agenting (leadership action). This could include things that the fellows see themselves doing some time down the road, which might be indicative of a view of staying in the profession; in these cases, Envisioning would not be followed by data coded as Agenting.
Agenting	Needs to be an action taken by a fellow that represents her/him exercising leadership capacity. It may be clear where the authority to exercise that capacity came from (e.g. preceded by Positioning) or this may be left unidentified. We need to keep a broad definition of what a leadership action may be since there are myriad forms of teacher leadership.
Re-Acting/Responding	This code includes things that represent responses to factors that might be impeding the fellows' ability to function as a teacher leader, either internal things such as qualities or dispositions that the fellow must change (Changing) in order to be productive as a teacher leader or external things in the system that the fellow must learn how to work around to conduct their work as a teacher leader (Navigating). Year 3 Interview questions 8. ('Has the way others see you as a teacher leader . . . ?') and 9. ('What activities do you engage in now that reflect teacher leadership?') will likely contain data that should receive this code.
Changing	This should involve a fellow describing an action or attitude that shows they are functioning differently than previously in their professional career. It is expected that Changing should be tied to Qualities that the fellows see as ineffective in relationship to their TL efforts. What should be coded along with this is what brought about the change (i.e the cause). If the cause is something that came out of the Noyce program, then it is likely that that cause should be coded as Support.
Navigating	Involves fellows discussing how they recognize barriers and formulate solutions in order to work within the system to accomplish their leadership goals. This would include how they navigate challenges related to ill-defined or ambiguous roles. Envisioning represents a plan or an image of what it would look like to do leadership activities, while Navigating is working around the challenges that may prevent those activities from being completed.
Professional Vision (PV)	PV was defined by Goodwin (1994) as "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (p. 606). Made up of the component activities of (1) highlighting, (2) coding, and (3) producing/ articulating material representations, PV can be understood as developing the capacity to 'see' (highlighting), 'talk/label' (coding), and 'symbolize' (producing artifacts) the practices and actions that are critical to a profession. Greg and Brett have argued that developing/ strengthening one's PV is critical to growing as a teacher leader. One has to be able to see the system – at different levels – and understand what is going on in it before one can think about how to change it. Based on this argument, we want to code things as PV when fellows describe being able to see, talk about, and understand things in ways that help them function more effectively as teachers or teacher leaders.

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CODE and subcode	Definition
PROGRAM FEATURES	Focused on details related to the nature of the Noyce program and its impact on fellows.
Structure	This code should be used when fellows discuss any aspect of the structural/design features of the program, including the criteria by which they were selected, schedule and duration of meetings, the kind of community that exists in the program, and how that community is developed. This should include statement about financial incentives that are built into the program's design. If the data describes what the Noyce project is like, this code should be used. It is important that we distinguish data related to the features of the Noyce program from data related to features of the school system, even in cases where these might be interwoven in a single turn or statement from a fellow.
Culture	Statements about relationships, interactions with peers and PIs in the Noyce program. This could include norms of the Noyce program and how those norms are engendered.
Activities	This represents all of the the things that fellows describe themselves doing (Experience) or getting(Support) as a result of being part of the Noyce program. It should include common PD activities (Experiences) as well as Opportunities that the Noyce program provides to the fellows. We should further use this code when a fellow describe Activities in which s/he could have participated (Opportunities) but chose not to, as that will allow us to look for patterns in what fellows choose not to do. Also, we should apply this code to actions by the project team that assist the fellows in doing their work as teacher leaders (Support).
Experiences	General descriptions of what the fellows engage in as part of their work in the program. This would be distinguished from Opportunities in that (1) these should be definite activities that are part of the program (PDs, particular speakers, panel discussions), (2) should be uniform across fellows in that all or most of the fellows should be doing these activities, and (3) may be the 'cause' for 'effects' like Opportunities.
Opportunities	Chances to participate in actions/activities as a result of Noyce that the fellows would not have otherwise. These should be things beyond set programmatic experiences that fellows can choose to do or not to do. Instances where fellows pursue an Opportunity themselves that they were made aware of through Noyce are particularly of importance. These would just be the Opportunities themselves, as distinguished from the Impact (coded separately) of the opportunities on the fellows
Support	Resources, actions, structures of the Noyce program that assist the fellows in accomplishing their professional and leadership activities. These could be tangible things like financial support or more intangible things like emotional support. If fellows talk about the stipend as a general incentive of considering the program, that should be coded under Structure = > Pathway, not here. If, however, they talk about how they used funding to engage in specific activities (e.g. attending conferences), then it should be coded here.
Tensions	In the year 3 interview, item 11 asks, 'What tensions have you experienced between what you have/had learned or done in the Noyce program and what you are doing/have done within your school?' Any description of such tensions should be coded at the higher level of 'Activities' and then sub-coded as tensions. It would be valuable to add a memo labeling the nature of the tension so that we can try to locate sources of these tensions between the Noyce programs and the school systems.
Impact	See definition below. As with other similar codes, since this is broad, each different mention of an impact – even within the same speaker turn – should be labeled separately with this code.
Impact	Effect of program Experiences and Opportunities on fellows in terms of dispositional, attitudinal, or behavioral items, including changes in professional identity, etc. Could consider sub-codes for particularly significant impacts (e.g. Awareness, Sense of Responsibility). This should include long-term outcomes such as fellows becoming members of an association board (e.g. state math-science teachers' association).
SYSTEM FEATURES	This is all data associated with school or broader system factors that influence the work, thinking, attitudes of the fellows. There needs to be flexibility in what we define as the system to allow it to be the school level or broader district level (even state or national). When it is at the much broader level of state or national, we should identify that ...

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CODE and subcode	Definition
Context Labels	Use sub-codes (e.g. C1, C2, C3) to distinguish different school/system contexts, such as when a fellow has moved between schools. These sub-codes should be used with all codes in this domain, as for example, a school in which a fellow began her/his career might have had one kind of environment that was a function of certain relationships (C1), and a school to which a fellow moved might have a different environment produced by a different set of relationships (C2).
Setting	This code should be used when the fellow describes any feature of the local educational system of which s/he is a part. This would include location, demographics, information about the school culture, the relationship with the community, etc. At a most basic level, this should be seen as a description of the conditions of the school system(see Interactions). Since this is a broad code, it is critical that each mention of a different feature of the Setting be coded separately so that different features can be identified and explored later.
Context Characteristics	Information about the school and the community that relates to general characteristics like location (rural, urban, suburban), demographics, economic strength/weakness of area, etc.
School Environment	General statements about what it is like to teach in the fellows' particular schools – what the condition of the school is like from an educator's perspective. This would include statements that describe the kinds of culture that has been established by administrative actions or by the work of teachers/teacher leaders. The administrative actions or work of the teachers/TLs that create that culture should be coded under Interactions (most likely, Professional Relationships).
Community Association	Any data related to interactions with the community – other than relationships with parents (see above). This would include comments about how the community views the school, statements about partnerships and how those have been established, and notes about resources/support provided by the community.
Interactions with System	This code should be applied whenever the fellow discusses his relationships/interactions with entities within the system, which would include colleagues, administrators, district personnel and even community members. It should also be used when a fellow describes how the interactions or nature of the system affects her/his feelings about the job or the profession. At a most basic level, this should be seen as the actions/interactions/relationships that produce the condition of the school system(see Setting). Responses to year 3 interview question 4. ('How have your relationships/interactions with colleagues and administrators changed as a result of the COVID-19?') will likely be coded with this, since 'Professional Relationships' is one of the sub-codes. Also, this data would be double coded as 'COVID'.
Professional Satisfaction	Statements about the fellows' sense of contentment/fulfillment with their work at the school specifically and the profession in general. Include any statement about what contributes to this sense of satisfaction or lack thereof.
Professional Relationships	Any statements about relationships that impact on the fellows' professional work. This should include relationships with students, peers, administrators, and parents – with the latter being coded as this when it is not a part of the general discussion of Community Engagement (see above). It is particularly important to code comments about any factors responsible for the nature of these relationships. For any data coded as this, there should be a sub-code identifying the group with whom this relationship is formed (Students, Colleagues, Administrators, Parents).
Affordances & Constraints	This code is a truly critical one as it is an attempt to identify aspects of the system to which the fellow may be responding in terms of her/his (1) feelings about the profession and (2) activities as a teacher leader. Setting (see above) describes the conditions of the system in which the fellow operates; Interactions delineate the actions/interactions/relationships that may be related to those conditions. Affordances and constraints should capture instances of explicit recognition by the fellows of structural features in the system that serve as catalysts in terms of how the fellows respond to the system or challenges that they need to address. The fellows do not have to describe what their response(s) has (have) been, but simply note that they recognize these things as affordances or constraints of the system. Responses to year 3 Interview question 3. (challenges created by COVID) and 5. (opportunities created by COVID) will likely be coded with this, along with 'COVID' as a double code.
Driving Forces	Statements related to the factors that determine why the school culture/environment is the way it is. This would include things like the goals/philosophy of administrators, the impact of state and federal policy, the presence or lack of resources, etc.

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CODE and subcode	Definition
System Challenges	These include statements of the things that function as barriers to what fellows see as effective educational practice or to them implementing their TL plans. As such, data coded as this could eventually be connected to Navigating, and would help explain why particular approaches to Navigating were taken. For things coded as this, the coder should add a memo identifying the nature of the challenge, such as educational policy, lack of resources, etc.
System Affordances	Statements that include things that function as affordances to what fellows see as effective educational practice or TL
Broader Contexts	This should be viewed as one of the main, Cycle 1, phase 1 codes along with the 15 codes shaded gold. Its purpose is as a label for any data that describes contexts beyond the fellows school system and outside of the Noyce program. For instance, a fellow might describe engagement in a state level activity that was not a part of her/his Noyce experiences and was not a leadership activity. Or, there might be descriptions of community engagement that are not limited to the local school community.
PROFESSIONAL TRAJECTORY	Information related to the past and future pathways for fellows.
Trajectory Description	This code should be applied any time a fellow describes their pathway into/through teaching. This should include information about changing careers to go into teaching so that we know how those previous job experiences influenced their thinking. It should include changes of schools or positions once they became a teacher. Finally, this code should be used when fellows discuss their future plans for the profession. Responses to year 3 Interview item 15 (Tell me what you see happening related to teaching in your future) will likely be coded with this or with 'Trajectory Factors' (if the MTF explains the why).
Past Trajectory	Descriptions of (1) pathways into teaching (as distinct from pathways into the Noyce program) and (2) moves to different schools/shifts to different positions. This should include previous careers in which fellows might have been employed and that might have influenced their thinking about teaching and about teacher leadership. Information about why fellows made career or school changes should be coded with the next label.
Future Trajectory	Descriptions of any future professional plans fellows envision for themselves, including such things as how long they might stay in the profession and any consideration of non-teaching activities (administration positions, consulting, etc.)
Trajectory Factors	As the note for the first code suggests, this code should be used when fellows discuss why there is a change in their professional trajectory – what made them change careers, change schools, etc. The other data that should be coded with this label is any descriptions the fellows provide of what needs to happen for them to stay in the profession (which is also, in a sense, a 'why' factor – why they would stay).
Change Trajectory	This should be used whenever fellows discuss the factors that lead them to shift careers or move schools. It would be valuable to try to add a memo identifying this factor such as Broader Impact or Making a Difference.
Retention Requirements	This is to be used to code fellows responses when they are asked what would be necessary for them to stay in the profession. It would be helpful to include memos that identify the nature of these requirements and categorize them.
TEACHER LEADERSHIP	Information about fellows' views of TL and the kinds of activities that represent it.
Stance	This code is to be used to label data associated with items 7 and 10 of the year 3 protocol where fellows are asked to revisit their year 1 definition of teacher leadership, and to comment on the ideal teaching/teacher leader position. It is labeled Stance because it represents their position on what teacher leadership represents. As with some other codes, each different component of the fellows' definitions or each rationale they give for why STEM TL is different should be coded separately so we can later explore the specific ideas fellows have in these regards.
TL Definition	How the fellows define TL. Each different aspect of their description/definition should be coded separately. It will be valuable to note if they distinguish between formal and informal TL roles. Also, it would be valuable to add memos (possibly sub-codes) to note whether the items represent (1) Roles, (2) Skills, or (3) Dispositions.
Differences STEM TL	This is another specific question at the end of the protocol. Even if fellows don't see a difference between STEM TL and other disciplinary TLs, that should be coded. Memos should be written to capture things fellows identify when they do feel there are differences (e.g. Problem-solving skills).

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CODE and subcode	Definition
Engagement	This code is designed to be used with fellows responses to question 9 about what activities they do that they think reflects TL and what activities they think are most impactful. It is important to recognize that this code, Engagement, is for things that fellows discuss after they have been asked to define what TL is – it is critical that this data is coded differently than things the fellows discuss before having been asked that question.
TL Activities	Descriptions of the kinds of things in which fellows engage that they feel are representative of them functioning as TLs. This would be different from Agenting because it would be the direct response to the question at the end of the protocol when the fellows are specifically asked what things they do that demonstrate TL.
TL Choices	At end of protocol, fellows are specifically asked about how they make decisions about what TL activities to engage in. This code should be used to label responses related to this question.
Opportunities	At end of protocol, fellows are specifically asked about how they determine whether their TL efforts are successful. This code should be used to label responses related to this question. It will be important to separately code different means by which fellows analyze the effectiveness of their efforts.