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Collaborative professional learning: cultivating science teacher leaders through vertical communities of practice

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ABSTRACT

This article presents findings from a multi-year study of a grant-funded professional development fellowship program that supports teachers in becoming science teacher leaders and improving science curriculum and instruction. The program's activities are designed to: (1) create and support a corps of teacher leaders, (2) institute a culture reflective instruction, and (3) improve teacher quality through vertical articulation of curriculum and professional development. This paper shares the experiences of fellows in our third cohort during their first year in the program and focuses on their collaboration in a vertical group. Three significant themes emerged in the data: tendency to participate in a pseudo community (engaging in superficial conversation); focus on emerging problems of practice; and finally, interactions that encourage pulling back the curtain and reflecting on the details of practice.

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In recent years, accountability policies have raised the stakes for school improvement, resulting in an almost continuous stream of reform efforts to increase student achievement (Coburn 2003, Hatch *et al.* 2005, Henig and Stone 2008). A range of formal structures guides the implementation of these reforms with the direct intention of building the individual capacity of teachers to improve their performance (Spillane 1999, Darling-Hammond 2000, Datnow *et al.* 2002). Thus, the role of the teacher is redefined. Teacher leadership represents a major shift in conceptualizing a teacher's role from a focus solely on student achievement to collaborating with other professionals and influencing the success of all (students and teachers) within a school (Barth, 2001, Katzenmeyer and Moller 2001, Robinson 2009). Even with recent emphasis on teacher leadership from a reform perspective, there is little empirical research on how emerging teacher leaders navigate the structure of schools and districts, build collegial relationships, encourage collaboration, and foster educational improvement at the classroom level.

While the idea of teacher leadership is not new, there has been an increased scholarly and policy interest in fostering teacher leaders as change agents to address challenges such as innovating curricula, addressing the needs of diverse student populations, and committing to continual reform efforts. As central members of the school community, teachers play a unique role in helping colleagues initiate and sustain a community of learners and leaders to support such demands. They can improve instructional practice in schools and impact student learning (Crowther *et al.* 2002). Teacher leaders are teachers who lead within and beyond the classroom, contribute to a community of teachers, learners, and leaders, and influence other teachers toward improved educational practice (Katzenmeyer and Moller 2001). They act as facilitators

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within the school, strengthening school reform and instructional improvement. There has been a rise in scholarship of the emergence of teacher leadership as a result of collaborative groups of teachers working to improve practice in response to reform efforts (Smylie *et al.* 2002, Muijs and Harris 2003, Murphy 2005). Having opportunities to make meaning for themselves, own their learning, and reflect on their practices has the potential to empower teachers as leaders (Katzenmeyer and Moller 2001). There is an increased need for science teacher leaders in the United States, especially with the implementation of the Next Generation Science Standards (2014) as well the expanding emphasis that the nation places on a highly qualified science, technology, engineering, and mathematics (STEM) workforce.

Teacher learning within a social context allows for a deeper understanding of the conditions needed to improve teacher practice (Cochran-Smith & Lytle, 1993; Wenger 1998, McLaughlin and Talbert 2006). Cultivating a common understanding shifts learning from a solely individual process to a social one that occurs through interactions and experiences. Fundamental to this idea of teacher learning is the notion that teachers learn collaboratively in communities and/or networks (Lieberman 2000) where participants attempt to construct meaningful knowledge together to transform teaching and learning. For this to occur, teacher learning must be conceptualized as a complex system rather than an isolated event (Collins and Clarke 2008). Essentially, teacher learning can flourish when teachers feel a sense of belonging to a community and are contributors to that community.

Teachers transitioning into teacher leadership roles position themselves within both the leadership and teaching context (Cooper *et al.* 2016). Empirical research about teacher leader preparation is limited but some have focused studies on programs designed to model instruction, empower teachers through collaboration, and support a process of shared inquiry (Caine and Caine 2000; Taylor *et al.* 2011).

This study focused on five K-12 science teachers engaged in vertical articulation during their first year of the XXXX science teacher leadership fellowship program. Our two-year program is led in collaboration with university faculty and district coordinators from five participating school districts. During year one, teachers work in vertical teams and then in horizontal teams to study their practice through video. The vertical team is comprised of science teachers in the elementary, middle, and high school that focus on the same content (i.e. biology, chemistry, or physics principles). The horizontal team is comprised of all teachers in the same grade level (i.e. elementary, middle, or high school) who discuss science process skills at the appropriate levels. This study centered around our vertical teams that engaged in vertical articulation. Vertical articulation refers to the continuity of a program throughout the K-12 length of the program.

Vertical teams of five fellows choose a teaching practice to study, select and discuss a research article about that practice, and meet to provide feedback on each videoed lesson. The fellows follow protocols for pre- and post-video debriefs and submit reflections forms for each observed teacher. The entire cohort meets monthly with faculty in professional development workshops. Topics include backward design, classroom discourse, standards-based teaching, teacher leadership, and action research. The goal of the first year of the fellowship is to encourage reflective practice and collaborative work around a targeted specific scientific topic.

In this article, we examine a vertical team focused on physics instruction at the elementary, middle, and high school levels. Using forms of energy as their physics topic, they explored the use of questioning in their lessons. They read and discussed the article titled *Question asking in the science classroom: Teacher attitudes and practices* (2014), developed and taught physics lessons focused on questioning techniques, videotaped lessons, and then analyzed and debriefed about each teacher's lesson during monthly meetings. These meetings involved conversations on teaching and learning across science content areas and grades levels.

For this study, we engaged in a microanalysis of how these five fellows examine, analyze, and reflect on practice within their vertical team interactions. We explored how experience in this

professional community of practice influenced their stance as reflective practitioners and teacher leaders. We asked:

- (1) What happens when science teacher leaders collaboratively examine their teacher practice in a vertical community of practice?
 - (a) What do we notice about how fellows engage in conversations around, and examine and analyze teaching practices?

Literature review and theoretical framework

Conceptualizing teacher leadership

Although many definitions have surfaced, articulating a meaningful and encompassing definition of teacher leadership continues to evolve and reflects the fluid and ambiguous ways in which teacher leaders construct their role in response to their context. The existing literature characterizes teacher leadership in terms of the behaviors and personal qualities demonstrated by teacher leaders; these qualities vary among contexts and environments; therefore, many competing definitions of teacher leadership exist.

Collectively, the literature describes teacher leaders as educators who positively influence their peers by establishing and sustaining collegial relationships for affecting change (York-Barr and Duke 2004, Lieberman and Miller 2005). Teacher leaders also possess a strong sense of purpose (Lambert 2003, Donaldson 2007), but they do not impose their values upon colleagues (Frost and Durrant 2003). They are willing to extend their work beyond their respective classrooms (Fullan and Hargreaves 1996) and foster collegial interactions that focus on instructional strategies. They shine as risk takers and role models (The Center for Comprehensive School Reform and Improvement, 2005). As lifelong learners, they continually reflect and refine their practice. Finally, teacher leaders cultivate a positive school environment because they understand how political factors of the school influence the needs of their peers (Frost and Durrant 2003; Donaldson 2007).

Teacher leader collaboration

Teacher leadership involves collaborative efforts that seek to influence instructional practice. Because teacher leadership is not an individual action, they require a relationship between themselves and members of their school (Donaldson 2007) and collaboration is one important factor in teacher growth (Lucas and Valentine 2002). Smylie *et al.* (2002) suggest that teachers have greater feelings of contributing to the school and self-worth when they interact and collaborate with one another and when they take on leadership roles. Being in a leadership role typically helps teachers to grow professionally. In contrast to the notion of collaboration, the nature of our educational system tends to isolate teachers (Donaldson 2007, Robinson 2009, Smylie 2010) and cause teachers to exert less effort outside of their classroom, and avoid taking on leadership roles (Smylie, 2010). Collaboration encourages teachers to exercise leadership skills by sharing expertise, knowledge, and support (Mujis, 2010). Teachers who have experience, credibility, and expertise are sought after by other teachers for their help and guidance and through collaborative leadership, and can influence others informally (Smylie *et al.* 2002, Donaldson 2007).

Regardless of the varied teacher leadership structures established within schools, teachers need to recognize their ability to engender change. Katzenmeyer and Moller (2001) acknowledge that teacher leadership may not be for every teacher at all points in a career; there are times when participation may be inviting, and times when teachers may need to avoid extra responsibilities (Barth, 2001, Katzenmeyer and Moller 2001). Depending on the actors and the current need of the school, enacting teacher leadership manifests differently.

Communities of practice

To situate the professional development of teacher leader fellows within the context of their lived experiences, we drew on the literature from communities of practice (CoP) (Lave and Wenger 1991). The CoP conceptual framework addresses how we manage the human and social aspects of knowledge creation and dissemination while improving human performance (Lave and Wenger 1991). CoP also offers a way to theorize tacit knowledge that is hard to communicate, something particularly of interest to the educational research community (Nonaka 1994).

A CoP is a group of practitioners ‘who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis’ (Wenger *et al.* 2002, p. 4). The three main characteristics of a CoP are: ‘a domain of knowledge, which defines a set of issues; a community of people who care about the domain; and the shared practice that they are developing to be effective in their domain’ (Wenger *et al.* 2002, p. 27). Seashore Louis *et al.* (1996) describe the elements of professional community as well as the cultural and structural conditions that support it. They write that these elements include: shared norms and values, a focus on student learning, reflective dialogue, deprivatization of practice, and collaboration. Building CoPs has evolved as a potential strategy to help teachers develop their content and pedagogical content knowledge (Borko 2004). In an extensive study of the contexts of high school teaching, McLaughlin and Talbert (2001) write, ‘How high school teachers experience their careers depends a great deal upon the strength and character of their professional community’ (p. 90). They suggest that looking at teacher communities is important for what they might teach those interested in creating sustainable change.

While not all forms of teacher community necessarily improve teaching and learning, there is some evidence that certain professional communities do make a significant impact on the work teachers do and the students’ experiences in the classroom (Hollins *et al.* 2004, Lieberman and Mace 2008). McLaughlin and Talbert’s (2001) study of teacher professional communities differentiates between strong and weak professional communities. They define strong professional communities as groups ‘characterized by mutual engagement, joint enterprise, and shared repertoires of practice (such as materials and concepts)’ (p. 127). Although most teachers are members of weak professional communities, the researchers do unearth a number of strong professional communities. Thus, in an examination of strong professional communities it is important to look at both their quality and intentions.

The focus on professional community begs the ‘so what’ question. Why does it matter if schools create strong professional CoPs? Wilson and Berne (1999) in their study on teacher learning and the acquisition of professional knowledge discovered the ‘urge’ for community: ‘In every case of teacher ongoing learning ... teachers were engaged in learning communities that allowed them to test, discuss, revise, and retry their ideas about children’s mathematical thinking and its relationship to instruction’ (p. 183). The two most significant features of these communities were that they were self-sustaining and focused on students’ thinking. Grossman *et al.* (2001) argue that there are four reasons it is important to develop professional communities: (1) because they are a source of intellectual renewal; (2) they serve as a venue for new learning; (3) they are a venue for cultivating leadership; and (4) it is good for students.

Strong professional communities are inextricably bound up in strong relationships among members. How we assess and develop such relationships is complex and often focused on successes rather than the challenges. Grossman *et al.* (2001), in their study of a group of English and Social Studies teachers working together, warn about the dangers of ‘pseudo-community’ believing that ‘individuals have a natural tendency to play community – to act as if they are already a community that shares values and common beliefs’ (p. 955). People like to ‘behave as if we all agree’ and people do this by ‘suppressing conflict’ in order to preserve the ‘illusion of consensus’ (p. 955).

The CoP framework is instrumental in advancing understanding of how collaborative interactions in teachers' professional learning lead to organizational learning and change (Coburn and Stein 2006, Levinson and Brantmeier 2006); it offers us a means of understanding necessary teacher leadership skills. The framework shifts attention from focusing solely on individual learning to the learning of the individuals in a group, to the group's learning, and, in particular, to the outcomes of their collaborative interactions (Stein *et al.* 1999, Meirink *et al.* 2007). The framework highlights how groups of educators work and, develop new practices together. We sought to specifically examine the features of teacher professional communities described by Little (2003). These are focused on groups of teachers that: 1. Come together to identify and examine problems of practice; 2. Explore the problem in collaboration with colleagues, seeking new answers and understandings to their concerns; 3. Have discussions around artifacts of classroom practice; and 4. 'display dispositions, norms, and habits conducive to teacher learning and the improvement of teaching practice' (p. 938). We see this as essential to the kinds of work that help support and sustain teacher leadership.

Collaborative inquiry in a community of practice

In a CoP, the focus of collaboration is on improving outcomes for students through changes in instructional practice. Collaboration involves working together on shared challenges that have been identified with evidence. Effective collaboration engages participants in ongoing cycles of inquiry where they identify what is going on for students in relation to valued outcomes. Once this is done, they can discover credible evidence and identify a problem of practice that will stretch existing knowledge and capacity but also be manageable. From there they can design, try out, and test changes in practice that are aimed at solving the identified problem. In order to evaluate the changes, they can accumulate evidence of impact, refine or discard ideas based on evidence of their effectiveness, and embed changes that prove to be effective into daily practice. Their final step would be to identify the next student-related challenge (Chapman and Muijs 2014, Butler *et al.* 2015)

Similar to this was Baker, Jensen, & Kolb's (2005) work on conversational learning, 'a process whereby learners construct new meaning and transform their collective experiences into knowledge through their conversations' (p.2). They proposed that conversation is essential to any type of dialogue where participant reflection is the driving force to unpack meaning. Furthermore, the authors claim that this process creates an atmosphere where learning can take place due to new experiences. For this process to be successful, Baker *et al.* (2005) suggest that conversational learning cannot exist without a structure or 'learning space' (p. 14).

Teacher leaders have been identified as possessing the needed skills and knowledge to co-lead collaborative inquiry activities (Neslon & Slavit 2008, Vineyard 2010). Teacher leaders not only help ensure that the work they are leading is relevant to group members, but they tend to help build rapport between their colleagues by encouraging productive discussions among group members.

Challenges of communities of practice

Despite the potential value and contributions that CoPs offer to educational organizations, there are unresolved issues and difficulties that are apparent in the literature (Probst and Borzillo 2008, Vescio *et al.* 2008, De Waal and Khumisi 2016). These challenges include time demands and constraints (Roberts 2006), organizational structure and hierarchy (Leavitt 2003), and lack of investment in the process (Probst and Borzillo 2008).

Frequently members of a CoP remark on the lack of time to engage in activities necessary for them to be catalysts for change (Roberts 2006, Pemberton *et al.* 2007). Additionally, CoPs are frequently conceived within established organizations, and as such must coexist with a preexisting organizational hierarchy (Leavitt 2003, Roberts 2006). Leavitt (2003) argues that an organizational

structure is problematic for CoPs because of its reliance on a centralization of control and power, the designation of who has authority to give orders (Vescio *et al.* 2008), and the overall relationships in general. In other words, members of a CoP tend to replicate the power hierarchies of a school (Leavitt 2003, Vescio *et al.* 2008, De Waal and Khumisi 2016). Another issue of practice arises within the CoP when members cannot ‘put aside their personal perceptions and to adapt to the collective decisions of the community of practice’ (Flogaitis *et al.* 2012, p. 225). Such disagreement is not altogether a problem as Fullan (2001) argues that people ‘are more likely to learn something from people who disagree with us than [they] are from people who agree’ (p. 41). Lastly, groups that function as CoPs may sometimes be resistant to change and may not externalize their collective learning (Mittendorff *et al.* 2006). A reluctance to change (both collectively and within individuals that make up the group) can hinder the groups’ progress toward sharing their repertoire since it indicates acceptance and support of change.

This paper looks at the cross-school communities created by a grant-funded program seeking to develop both content knowledge and pedagogical content knowledge. We examine the extent of building innovative professional communities, and the impact these have on teachers’ reflective practice. Particularly we looked at the following aspects of the work among these teachers: discussion around professional practice, collaborative problem solving, and critical reflection of teaching and learning.

Methods

This study used qualitative research methods to explore the dynamic and complex work of how science teacher leaders collectively influence practice (Merriam 2009). We focused on the physics vertical group composed of five science teachers. By studying their interactions in vertical articulation meetings, learning through research, and practices of teacher leadership *in situ*, this study strove to uncover the dynamics of the fellows engaged in collaborative work.

Setting

This grant-funded professional development program in science teacher leadership was funded by a private corporation and housed at a public state university in the Northeast. Faculty in the college of education and in the college of science and mathematics lead this program. It is a two-year cohort experience in which fellows study their teaching practices collaboratively, implement an individual professional development plan, and design and facilitate professional development in their schools and districts. The funding supported three cohorts.

Participants

Selection included five of the 20 members of the third cohort of the program based on their reflections of the vertical team experience. Fellows were male and female, between the ages of 25 and 55, and with 3–20 years of teaching experience. There was one high school teacher, two middle school teachers, and two elementary school teachers representing each of the five participating high needs school districts. The participants all were assigned their group based on content they taught, in this case physics/physical science. During the initial vertical team meeting, participants received structured protocols to use during each of the mandatory vertical team meetings over the course of 5 months. All vertical groups used the same meeting format dictated by the grant program. The group’s only choice was the problem of practice and scientific topic they focused on in each lesson.

Data sources

In accordance with qualitative methods, we collected the following data throughout the program.

Video artifacts of teaching

Each participant created a video artifact from a lesson taught. Additionally, all debrief sessions were videotaped. These transcribed videos focused on the fellows' teaching practices and interactions during debrief sessions and served as a means of checking teacher reflections on practice and analyzing group interactions.

Written artifacts

Artifacts included observation forms, video reflections, group presentation reflections, and second year action plans.

Data analysis

The constant-comparative method of qualitative data analysis (Glaser and Strauss 1967) was used to code, sort, and categorize data, using both inductive and deductive methods of analysis. As a research group of faculty and four doctoral students, we began by individually reviewing the data; upon this initial review, we decided to use a CoP framework for data analysis. We then created a protocol that used the CoP framework to again review data (see Appendix A). Each video and written artifact was reviewed using the protocol developed. The completed protocols became the source of information used by the researchers when coding the data. This first round specifically looked at the elements of a CoP described by Little (2003): identifying and examining problems of practice, exploring the problem in collaboration with colleagues and seeking new answers and understandings, discussing practice using classroom artifacts, and adhering to CoP norms. The research team collaboratively reviewed our individual responses to the protocol in order to develop the codes that formed our findings section. Upon returning to the data using this framework for analysis, we discovered that it did not fully explain what we were reading. Thus, we developed a deductive/inductive coding scheme that included both elements of the COP framework as well as codes that emerged from our data sources. These included additional codes including: affirmation of practice (i.e. 'that was a great lesson!'), organic problems of practice (separate from the originally defined problem the group started with), superficial observations of practice ('I liked the fact that you used technology'), pulling back the curtain of practice (when teachers talked through why they did what they did), pedagogical content knowledge, pedagogical knowledge, and vertical discussions (when teachers mentioned differences and similarities across grade levels). Below we discuss the larger themes resulting from collapsing the codes. They include a tendency to participate in pseudo-community, focusing on emergent problems of practice, and interactions leading to pulling back the curtain and reflecting on the details of practice.

Findings

Our data reveal two preliminary findings about the fellows' engagement in the vertical team and how these influenced their reflective practice and their meaning making of their teaching.

Participating in a pseudo-community

As noted in the literature about CoPs (Grossman *et al.* 2001), when fellows met in their vertical teams, they often struggled to engage in deep conversations about practice. We found a large percentage of talk (up to 1/3 in some debriefs) focused on what we think of as 'superficial' discussions, which included generalized affirmations of what the other teachers did. For example, during the second debrief session, fellows commented on the teacher-student relationship observed during a middle school lab activity. One fellow noted, 'I think you had a very good repertoire with your students. They were comfortable, you were comfortable ... You still had command in terms of classroom management. I don't think they would have done anything

to upset you.’ Another fellow added an artificial takeaway from the observed lesson, ‘I’m taking away the fact that you utilized the day before a holiday.’ We found continued examples of affirmations throughout the semester long debriefs. These affirmations did not address pedagogical applications or risk taking within the participants practice. ‘Safe’ praise overpowered criticality to practice within this community; which may have inhibited the potential professional growth occurring. During the final debrief session, when asked how the lesson observed related to the research article on questioning, one teacher said:

It was great. Um, the questioning, the prompting, your demeanor, the way you talk about it . . . I think you know, if every science lesson could be, could end like that it’s golden. . . I think you did a very good job. It ties in very well to the article. Your higher level for a second grader. Perfect!

The fellows’ observations led to a proclamation of ‘great’ teaching which followed an agreed affirmation from the other fellows. The purpose of the initial question was to make curricular connections to the problem of practice, yet the superficial feedback was unlikely to improve or challenge a teacher’s practice, as it did not provide analysis of what made the practice effective. For example, during the second debrief session the teacher responded, ‘Umm thank you. I agree with just about everything and umm pretty much everything.’ Feedback such as this did not change the observed teacher’s initial notions of what constitutes an analysis of practice, and the lack of concrete examples or other information did not help the teacher improve her practice. It is interesting to note that faculty modeled a more critical kind of feedback in an early group session with fellows, offering alternatives for the kinds of talk that might be more productive. Despite this modeling, fellows struggled to provide productive criticism consistently.

Fellows sought to make each other comfortable, emphasizing what they ‘liked’ about each other’s classrooms and being excessively polite rather than providing more elaborate detailed observations of practice. Comments included, ‘I learned you have a really nice lab classroom. I’m jealous,’ ‘I really like this,’ or ‘the simulation program . . . really drew everyone’s attention and they’re actively thinking about the lesson.’ These examples exemplify the kinds of discourse offered during the warm and cool feedback sessions. Fellows seemed to find it difficult to provide feedback with concrete evidence, which resulted in warm subjective comments about what struck them personally rather than fostering a sustained conversation about the teaching practice observed. These conversations failed to push the boundaries of teachers’ practice to lead to a better understanding of their professional learning.

Finally, these superficial discussions often included commentary about off-topic comments related to less significant aspects of the videotaped lessons. For example, one person knowingly veered off topic, ‘I’m going to break protocol here for a sec, . . . when you’re with the group, you have to be able to tune the rest of the class out. Because, at one point we heard metal hit the floor and it sounded like something broke and the teachers, most teachers’ first response is “Oh, what now?” But you completely tuned it out.’ While, it is apparent that the fellow was praising the teacher for not reacting to off task behaviors, his feedback did little to support improvement in practice, especially addressing the identified problem of practice related to higher level questions. Similarly, in a separate debrief, a fellow mentioned an announcement that was made over the PA during the lesson, ‘I was listening to that [announcement], it kind of blew me away that they would think that it’s okay to make that kind of announcements to teachers.’ Again, this back and forth digression took the focus of the critical analysis away from the teacher’s practice and to the uncontrollable things that happen in a classroom at any given time. We do not argue that such conversation is irrelevant to the work of teachers, but rather note that the amount and consistency of such talk illustrate the challenges of engaging in deep dialogue about the nuances and details of practice.

Although the fellows had some guidance in how to observe and give feedback about professional practice, they were not adequately prepared to engage in discussions that would change aspects of their practice. They struggled with providing specific feedback or asking probing

questions that could extend or deepen reflection, something we see as central to their development as teacher leaders. Instead, they tended to focus on what happened in the classroom or what lessons they might take away from the experience. Even though university mentors provided some structure using protocols, these were not sufficient to create the kind of practice-based discourse for which we hoped. Visible in all debrief sessions, the superficial feedback always began with a general statement such as: ‘for warm feedback . . . I really liked when you called the students little scientists.’ These kinds of empty and ineffectual comments did not direct teachers to reflect upon central aspects of instruction or student engagement.

When teachers fall into ‘pseudo community’ they lack the capacity to tackle problems of practice, thereby disallowing teachers the same kind of opportunities to ‘examine taken-for-granted assumptions’ and move toward change (Horn 2010, p. 234). Before beginning work in their vertical collaborations, fellows were instructed to identify a problem of practice, find and read a research article about this, and plan lessons that might exemplify what they learned. When fellows engaged in discussion around the identified problem of practice their remarks were insubstantial. For example, ‘watching you have those higher order questions, pushing them and trying out what we’ve been talking about in the meeting, was really good.’ As the fellows continued to engage in dialogue around the practice of questioning throughout the meetings, the talk was usually insubstantial and not informative. One fellow shared, ‘I think the warm-up activity really built the foundation for you to ask those higher-level questionings later on.’ The fellow then stopped and did not elaborate, give examples, or provide any context to that comment; instead, he shifted the conversation to that of planning. Similarly, it seems as if the fellows did not know how to discuss evidence relating to the lesson and the article. One teacher said, ‘I think the students were engaged because of the questions, because I saw a lot of hands up.’ As this may indicate that a number of students knew the answer to the question posed, it did not actually provide feedback or insight around the identified problem of practice of higher-level questioning practices. When the initial goal and purpose of having the vertical team identify a problem of practice is up front, it seemed as if conversations, reflections, and feedback around the practice of questioning became flat or abruptly ended during the debrief sessions.

From the perspective of researchers, this study succeeded only to create a pseudo-community, one characterized by participant congeniality. The vertical pseudo community of practice at times functioned to reiterate existing ideas and information instead of generating new learning, especially when situated around the predetermined problem of practice. As researchers, we question the authenticity of the discourse within the vertical community of practice.

Emergent problem of practice

Our analysis of the data suggested that rather than talking about the identified problem of practice, there was a disproportional amount of talk about what we call the ‘emergent problem of practice.’ By this we mean extended talk about other problems of practice that emerged from their analysis of each other’s videos. While these varied from debrief to debrief, for this group, these emergent problems of practice usually centered on increased student engagement. Additionally, when the group did engage in discourse around the identified problem of practice, their conversation usually resulted back to the superficial discourse discussed in the previous finding.

For example, during the debrief session of a high school physics lesson on energy, the fellows engaged in a lengthy discussion around student engagement, specifically describing elements of a successful student-centered lesson. One fellow began by elaborating on her observations/reflections during the lesson:

I don’t know if it’s because you’re obviously with 11th or 12th graders or your teaching style or the combination of it both. Your students were so comfortable to say, wait why? They didn’t just take an answer at face value and they didn’t turn to you, they turned to each other and they didn’t wait to be called on by you, they just openly said, well this is what I think. And even when the students when up to the board to do the

simulation, there's still that back chatter, but it was about their predictions. They were continuing that conversation of, no I don't think that was right, but I like what you said there. There was a lot of that open communication between you students and I think they were asking each other questions and it wasn't so teacher directed.

This debrief immediately developed into an extended and meaningful conversation around student interactions and engagement. Another fellow added, 'A lot of the lesson was student kind of run, for lack of better term. They're the ones that were presenting, they were the ones that were manipulating the math ... they asked each other for clarification.' A discussion around the emergent problem of practice also challenged teachers to truly rethink their planning and purpose of various parts of the lesson. One fellow questioned a teacher's choice of classroom setup, implying that it may inhibit student interaction and engagement, 'I almost feel like your seating arrangement didn't benefit them ... I almost feel like a U-shape ... because they are asking really important questions.' These questions, which provided specific examples and remediation, foster further conversations. Another fellow followed with, 'Even though they were all engaged ... it would have been a great idea if the seating arrangement would have them literally turn to each other.' Exploring student engagement was not unique to the upper grade lessons; it was just as evident in the analysis of a second-grade science lesson. The dialogue about the pedagogical challenge of engaging students led fellows to analyze and question their colleagues about the choices they made in carrying out the lesson. A deeper discussion occurred with the focus being improving teacher practice for professional growth. For example, a fellow posed a question about student engagement to the group: 'The students were so engaged like most of the time you were staying back ... there was a very good connection. So how do you develop those kinds of connections?' Her comment led to some reflection on the part of the teacher about how he was navigating this challenge and invited others to try out strategies in their own classroom. When the fellows focused the discussion on student engagement, the emergent problem of practice, the analysis of lessons expanded the fellows' vision of what criteria to consider when determining features of instruction that might constrain or support student learning and engagement. Student engagement functioned as the contextual anchor that grounded the conversations about teaching and learning in concrete relevant examples and thus made those conversations more focused and productive.

When the feedback became focused on instruction and student engagement, the fellows grew confident in engaging in extended discussion around professional practice. One fellow mused about how to extend what they were doing in a future lesson, 'I was thinking maybe the students share their ideas with other students, so they come to the front and speak about what they did.' As the fellows engaged in these discussions, they developed their knowledge and skills about facilitating instructional practice, something key to their role as teacher leaders within their schools.

In these examples, when fellows reflected on their practice, they were able to specifically identify aspects of instruction and student engagement that may be fruitful for others to notice in their own classroom. The fellows' integrated into their practice their co-constructed knowledge about teaching. Similarly, guiding fellows to reflect on examples of instruction with their peers has the potential to improve their ability to notice consequential aspects of their facilitation of student engagement.

Extending reflection about practice

Furthermore, our data revealed that when fellows discussed the emergent problem of practice in the debrief videos, their peers' questions and observations led fellows to engage in extended reflection about the thinking behind their practice. By locating problems in the specific interactions viewed in the lesson, the teachers often faced the ambiguity and complexity of their teaching choices. This took several forms: pulling back the curtain--talk about planning and organization; exploring why they made choices of instructional strategies; describing what their expectations were of their students; and deepening pedagogical content knowledge. Again, the discourse which

highlighted this unpacking of practice was less formulaic and provided a more organic and insightful conversation.

In keeping with the emergent problem of practice and student engagement, one fellow reflected on how she grouped her students in this particular lesson and how she might group them differently in the future, ‘I would group students differently next time, more heterogeneously. One group was giving very basic answers, “this is what I saw” or “this is what happened . . . I have not mastered how to group my students.”’ Another shared, ‘I feel like I don’t know why I didn’t think of it before? I model everything else.’ Fellows used the vertical team meetings as opportunities to reflect on and broaden their teaching practices. Teachers not only questioned their own practice, but shared deeper conversations around what they learned. One teacher said, ‘So I learned that you have to be well-orchestrated especially with the . . . student population that you have. I am taking notes down for my next investigation to make sure that it is organized.’ Through this ‘uncovering,’ the fellows began to see reasons for or affirmation of the instructional choices they made.

These insights led to further in-depth examination of practice and a grass root discussion around pedagogical content knowledge. One fellow questioned a teacher about the use of marbles for a particular energy experiment, fostering a deeper discussion around the pedagogical content knowledge of teaching energy in various science units. The teacher’s response was: ‘The marble I chose is a nice shooter and it . . . gets a good bounce. Bouncy balls have too much [bounce] and then they are all over the classroom. But the glass marble . . . works.’ Her reflection became more substantial when she explained the choice of using different materials and its connection to Newton laws. Through extended discussion, fellows began to unpack their planning and instructional decisions. Similarly, when trying to relate to the designated problem of practice, questioning, the second-grade teacher reflected on his challenges:

... this is tough to tie, this kind of assessment . . . you have to understand before they write words on paper they have to sketch and illustrate. First, they have to sketch it in planning boxes . . . so to ask them to write words now and explain their thinking that’s tough . . . [holds student sample up to camera]. I wish there was something deeper there but um, but you know as an observer what does the student work tell me? It tells me they’re trying . . . they’re doing their best right now, they have limited vocabulary still in second grade but you can see the effort . . . and those that had to record wrote words if they could.

Through reflection, the second grade teacher provided insight to his fellow science teachers about what the learning opportunities are that facilitate elementary science teaching. Sharing the strategies of how second graders can begin to understand what science is, who does science, and how scientists’ work highlights the need for teachers to reflect on their pedagogical content knowledge. Teachers need to reflect on why and how they teach specific ideas the way they do it is through these discussions that teachers continue to build instructional strategies and strengthen their pedagogical content knowledge.

In the above example, the discussion around pedagogical content knowledge led the vertical team to discuss what science teaching looks like across varied grade spans. The purpose of the vertical teams was to support an environment where fellows could discuss and analyze science teaching across various grade levels. The data revealed that teachers were unaware of the conceptual depth of content across different grade levels. For example, during a debrief session of a second-grade physics lesson, one fellow stated, ‘What you got in 2nd grade that I don’t see any more in 7th grade is whenever there was an exciting part of the video your kids would go “ohhh, wahh!” and you prefaced the whole thing with “you are going to hear words that you don’t understand but don’t worry about it, just enjoy the video.”’ A different fellow added a thoughtful suggestion to the same second grade lesson, ‘I would’ve liked the student to kinda predict what would happen. Then when we make formal predictions in 4th grade it wouldn’t be the first time.’ Lastly, in this example the teacher really pondered what happens year to year in science. She stated, ‘And I would love to spend time thinking about what happens between 2nd, 4th, and 7th grade where I start to get student that are scared to raise their hand.’ This debrief session revealed

a lack of understanding of science teaching at different grade spans. As the fellows transitioned and discussed the 7th grade and high school classrooms, the secondary teachers emphasized the need for independence and self-discovery while the elementary teachers were amazed at the level and pace of instruction at the high school.

The vertical nature of the team make-up allowed for natural dialogue around the concept of energy that each teacher was responsible for at his or her grade levels. By having the teachers from multiple grade levels unpack the same concept, the discussions focused on prior learning building blocks and the connections to related concepts, which helped them, see the pattern in the development of ideas. Our finding revealed that working in vertical teams allowed teachers to understand what ‘science’ sounded like, felt like, and looked like in an elementary, middle, and high school classroom.

The fellows further ‘pulled backed the curtain’ to center these conversations of student engagement on a deeper analysis around purposeful planning and instructional choices. When asked by a fellow if conferencing with students is a routine activity, the teacher responded: ‘I’ve been experimenting on that ... I started it last year and I do that for science particularly. One, because when I give them a worksheet, they don’t all fill it out. At the end when it’s time for me to grade it, most half of them is blank. I try to go back and conference with them.’ By removing the initial layer of conferencing with students, this teacher moved to question her own choice of grouping. Essentially, through back and forth questions posed by the group, the teacher determined that to effectively reach all the students in this class through experimentation and conferencing, the grouping must be changed. She reflected,

The thing that I wish I had done differently was grouping ... There were two groups that really could not understand what’s going on. They’re giving me plain and simple, “this is what I saw,” and “this is what happened” and they cannot think deeper into what the concept is. That’s when I combined ... I think you saw in one of the conferences, the two groups got combined together. They’re all girls. They were the ones that were trying to figure out how to put the spool racer back together. One group really did not have, in terms of their level, [she] really needed another student to be with her to start off the discussion further than what we saw.

A different fellow responded to questions by her colleagues during the debrief by describing the frustrations of the simplistic answers her students provided, ‘There were two groups that really could not understand what’s going on. They’re giving me plain and simple [answers] “this is what I saw” and “this is what happened” and they cannot think deeper into what the concept is. That is when I combined groups.’ The fellows continued to suggest strategies and tactics to support this teacher in grouping students and designing probing questions for engagement. Realizing that this is a common problem, the discussion concluded with a brainstorming of strategies that all could use to address simplistic responses.

Conclusion

As highlighted in the literature, teacher leaders have substantial teaching experience and the potential to influence and contribute to their colleagues’ professional practice to continuously improve educational practices (Katzenmeyer and Moller 2001, York-Barr and Duke 2004, Roby 2009). Researchers have found that strong teaching practice alone is not sufficient to make a teacher leader; being a teacher leader entails the increased responsibilities of engaging in discussion around professional practice beyond the classroom (Roby 2009). Teacher leaders begin to understand the value and importance of moving outside of the isolation of their classroom and into a collaborative learning community where they can co-construct meaning with their colleagues through dialogue.

The CoP framework helped reveal to us the importance of an organic community of practice in improving teaching practices from the inside out, where teachers have ownership of their learning and professional development. Providing set vertical teams, structured protocols, and the invitation

to identify a problem of practice prior to teaching limited the fellows' ability to make substantial meaning of the work they were doing within the vertical teams. To be an effective teacher leader and critical friend, fellows must be able to engage in authentic discussions around practice.

We have argued that part of what the science fellows need to develop as teacher leaders within and beyond their classrooms is the ability to reason, reflect, and critically analyze professional practice, and to make well-informed instructional decisions in collaborative contexts. The purpose of engaging the fellows in vertical articulation within the CoP was to provide them with a community in which they could pose questions, analyze their teaching practices, and unpack their experiences together. Their ability to grow as reflective practitioners relied on the interactions that they had with one another. By acting as peer coaches, they were able to nurture a deep and thoughtful analytical lens on their classroom practices. Being a teacher leader cannot be the responsibility of one teacher in isolation. Instead teacher leaders need opportunities to work with partners for instructional change, where they can collaboratively examine practice and provide feedback to one another that extends and improves teaching.

This study offers insight into how to support teachers in becoming teacher leaders who can together engage in discussions around professional practices. Analysis of vertical team conversations suggest that teacher leaders need professional development and guidance about how to critically analyze one another's teacher practice and provide meaningful feedback. We believe that our study's implications also provide insights into how universities and professional development programs can foster collaboration in vertical teams and address the needs of developing teacher leaders as they engage in leadership activities.

As this science teacher leadership fellowship begins to spread to more and more teacher education institutions around the country, we are faced with thinking through the implications of this study for other contexts. In going to scale, one of the tensions that reformers face is how much 'fidelity' versus how much 'adaptation' to include in their program (Xxxx, author, xxxx, 2009). Through the use of a CoP framework, we have begun to realize that the professional work that occurs in a prescriptive CoP with defined structural components reveal a pattern of superficial meaning making around professional practice. As the fellows engaged in the collaborative sessions, their actions were driven by task accomplishment around the structured protocols. To examine teacher leaders' work in vertical teams, it is more useful to use an authentic approach to CoPs, where members who have common interests have opportunities to examine practice through questions that emerge from their classroom teaching (Printy, 2008). This might still involve a protocol to support teachers in identifying a problem of practice, but their focus would emerge from the videoed lessons, rather than a predetermined lens. As described by Wenger (1998), CoPs exist because its members have common understanding and knowledge to share with one another. The social relations between members in CoPs place our fellows as informal leaders who help shape social relations among members to facilitate learning (Wenger 2000). Leadership within the community is emergent and distributed among others outside (Ogawa and Bossert 1995, Pounder *et al.* 1995, McLaughlin and Talbert 2001, Spillane *et al.* 2001). The pseudo communities that we described diminish the stature of teachers and constrain the emergence of their leadership; thus, we have begun to think about how teacher leaders can foster emergent and natural CoPs. Teachers are more likely to incorporate learning into their own practice that occurs in a CoP with which they identify and in which they are fully invested. When the problems were authentic, the discussion was extended and analytical. In essence, teacher's communities emerge where they feel included and vested in the work they deem important. As an implication for scale, we believe it suggests that each additional site has to respond to the local context and needs of their teacher fellows.

These findings have important implications for how our program foster teacher leadership, but also how schools, without a formal professional development program, can nurture teacher leadership. Perhaps one of the challenges faced in the field of teacher leadership is locating from where teacher leadership emerges. From the longitudinal data we have collected from our program, we have noticed that authentically exploring emergent questions together extends

and deepens reflections. The forced structures we put in place for our fellows often limit and constrain their potential. We question whether the superficial nature of the interactions would lessen over time as the group begun to set their own norms and establish trust among its members. We need to create additional sustained and supportive opportunities to model what authentic teaching and learning should look like in collaborative settings. To make a significant impact, we need to better model the analytical process as well as begin to think of ways the fellows can have ownership of establishing their community. We believe that the structured protocols should be provided as a basis for modeling, but that each community must develop their own protocols that are context specific for their intended goals, since what works for one group may not work with another group of fellows.

When community members identify a problem of practice, which the group considers a shared challenge that has been difficult to address alone, they create a common purpose for opening their doors together for deep collaborative work (Keay *et al.* 2014). The emergent secondary problems of practice fellows identified remind us that selecting a problem of practice is not *our* goal, rather being able to address tangible relevant questions that emerge from the classroom is. It appears that having the fellows identify a problem of practice prior to examining practice was not a powerful catalyst for change. This study provides practitioners and policy makers with a model for content-based vertical collaboration that enhances teacher learning. Attention also needs to be paid to creating school cultures that embrace teacher leaders' interactions with a whole continuum of individuals and this may illuminate strategies for how to do this.

Disclosure statement

No potential conflict of interest was reported by the authors.

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