AN ABSTRACT OF THE DISSERTATION OF

Ellen Aster for the degree of Doctor of Philosophy in Science Education presented on June 4, 2019.

Title: Exploring Pedagogical Improvement Strategies Targeting STEM Faculty: Towards Understanding Teaching-Related Conversations and Identities in Community Engagement.

Abstract approved: _____

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There is a national interest in improving the quality of STEM education in institutions of higher education. One goal of multiple initiatives focusing on such improvement is empowering more STEM educators to implement evidence-based instructional practices, that research has shown best help students learn. Related strategies target change in STEM faculty members' teaching-related beliefs/knowledge via various tactics, such as faculty learning communities, wherein faculty collaboratively learn about teaching and find support for making teaching improvements. Although research has suggested that engaging faculty in such learning communities helps STEM faculty explore instructional improvements, little is known about how STEM faculty engage in teaching-related conversations (core to the success of learning communities), including their rationales for engagement and with whom they engage. Furthermore, little is known about how institution-wide instructional improvement opportunities, particularly those using the strategy of creating faculty communities, affect STEM faculty members' conversations around teaching-related topics. An additional consideration for instructional improvement efforts is the professional identities of STEM faculty, or generally

how STEM faculty see themselves in light of professional norms and values. Researchers have suggested that the professional identities of STEM faculty have the potential to be shaped by (as well as shape) STEM faculty members' engagement in instructional improvement efforts. That said, too little research has investigated how engagement in different types of instructional improvement opportunities interact with STEM faculty members' professional identities, including practitioner inquiry groups, one type of faculty learning community wherein faculty collect and analyze data to inform instructional changes. Research is particularly lacking that investigates how fixed-term faculty (i.e., non-tenure track) experience practitioner inquiry in light of their professional identity. This dissertation attends to these research interests by exploring: 1) how STEM faculty engage in teaching-related conversations at an institution of higher education in light of a pedagogical improvement initiative, and 2) how STEM faculty experience practitioner inquiry in light of their professional identities.

The results of these studies offer insight about how working at an institution of higher education influences the experiences of STEM faculty engaged in instructional improvements. Together, both studies illuminate the efforts of STEM faculty who, despite numerous barriers, make efforts to engage in instructional improvement opportunities. In particular, these studies draw attention to the importance of creating safe and inclusive spaces for faculty to collaboratively learn about teaching-related topics of their interest and of relevance to their educative realities. Furthermore, the studies point to the important role administrators play, who have greater positional power than most STEM faculty, in helping to foster and sustain improvement endeavors and faculty learning communities. The results and implications from these studies are important, towards informing ways to provide STEM faculty with meaningful

opportunities to learn about instructional improvements to better help students engaged in STEM coursework succeed.

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Exploring Pedagogical Improvement Strategies Targeting STEM Faculty: Towards Understanding Teaching-Related Conversations and Identities in Community Engagement

by
Ellen Aster

A DISSERTATION

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Presented June 4, 2019
Commencement June 2019

Doctor of Philosophy dissertation of Ellen Aster presented on June 4, 2019

APPROVED:

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Dean of the College of Education

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Ellen Aster, Author

ACKNOWLEDGEMENTS

I am so grateful to the many wonderful and supportive people I have had the great fortune to meet while being a graduate student at Oregon State University. First, I am immensely grateful to my advisor, Dr. Jana Bouwma-Gearhart, for the constant guidance, help, and support with my Ph.D. program, dissertation, and overall growth as a writer and researcher. I am also grateful to my committee members, Drs. SueAnn Bottoms, Milo Koretksy, and Shawn Rowe, who all offered me support and guidance to help me succeed. I also thank my Graduate Council Representative, Dr. Brian Haley, for helping me stay organized and checking in on me. Furthermore, I thank Dr. Kathy Quardokus Fisher for teaching me about social network analyses and supporting my research efforts. I also am grateful for the education-related research collaborations I have had the opportunity to engage in with faculty across Oregon State University, as well as the wonderful instructors I have taught with in the College of Education.

Furthermore, I am grateful to the faculty and students I have met during my time in the College of Education. You have all supported me at various points in my doctoral journey. In particular, I am indebted to the graduate students in the Ph.D. programs in the College of Education: You all helped me feel like I could finish my research, especially on those days when I struggled to feel like I could myself.

I am also grateful to my larger community of family and friends, both near and far. You all helped remind me to take time to enjoy life outside of graduate school. In particular, I am grateful to my roommates, Jenny DiGuillio, Katie Qualls, and Megan Brunner, for loving me even when I completely neglected all of the yardwork on our rental property this spring. Last, I am grateful to my partner, Grant Zoch, who supported me throughout my dissertation work, always with love and delicious cooking. Thank you, thank you, thank you, everyone.

ACKNOWLEDGEMENTS (Continued)

I am also grateful for financial support provided by the National Science Foundation grant DUE 1347817. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

CONTRIBUTION OF AUTHORS

Chapter 2/Study 1: Dr. Jana Bouwma-Gearhart contributed to the research design, preliminary reviews of research results, and writing of this manuscript, particularly with respect to the discussion section. Dr. Kathy Quardokus Fisher also contributed to the research design, review of research results, writing of this manuscript, as well as ran social network analysis software.

Chapter 3/Study 2: Dr. Jana Bouwma-Gearhart contributed to the research design, preliminary reviews of research results, and writing of this manuscript, particularly with respect to the discussion and introduction sections.

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CHAPTER 1 — General Introduction

Motivations for Research Studies

Education experts have called for improvements to STEM education at institutions of higher education (National Academies of Sciences, Engineering, and Medicine, 2016; 2018). Proposed changes include: a) better supporting undergraduate students' learning of STEM concepts and skills; b) making STEM learning environments more accessible and inclusive to diverse undergraduate students; and c) increasing STEM credential holders to grow numbers of STEM professionals (National Academies of Sciences, Engineering, and Medicine, 2018). These goals charge institutions of higher education with the complex task of reforming STEM education, including increasing postsecondary STEM educators' use of evidence-based instructional practices. *Evidence-based instructional practices* consist of teaching techniques (e.g., engaging students in 'active learning' through collaborative activities, doing formative assessments on students' learning, providing undergraduates with research experiences), that research confirms helps with student success and retention. Getting faculty to 'take up' such practices is at the root of many postsecondary STEM improvement initiatives.

There have been numerous and varied improvement initiatives targeting STEM education. In 2011, Henderson, Beach, and Finkelstein reviewed nearly 200 research articles on STEM education improvement efforts in institutions of higher education, finding that initiative change strategies differ in terms of intended outcomes and the aspect of the system to be changed. Specifically, some initiatives intend to achieve prescribed outcomes, meaning the change leaders and/or designers know "upon initiating a change process, what kind of behavior or mental states in individuals or groups are expected and sought, driven by the assumption that [initiative leaders/designers] have the key knowledge needed to define the outcomes"

(Henderson et al., 2011, p. 959). Other initiatives intend to foster emergent outcomes, wherein initiative leaders use faculty knowledge and self-identified needs to inform the purpose, goal, and/or vision of the initiative. Initiatives' means for change include targeting the environments faculty work in, structures faculty work with, and/or faculty members' teaching-related knowledge.

One type of change strategy identified by Henderson et al. (2011) is 'developing reflective teachers.' Henderson et al. (2011) explain that this type of change strategy targets change of faculty members' teaching-related beliefs towards emergent outcomes, or outcomes built off of faculty members' knowledge and experiences. This change strategy composed roughly a third of the articles reviewed by Henderson et al. (2011), indicating that it could be a common change strategy. Initiative leaders using this type of strategy may provide opportunities for STEM educators to engage with others in learning communities, where faculty collaboratively learn about teaching-related topics to expand their teaching-related knowledge and inform instructional improvements (Gast, Schildkamp, & van der Veen, 2017; Henderson, et al., 2011; National Academies of Sciences, Engineering, and Medicine, 2016). Specifically, learning communities are thought of as places where faculty can come together to debate and discuss pedagogy, developing "new (at least new to them) instructional strategies or conceptions" (Henderson et al., 2011, p. 962). It is assumed that faculty participating in these learning communities will learn about new and improved pedagogical practices, becoming leaders and change agents "who can scale up and sustain changes" across the institution (National Academies of Sciences, Engineering, and Medicine, 2016, p. 155).

One type of learning community is a practitioner inquiry program, where faculty meet with program leaders and other faculty to learn about conducting studies on their classrooms,

courses, or programs towards informing instructional improvements relevant to the educational contexts they work in (Bouwma-Gearhart, 2012d; Connolly, Bouwma-Gearhart, & Clifford, 2007; Henderson et al., 2011). Practitioner inquiry has been termed many ways, including 'action research,' 'teacher research,' 'self study,' 'the scholarship of teaching and learning,' 'the use of teaching as a context for research,' 'teaching-as-research,' 'classroom assessment,' 'classroom research,' 'action learning,' 'classroom action research,' 'scientific teaching,' 'research-led teaching,' and 'teaching-based research' (Bouwma-Gearhart, 2012d; Cochran-Smith & Lytle, 2009; Connolly et al., 2007). Generally, faculty engaged in practitioner inquiry: a) formulate a research question about their teaching practice; b) create a research plan that builds off previous knowledge; c) implement a research plan, studying changes to answer the research question (i.e., gather and analyze data); d) reflect on findings to inform pedagogical changes and potential need for further inquiry; and g) organize and share results (Connolly et al., 2007).

Although faculty learning communities, and practitioner inquiry learning communities specifically, are generally considered effective methods for fostering STEM faculty members' instructional improvements, research on STEM faculty engagement in this type of change strategy is still an emerging area of study. My two dissertation studies contribute to this growing area of research and provide suggestions for stakeholders (e.g., initiative designers, leaders, administrators) engaged in improvement efforts, particularly those efforts seeking the development of reflective practitioners via faculty communities and practitioner inquiry.

Motivation for study 1 (chapter 2). Improving communication amongst faculty about teaching-related topics, and engaging faculty in teaching-related discussions, are goals of many improvement efforts towards fostering collaborative learning around instructional improvements

(Bouwma-Gearhart, 2012c). Research on how STEM faculty engage in teaching-related conversations, particularly in light of instructional improvement efforts that develop faculty communities, is still an emerging area of study. Previous research has used social network analyses to: a) demonstrate how teaching-related ideas might spread through STEM units (Henderson et al., 2018); b) help identify who STEM faculty talk with towards finding potential leaders of change efforts (Quardokus & Henderson, 2015; Knaub, Henderson, & Quardokus Fisher, 2018); and c) understand what teaching-related topics STEM faculty talk about (Quardokus Fisher, Sitomer, Bouwma-Gearhart, & Koretsky, 2019). Also, we have some indication of factors that influence STEM faculty members' engagement in postsecondary STEM reform endeavors (Bouwma-Gearhart, 2012a) and what motivates science and engineering faculty to engage in teaching professional development (Bouwma-Gearhart, 2012b). Furthermore, we have knowledge about what features constitute meaningful and effective teaching professional development for science faculty (Bouwma-Gearhart, 2012c). However, still relatively little is known about how STEM faculty specifically engage in conversations with others about teaching-related topics and well as how those conversations are influenced by improvement initiatives developing faculty communities. My first paper responds to this gap in the literature, exploring how STEM faculty engage in teaching-related conversations in light of an institution-wide, comprehensive STEM education improvement initiative.

Motivation for study 2 (chapter 3). Brownell and Tanner (2012) have suggested that instructional improvement efforts for science faculty may not always be successful due to science faculty members' *professional identities*, or how they "view themselves and their work in the context of their disciplines and how they accrue status among their professional colleagues as academic scientists" (p. 341). This is likely true for faculty across the STEM disciplines,

especially those who work at institutions of higher education where the identity of being a 'researcher' might be privileged over being an 'educator' (Robert & Carlsen, 2017). STEM faculty engaged in practitioner inquiry, specifically, may feel their professional identities challenged, since practitioner inquiry work may involve engaging in unfamiliar and new practices. For example, previous research has suggested STEM faculty engaged in practitioner inquiry might struggle with the perceived subjective nature of practitioner inquiry research (Miller-Young, Yeo, & Manarin, 2018), collecting qualitative data from human subjects (Marquis et al., (2017), and, overall, the "immersion in a different intellectual language and culture, experiential learning, personal reflection[,] and [the] iterative process of moving backwards and forwards between the familiar STEM approach and a different way of thinking" (Kelly, Nesbit, & Oliver, 2012, p. 4). Although this previous research has pointed to these potential tensions for STEM faculty engaged in practitioner inquiry work, more research is warranted to better understand how STEM faculty experience practitioner inquiry work in light of their professional identity. Specifically, we need more research exploring how fixed-term STEM faculty (e.g., instructors) experience practitioner inquiry in light of their professional identity. Thus, my second study focuses on understanding STEM faculty members' experiences in a practitioner inquiry program in light of their professional identity. Similar to the focus in my first study, this particular practitioner inquiry program was one of the communities created and sustained by an institution-wide, comprehensive STEM education improvement initiative.

Research Questions

My two manuscripts are guided by research questions seeking to understand STEM faculty members' teaching-related experiences at an institution of higher education, including

their engagement in instructional improvement opportunities fostered by an institution-wide change initiative. These research questions are:

1. How do STEM faculty engage in teaching-related conversations within the context of an institution of higher education with an ongoing teaching improvement initiative?
2. How do STEM faculty experience practitioner inquiry in light of their professional identity?

All faculty research participants, in both studies, worked at the same institution of higher education classified by the Carnegie Classification of Institutions of Higher Education (n.d.) as a *doctoral university with the highest research activity*. This institution of higher education recently enacted a comprehensive STEM education improvement initiative. The initiative, which was implemented in early 2014, intended to foster instructional changes by leveraging the distributed teaching-related expertise of tenure-track and fixed-term faculty across targeted STEM departments. Specifically, the initiative attempted to support and foster communities within and between units where STEM faculty could share and learn about evidence-based instructional practices. Evidence-based instructional practices encouraged by the initiative included interactive engagement of students during class, promoting student collaboration and cooperative learning, and using frequent formative feedback to inform students' learning and instruction; yet faculty who engaged in the initiative were also encouraged to propose topics of interest to focus on in initiative-supported activities. Communities supported by the initiative included: a) an elective practitioner inquiry program, where STEM faculty conducted small scale (i.e., classroom-, course-, or program-based) research projects to inform teaching improvements; b) an undergraduate learning assistant program, where undergraduate students learned about pedagogy and applied that understanding to help peers learn STEM concepts; c) larger socials

three times a year, open to all faculty, to discuss relevant teaching-related topics; and d) regular meetings between initiative designers/leaders and unit faculty.

My first study uses both quantitative and qualitative methods to answer the first research question, or *How do STEM faculty engage in teaching-related conversations within the context of an institution of higher education with an ongoing teaching improvement initiative?* My coauthors (Drs. Jana-Bouwma-Gearhart and Kathy Quardokus Fisher) and I used analyses of interviews with STEM faculty and analyses of the social networks STEM faculty use to talk about teaching-related topics to understand how STEM faculty engage in teaching-related conversations. Specifically, this study reports on why STEM faculty engage in conversations about teaching-related topics, how a pedagogical change initiative influenced STEM faculty members' engagement in teaching-related conversations, and how STEM faculty conversation networks changed over the life of an initiative. It concludes with suggestions for those designing and implementing instructional improvements opportunities for STEM faculty, particularly those using the strategy of faculty learning communities.

My second study is guided by my second research question, or *How do STEM faculty experience practitioner inquiry in light of their professional identity?* Specifically, my coauthor (Dr. Jana Bouwma-Gearhart) and I used qualitative analyses of interviews with STEM faculty (largely fixed-term faculty) engaged in a practitioner inquiry program to understand how they experienced practitioner inquiry in light of their professional identity. As mentioned above, this practitioner inquiry program was created by an institution-wide, comprehensive STEM education improvement initiative. Like the aforementioned study, this study provides considerations for those designing and facilitating practitioner inquiry programs for STEM faculty.

Theoretical Frameworks and Ontological and Epistemological Perspectives

I utilize two different analytical frameworks to orient my analyses. In my first study, I use second-generation cultural-historical activity theory, advanced by Engeström (2009), Leont'ev (1981), and Foot (2014), as a heuristic tool to explore how the contexts STEM faculty work in influence their engagement in teaching-related conversations. Cultural historical activity theory usefully illuminates rules, community members, roles, tools, and objects that potentially influence and explain STEM educators' engagement in the 'activity' of teaching-related conversations. Cultural-historical activity theory also helps locate 'tensions' in the activity system, or pieces of the activity system that are at odds with each other towards fostering STEM faculty members' engagement in teaching-related conversations. Elucidating these tensions can help raise awareness of aspects that can be changed to help STEM faculty engage in teaching-related conversations.

In my second paper, I use Gee's (2001) analytic lens of identity to explore how STEM faculty experience practitioner inquiry in light of their professional identity. This orientation draws attention to how professional identity is shaped by STEM faculty and the way they are recognized in the contexts they work in. Specifically, Gee (2001) provides a topology of four different identity perspectives, including nature-identity, institution-identity, discourse-identity, and affinity-identity, that illuminate subtleties in how professional identities gain power and/or significance via different forms of recognition. This framework also usefully draws attention to how power is imbued in different identities in varying contexts, which helps explain how different facets of STEM faculty members' professional identities are recognized, to different extents, in the hierarchical environment of an institution of higher education.

Overall, my research is guided by the paradigm, or worldview, of constructivism (Creswell, 2014). Specifically, I am guided by a social constructivist perspective, which suggests that people, throughout their lives and work, construct subjective meanings shaped by society and history (Creswell, 2014). Because meaning differs from person to person, as a researcher I strive to understand the breadth (i.e., variability) of multiple participants' experiences. As a researcher, these epistemological and ontological considerations mean it is important for me to study participants' experiences rooted in the contexts they live and work in, with attention to how culture and history shape participants' diverse constructions of meaning.

Although my papers are influenced by a social constructivist perspective, they are also shaped by a pragmatic approach (Morgan, 2007). By 'pragmatic approach' I mean I acknowledge I never completely use inductive methods or deductive methods to study participants' experiences, but rather use abductive reasoning wherein I move "back and forth between induction and deduction" to answer my research questions (Morgan, 2007, p. 71). Additionally, I acknowledge that I "work back and forth between various frames of reference," meaning my research embraces both subjective and objective approaches, or uses an *intersubjective* approach (Morgan, 2007, p. 71). Last, I do not adopt the perspective of research as either being wholly locally-applicable if informed by qualitative methods or wholly generalizable if informed by quantitative methods: Rather, I believe research has a certain *transferability* to different contexts, in that it has the potential to provide important implications based on readers' assessments of my study context and how well I have communicated my claims (Morgan, 2007). My employment of a pragmatic approach becomes most apparent, perhaps, in my first study, where I use both qualitative and quantitative methods to "emphasize the research problem and use all approaches available to understand the problem" (Creswell,

2014, p. 10). Qualitative and quantitative methods, I argue, help me more robustly explore my research interest in this study.

Significance of the Dissertation

Ultimately, my research informs various stakeholders interested in STEM faculty members' experiences in teaching improvement opportunities. My research might be particularly useful to initiative designers and leaders intending to develop emergent outcomes by building off the knowledge and beliefs of STEM educators, via faculty engagement in learning communities and practitioner inquiry opportunities.

My first study uses interviews with STEM faculty, as well as quantitative analyses on the networks they use to talk about teaching-related topics, to understand how they engage in teaching-related conversations. This study identifies system tensions that might inhibit teaching-related conversations. For example, STEM faculty members may have great autonomy with respect to teaching practices and work in a community consisting of faculty variably interested in talking about teaching improvements, which might be a factor inhibiting those disinterested in improving their teaching to engage in teaching-related conversations. Also STEM faculty may have varied levels of support to engage in teaching-related conversations, from their institution, units, or as manifested in their professional positions: If faculty perceive that engaging in teaching-related conversations is not supported in their workplace contexts or in their roles, they may decide not to engage in teaching-related conversations. Finally, STEM faculty may be inhibited to engage in teaching-related conversations if they are afraid to confess a lack of teaching-related knowledge or if they perceive their contributions as not being listened to because they have a gender underrepresented in STEM/academia. We also consider how these tensions may manifest in the networks representing who STEM faculty talk to about teaching-

related topics, which generally became more interconnected over the life of an instructional improvement initiative.

The results from this study illuminate recommendations for stakeholders involved in the construction and support of faculty learning communities, where faculty can talk and learn about teaching-related topics towards informing instructional improvements. Specifically, we suggest that initiative leaders and designers consider creating opportunities where faculty can talk with community members across the institution, particularly connecting those faculty interested in engaging in conversations about teaching improvements. Any discussions about teaching-related topics should be inclusive and safe to help faculty feel like they can air real teaching-related concerns and insights to respectful and responsive listeners. Our study also shows that STEM faculty members may have a diverse array of teaching-related interests, which suggests it is particularly important for stakeholders hoping to engage faculty in teaching-related conversations to build off faculty members' varied interests and teaching-related knowledge. Those hoping to foster new faculty learning communities might also consider working with members across the institution, such as administrators and STEM faculty, to understand the diverse instructional improvement opportunities STEM faculty may already take part in. Finally, our study echoes the results of prior research in that it draws attention to the potential importance of administrative support towards fostering and sustaining opportunities for faculty to talk with others about teaching-related topics.

My second study analyzed interviews with STEM faculty, largely fixed-term faculty, engaged in practitioner inquiry to understand how they experience practitioner inquiry in light of their professional identity. The results suggested that many participants sought to use their practitioner inquiry experience to broaden their professional identities towards including 'scholar

of education,' which might include research expertise more respected by the research-intensive institution within which they worked. Participants also provided information to suggest that their scholar of education identities were shaped by their disciplinary notions of research and methods. Furthermore, this study suggests that participating in a supportive group of STEM faculty, collaboratively learning practitioner inquiry, helped STEM faculty grow into scholars of education.

These results suggest implications for those leading and designing practitioner inquiry programs. Specifically, our study points the importance of engaging participants in lessons on the differences and nuances concerning practitioner inquiry and other forms of inquiry as well as helping STEM faculty learn about methodologies relevant to their projects and research goals. Our study also suggests that practitioner inquiry programs and designers consider leveraging the motivations of practitioner inquiry participants, who might be specifically interested to participate towards engaging in research and building identities as scholars of education. Practitioner inquiry program leaders and designers might also consider engaging STEM faculty in practitioner inquiry groups, that bring faculty together who are interested in doing practitioner inquiry from across the institution, as well as work with administrators towards conferring recognition to STEM faculty engaged in practitioner inquiry.

In the Conclusions chapter, I look across the studies' findings and associated stakeholder recommendations to communicate general findings related to STEM faculty experiences in instructional improvement opportunities, particularly those using the strategy of faculty learning communities. I also make recommendations for future research inspired by my dissertation work, that might importantly continue to contribute to our knowledge of how STEM faculty engage in instructional improvement in light of their workplace realities.

CHAPTER 2 — First Manuscript

Contextualizing and Configuring Communities: Exploring How STEM Faculty Engage in Teaching-Related Conversations in Light of a Teaching Improvement Initiative

Ellen Aster, Jana Bouwma-Gearhart, & Kathy Quardokus Fisher

Introduction

National education researchers and experts have called for improvements to STEM education, including that offered at institutions of higher education (National Academies of Sciences, Engineering, and Medicine, 2016; 2018). Proposed changes include: a) better supporting undergraduate students' learning of STEM concepts and skills; b) making STEM learning environments more accessible and inclusive to diverse undergraduate students; and c) creating more STEM professionals by increasing STEM credential holders (National Academies of Sciences, Engineering, and Medicine, 2018). These changes charge institutions of higher education with the complex task of reforming STEM education, including increasing postsecondary STEM educators use of evidence-based instructional practices. *Evidence-based instructional practices* consist of teaching techniques (e.g., engaging students in 'active learning' through collaborative activities, doing formative assessments on students' learning, providing research experiences) which research has shown help students learn. Getting faculty to 'take up' such practices is at the root of many postsecondary STEM improvement initiatives.

There have been numerous and varied improvement initiatives targeting STEM education. Henderson, Beach, and Finkelstein (2011) reviewed nearly 200 research articles on STEM improvement efforts in institutions of higher education to understand initiatives' commonalities and differences. Henderson et al. (2011) found that change strategies differ in terms of the outcomes they seek to create and the aspects they seek to change. Specifically, some initiatives intend to achieve prescribed outcomes, via (for example) implementing 'top-down' policies to promote/enforce teaching changes or disseminating novel teaching techniques for faculty to 'take up.' Other initiatives intend to foster emergent outcomes, wherein initiative leaders use faculty knowledge to inform the purpose, goal, and/or vision of the initiative and

teaching-related improvements. Initiatives also focus on changing different aspects of the system: Some initiatives seek to change the environment educators work in and/or structures faculty work with, while other initiatives try to enhance faculty members' teaching-related knowledge and/or beliefs about student learning.

One oft-cited tactic for fostering emergent outcomes, focused on changing faculty members' teaching-related beliefs, is engaging faculty in 'learning communities' (Bouwma-Gearhart, 2012c; Henderson et al., 2011), 'faculty development networks' (National Academies of Sciences, Engineering, and Medicine, 2016), or 'faculty teams' (Gast, Schildkamp, & van der Veen, 2017). This category of change strategy, which we broadly refer to as 'faculty communities,' focuses on creating opportunities for faculty to collaboratively learn and "use their own knowledge/experience/skill to improve their instructional practices" (Henderson et al., 2011, p. 962). It is argued that creating opportunities for faculty to connect with others will help faculty expand their teaching-related knowledge and change their teaching practices.

In fact, previous research has demonstrated that creating opportunities for STEM faculty to connect with others confers a variety of benefits. For example, fostering workplace communities creates vital spaces for educators to share pedagogical techniques and perspectives (Coldron & Smith, 1999; Gast et al., 2017) and can foster changes to faculty members' pedagogical knowledge, teaching approaches, and teaching identity (Gast et al., 2017). Creating opportunities for STEM faculty to specifically connect with administrators can help create more 'congruent' units (e.g., departments, schools), where administrators and faculty share beliefs about teaching (Wright, 2008). Additionally, creating opportunities for STEM educators to connect with others has been shown to motivate faculty in large-scale (e.g., national) change

initiatives “to continue to reform in the face of departments and institutions that may not be supportive” (Kezar, Gehrke, & Bernstein-Sierra, 2017, p. 232).

However, despite the prevalence of faculty communities/networks as a change strategy and research-documented benefits, relatively little is still known about how STEM faculty engage in teaching-related conversations, including why they engage in them and with whom they engage. In particular, investigation of STEM faculty engagement in teaching-related conversations at institutions of higher education undergoing teaching improvement initiatives is very much an emerging area of research. What little research exists in this area has pointed to the usefulness of social network analyses in illuminating the networks STEM faculty use to talk with others about teaching-related topics. For example, social network analyses can suggest how teaching-related ideas spread through STEM units targeted by improvement initiatives (Henderson et al., 2018) and can show who STEM faculty talk with towards identifying potential leaders of change efforts (Quardokus & Henderson, 2015; Knaub, Henderson, & Quardokus Fisher, 2018). Furthermore, social network analyses can show what teaching-related topics STEM faculty, of different professional positions, talk about (Quardokus Fisher, Sitomer, Bouwma-Gearhart, & Koretsky, 2019). That said, we still lack studies that contribute to our understand of why faculty engage in conversations about teaching-related topics, as well as how these conversations are potentially influenced by the contexts faculty work in and teaching improvement efforts. Specifically, we need more studies that utilize interviews with STEM faculty to help us more deeply understand faculty members’ rationales for engaging in teaching-related conversations as well as how those are affected by initiatives using faculty communities as a strategy for instructional change.

In light of this need, our study takes a systems-level approach to exploring how STEM faculty engage in teaching-related conversations within the context of an institution of higher education with an ongoing teaching improvement initiative. We combine social network analyses with interviews with STEM faculty to explore how teaching-related discussion networks change over the life of an initiative and what factors potentially influence STEM faculty members' engagement in teaching-related conversations. Our results help us communicate recommendations for stakeholders involved in the construction and support of faculty communities, where faculty have opportunity to collaboratively learn teaching-related topics towards informing instructional improvements.

Theoretical Perspective

We employ cultural-historical activity theory, which stems from the work of Vygotsky (1978), to focus our attention on how working in a community at an institution of higher education influences STEM faculty members' engagement in teaching-related conversations. Specifically, we employ second-generation cultural-historical activity theory (Engeström, 2009; Leont'ev, 1981), which orients our analysis to the 'activity' of teaching-related conversations. *Activities* are collective actions shaped and defined by the multivoicedness of those involved (Engeström, 2009; Foot, 2014). Activities are also shaped by culture, in that all human actions are affected by "cultural values and resources," as well as history, since "cultures are grounded in histories, and evolve over time" (Foot, 2014, p. 3). Specifically, we employ second-generation cultural-historical activity theory as a heuristic tool for exploring potential contributors to STEM faculty members' engagement in teaching-related conversations as well as help us identify how an initiative has influenced teaching-related conversations.

According to second-generation cultural-historical activity theory, collective activity can be studied via *activity systems* (Engeström, 2014). Activity systems have six interacting components (Figure 1.1). The first component in an activity system is the *subject,* or the actor(s) engaged in the activity. Subjects utilize *tools* to facilitate action towards the *object* of the activity system. The object can be described by different facets: It is "a thing-to-be-acted-upon," an *objectified motive* (which describes why the object is interacted with), and a *desired outcome* (which describes the intent from interacting with the object) (Foot, 2014, p. 10). For example, a STEM faculty member (i.e., a subject) might use Skype (i.e., a tool) to talk with a colleague to align course content between their courses (i.e., their desired object).

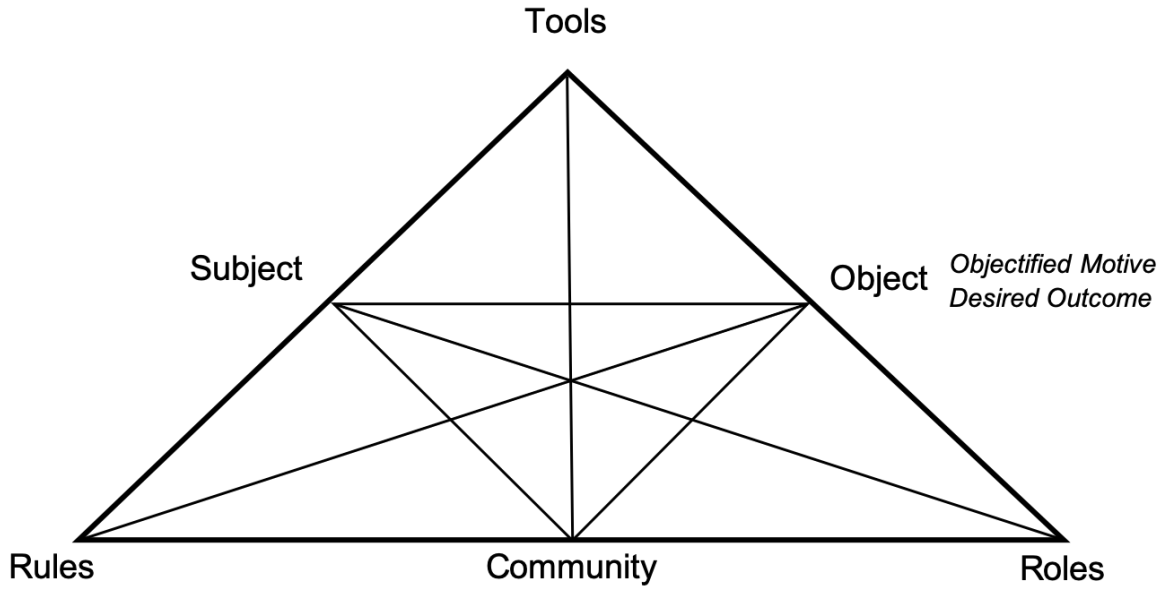

Figure 1.1. A representation of the components in an activity system, as well as their connections. This figure is based on conceptualizations of second-generation cultural-historical activity theory in Engeström (2014) and Engeström (2009).

The *community* of an activity system consists of the people in the activity who "share with the subject an interest in and involvement with the same object" (Foot, 2014, p. 6). For example, STEM faculty work with other members in an institution of higher education, including administrators, faculty of various positions (e.g., associate professors, assistant professors, professors, and instructors), and students (e.g., undergraduates and graduate students). These community members might shape the 'activity' of teaching-related conversations, since they may have different levels of interest in and/or incentive to engage in teaching-related conversations.

Rules also shape action within the activity system. For example, STEM faculty may believe it is part of their job to publish and communicate disciplinary-specific research but not part of their job to talk with others about teaching-related topics. This 'rule' might stem from official promotion and tenure guidelines, which might place an emphasis on research over teaching. It might also be more implicit, such as STEM faculty perceiving that engaging in teaching-related conversations is out of the 'norm' and, thus, this activity should not be engaged in.

Work is also differentially divided amongst community members, resulting in a division of labor or different *roles* for community members. For example, tenure-track STEM faculty might be expected to conduct discipline-specific research whereas tenure ineligible (e.g. fixed-term) faculty might be expected to deliver more teaching. Faculty who are assigned more teaching responsibilities may engage in more teaching-related conversations, since teaching is a larger portion of their official positions.

In an activity system, "contradictions, conflict, and breakdowns in coordination" can surface (Foot, 2014, p. 16). For example, in a capitalist society there always exists the fundamental contradiction of "everything and everyone as both having inherent value and being

an exchangeable commodity within market-based socioeconomic relations" (Foot, 2014, p. 21). For example, an institution of higher education provides education to students to both help them learn as well as to generate income. Contradictions in an activity system can also occur when components in the activity system, such as the rules and roles, are at odds (Engeström, 2014). For example, both tenure-track and fixed-term STEM faculty might want to engage in teaching-related conversations, but a departmental 'rule' exclude fixed-term faculty from unit meetings that end up being relevant to teaching and learning. This suggests a contradiction between the 'rules' for engagement in unit meetings and the community members invited to participate in meetings. Contradictions are inherent to activity systems and, when made explicit, provide opportunities to address tensions inhibiting activity (Foot, 2014).

We use cultural-historical activity theory to help us explore how STEM faculty engage in teaching-related conversations, particularly why they engage in teaching-related conversations and how those conversations might be affected by an institution-wide, teaching improvement initiative. Specifically, cultural-historical activity theory orients our attention to the ways components of the activity system potentially influence faculty connections with community members in the 'activity' of teaching-related conversations. It also helps us identify tensions in the activity system, which help us informatively suggest improvements to better foster faculty members' teaching-related conversations.

Methods

Research Questions

Our research is guided by the larger question, *How do STEM faculty engage in teaching-related conversations within the context of an institution of higher education with an ongoing teaching improvement initiative?* Specifically, we explore the following three subquestions:

1. Why do STEM faculty, at an institution of higher education, engage with community members around teaching-related topics? Specifically, what components of the activity system potentially influence STEM faculty engagement in the 'activity' of talking about teaching-related topics?
2. How has a pedagogical change initiative influenced STEM faculty engagement in teaching-related conversations? Specifically, how has an initiative influenced STEM faculty engagement in the 'activity' of talking about teaching-related topics?
3. How have STEM faculty networks, used to talk about teaching-related topics with community members, changed over the life of an initiative?

We use both quantitative and qualitative methods to answer these research questions. We pause for a moment here to note our distinction between quantitative and qualitative 'methods' and quantitative and qualitative 'methodologies.' Specifically, quantitative and qualitative *methods* are the "techniques for collecting data" and quantitative and qualitative *methodologies* are "paradigmatically different ontological and epistemological assumptions" (Twining, Heller, Nussbaum, & Tsai, 2016, p. A2). While some have argued that it is impractical to mix quantitative and qualitative *methodologies*, since they stem from different assumptions about reality (i.e., epistemologies) and knowledge (i.e., ontologies), others have made the case for the practicality of mixing quantitative (i.e., numerical) and qualitative (i.e., non-numerical) methods per the nature of research questions (Twining et al., 2016). Although our study is rooted in a constructivist worldview, in that we acknowledge our participants experience differing, subjective realities and we seek to capture the array of their experiences, our study is also guided by a pragmatic approach. Specifically, we argue that using both qualitative and quantitative

methods allows us to develop a more robust understanding of how STEM faculty engage in teaching-related conversations (Creswell, 2014, p.).

We use both numerical data (from social network analyses) and non-numerical data (interview text and survey data of who STEM faculty talk about teaching-related topics with) to answer our research subquestions. We analyze interview data to explore why faculty engage in teaching-related conversations, as well as how an initiative has influenced their engagement in teaching-related conversations. Specifically, interview analyses provide rich descriptions of how STEM faculty rationalize engagement in teaching-related conversations. We also use non-numerical survey data to identify who STEM faculty talk about teaching-related topics with. However, analysis of a list of people STEM faculty talk with provides limited information about how the social relationships, or networks, of faculty discussions creates a larger structure of ties among community members as well as how networks have changed over time. To explore this interest, we converted non-numerical survey data into numerical data via social network analyses, which helped us better and more easily understand how interconnected faculty are in the community is as well as how the network changed. As argued by Hollstein (2011), pairing social network analyses with qualitative interview analyses valuably generates an "understanding of how networks matter" and "what mechanisms and conditions figure in when producing certain network outcomes" (p. 408). In other words, pairing social network analyses with information from interviewees helps us infer why participants talk with others about teaching-related topics and how their rationales relate to the structure of their social networks.

Thus, we use qualitative and quantitative methods towards robustly exploring STEM faculty engagement in conversations around teaching-related topics. While our research question, and research subquestions, could arguably have been explored using just interviews, we contend

that using social network analyses (i.e., generating numerical data) on who STEM faculty talk with (i.e., non-numerical data) helps us understand the extent faculty social networks are interconnected and how their social networks have changed over the life of an initiative.

Participant Sample and Research Setting

The participants in this study were fourteen STEM faculty members. All participants worked at an institution of higher education classified by the Carnegie Classification of Institutions of Higher Education (n.d.) as a *doctoral university with the highest research activity*. Participants worked in both colleges, and five out of the seven units (i.e., departments or schools) targeted by a large-scale (i.e., multi-unit) change initiative to improve teaching in large-enrollment, first- and second-year STEM courses. Our participants consisted of 6 tenure-track faculty and 8 fixed-term (tenure-ineligible) faculty. In interviews, participants indicated varied involvement in the initiative including: a) little to no involvement; b) attending one or more initiative-related events; c) participating in a practitioner inquiry program; and d) involvement in the planning and unit-specific implementation of the initiative. Table 1.1 lists participant pseudonyms, participants' professional positions, and participants' indicated involvement in the initiative. We specifically list pseudonyms that are gender-neutral, since gender was not a construct explored in this study and we do not want to make assumptions about participants' gender identities.

The initiative, which began in early 2014, intended to foster instructional changes by leveraging the distributed expertise of tenure-track and fixed-term faculty across targeted STEM units. Specifically, the initiative attempted to support and foster communities, both within and between units, where STEM faculty could share and learn about evidence-based instructional practices. Evidence-based instructional practices encouraged by the initiative included interactive

Table 1.1

List of Participants' Pseudonyms, Participants' Professional Positions, and Participants' Involvement in the Initiative

Participant		Professional Position	Initiative Involvement
Unit A			
	Avery	Tenure Track Faculty	● Initiative planner/implementer ● Attended initiative-related event(s)
	Alexis	Fixed-Term Faculty	● Attended initiative-related event(s) ● Practitioner inquiry program participant
Unit B			
	Blake	Tenure Track Faculty	● Initiative planner/implementer
	Blair	Fixed-Term Faculty	● Initiative planner/implementer ● Practitioner inquiry program participant
	Bowie	Fixed-Term Faculty	● Attended initiative-related event(s) ● Little to no involvement
	Briar	Fixed-Term Faculty	● Attended initiative-related event(s) ● Practitioner inquiry program participant
Unit C			
	Charlie	Fixed-Term Faculty	● Initiative planner/implementer ● Attended initiative-related event(s) ● Practitioner inquiry program participant
Unit D			
	Dallas	Fixed-Term Faculty	● Initiative planner/implementer
	Dakota	Fixed-Term Faculty	● Initiative planner/implementer ● Practitioner inquiry program participant
	Drew	Tenure Track Faculty	● Attended initiative-related events ● Practitioner inquiry program participant
	Dana	Tenure Track Faculty	● Little to no initiative involvement
	Dane	Fixed-Term Faculty	● Little to no initiative involvement
Unit E			
	Ellery	Tenure Track Faculty	● Attended initiative-related event(s)
	Elliott	Tenure Track Faculty	● Little to no initiative involvement

engagement of students during class, promoting student collaboration and cooperative learning, and using frequent formative feedback to inform students' learning and instruction. Faculty who were engaged in the initiative were also encouraged to propose topics of their interest to focus on in initiative-supported activities. Communities supported by the initiative included: a) an elective practitioner inquiry program, where STEM faculty conducted small scale (i.e., classroom-based) research projects to inform teaching improvements; b) an undergraduate learning assistant program, where undergraduate students learned about pedagogy and applied that understanding to help peers learn STEM concepts; c) larger socials three times a year, open to all faculty, to discuss and learn relevant teaching-related topics; and d) regular meetings between initiative designers/leaders and unit faculty.

Data Collection

The data used in this paper are part of a larger dataset collected for research and evaluation on the initiative. For this paper, we use data from interviews with STEM faculty, concerning their teaching experiences and perceptions, as well as data from two social network surveys concerning STEM faculty members' conversations about teaching-related topics. Data from the fourteen STEM faculty who completed interviews and the two social network surveys (early- and late- project) are the basis for this study.

Interviews. We developed a semi-structured interview protocol to understand faculty members': a) position at the institution; b) classes taught; c) teaching responsibilities; d) autonomy with respect to teaching-related decisions; e) interactions with others around issues of teaching and learning; f) engagement with/in the initiative; g) changes to teaching practices; h) student assessment practices; i) notions of what constitutes a 'successful student'; and j) thoughts about the initiative's goal of widespread improvement to teaching practices and learning

outcomes as well as the initiative's change strategy of fostering interactions with other faculty. A copy of the interview protocol can be found in Appendix A.

In determining which faculty to invite for interviews, we considered faculty members' participation in initiative-related events, opportunities, or other on-campus evidence-based instructional events and involvement in unit teaching-related decisions. Nineteen out of twenty-one faculty invitees consented to interviews (90% response rate). Staff from a research corporation conducted the interviews in the spring of 2017, approximately three years after the initiative was first implemented.

Surveys. STEM faculty were sent a five-scale survey asking about their: 1) background information (e.g., years teaching experience, years at the institution of higher education, teaching assignments, hours spent on teaching-related tasks); 2) teaching practices (e.g., lecture, active learning, cooperative learning); 3) conversations with others around teaching-related topics; 4) teaching beliefs (identity as a teacher and/or researcher, confidence and activities related to teaching and teaching improvement); and 5) perceptions of unit climate related to teaching (e.g., sharing materials, discussing challenges amongst coworkers). The survey was completed in the fall of 2014, shortly after the initiative was first funded and again in the spring of 2017, approximately three years after the initiative started. STEM faculty (administrators, tenure-track, and fixed-term faculty) who worked in a STEM unit targeted by the initiative were identified via unit webpages and sent an invitation to participate in the survey[1]. Specifically, 141 of 262 invited

[1] The first survey also invited three postdocs from one department, because they were instructors of record for lower-division STEM courses.

STEM faculty completed the 2014 survey (response rate of 54%)[2] and 123 out of 329 faculty completed an identifiable[3] 2017 survey (response rate of 37%).

Results of the 2014 and 2017 social network sections of this larger survey are used in this study. Specifically, this social network section asked faculty to list up to 10 people they talk to (hereafter referred to as 'discussants') about teaching-related topics. If the discussant did not work at the institution of higher education, participants were asked to indicate the discussant's affiliation. Then, participants were asked follow-up questions about each discussant, including: a) the discussant's primary relationship to the faculty member; b) the highest frequency of interaction with the discussant over the course of a typical university term; c) the teaching-related topics talked about with the discussant; d) perception of the discussant's expertise with respect to teaching and learning; and e) comfort level with the discussant. To view the social network instrument used on the 2014 and 2017 survey, see Appendix B.

Data Analysis

Data analyses for this project were conducted in iterations of interview analyses and social network analyses. This gave us the opportunity to compare emerging inferences from social network analyses and emerging themes, or codes, from the interviews. The authors met regularly to discuss interview and survey analyses, brainstorming how each set of data offered information to help us understand how participants engaged in teaching-related conversations.

Interview Analysis. To understand why STEM faculty engage with community members around teaching-related topics, the first author coded transcripts using the open coding methods

[2] This count does not include the three postdocs, two of whom completed a 2014 survey and one who was invited, but did not complete, a 2014 survey.

[3] In total, 129 surveys were filled out in 2017. However, two surveys were not identifiable (the participants indicated no affiliated unit and did not identify themselves) and three surveys were completed by a faculty member who had already completed a survey. Additionally, one survey was completed by a postdoc, and thus removed from this study.

described in Auerbach and Silverstein (2003). Specifically, the first author read through transcripts, highlighting sections of *relevant text*, or text thought to help clarify why STEM faculty might engage in teaching-related conversations as well as how an initiative influenced engagement in teaching-related conversations. Relevant text was compiled and sorted into *repeating ideas*, or emergent codes. After emergent codes had been developed, the first author shared coding thoughts and categories with the two other authors for comments and edits. This *peer debriefing* allowed authors to check the first author's coding work, towards adding validity to our findings (Creswell, 2014). Authors' different interpretations from this preliminary round of coding were collaboratively discussed and resolved.

The first author then started a second round coding in the Dedoose analysis platform. The first author again read all interview transcripts and, keeping in mind the emergent codes constructed during prior coding work, re-sorted/grouped textual excerpts under previously developed codes, amended codes, or created new codes. This second round of coding, and resultant codes, were discussed again with co-authors to reduce risk of missed codes or analysis bias. As before, all authors discussed and resolved differing interpretations of codes.

After codes were finalized from this second round of coding, we then began considering our results in light of cultural-historical activity theory. The first author created memos, discussed with the other authors, and drew diagrams to keep track of, and explore, how codes related to the components (i.e., rules, etc.) of second-generation cultural-historical activity theory. This helped illuminate how cultural-historical activity theory could be used as a heuristic tool to organize results as well as help explore how activity system components (e.g., rules, etc.) potentially influence teaching-related conversations.

While coding, three main decisions were made about what excerpts to include in the final codebook, which included code names, definitions, and excerpts used to build and define codes. First, excerpts about teaching undergraduates, such as giving undergraduates formative or summative feedback or helping students in office hours, were not included. While this might broadly constitute 'engaging' in teaching-related conversations, we dubbed these scenarios more akin to teaching tasks and, therefore, less useful towards capturing our interest in how faculty talk, or discuss, teaching-related topics related to teaching improvement with community members. That said, interview excerpts wherein a participant consulted with students towards better understanding how students learn or how the course pedagogy works for students were included. In these excerpts, it was clear the faculty member's conversational intention was not to perform the task of teaching students but rather to discuss teaching-related topics with students to inform their instruction.

Second, we did not include participant comments about attending meetings, events, professional development opportunities, etc., unless participants explicitly stated or implied that these events served as opportunities to communicate with others around teaching-related topics. This is because some teaching-improvement events may have sought more prescribed outcomes, via, for example, disseminating curriculum and pedagogy, and not have been spaces where faculty were encouraged to engage with others to explore teaching-related practices and beliefs. We excluded these excerpts since we did not want to assume all teaching improvement efforts were spaces where faculty engaged in teaching-related conversations, as is the focus of this paper.

Third, towards understanding how a pedagogical change initiative influenced STEM faculty engagement in teaching-related conversations, we only included excerpts where

participants mentioned how the initiative influenced teaching-related conversations. In other words, we did not include participant perspectives of how the initiative generally impacted participants professionally or personally, unless these impacts related to our study focus of engaging in teaching-related conversations.

Social Network Analysis. To understand how STEM faculty networks, used to talk about teaching-related topics with community members, changed over the life of an initiative, we analyzed responses from the 2017 and 2014 network surveys. Specifically, we used social network analysis, UCINET software (Borgatti, Everett, & Freeman, 2002), and Netdraw software (Borgatti, 2002) to create network sociograms using the 2017 and 2014 social network responses. Social network analysis is a method for investigating the structure that emerges due to relationships between a group of people. A sociogram consists of a set of actors (in this case, STEM faculty) and the ties among them (in this case, STEM faculty are connected via teaching-related conversations). Figure 1.2 provides two examples of simple sociograms. These examples will be used throughout this methods section to provide a visual interpretation of the metrics presented. In Figure 1.2, the squares represent faculty members, and the lines between them represent discussions about teaching. The overall structure of squares and lines are the data used to calculate metrics in social network analyses.

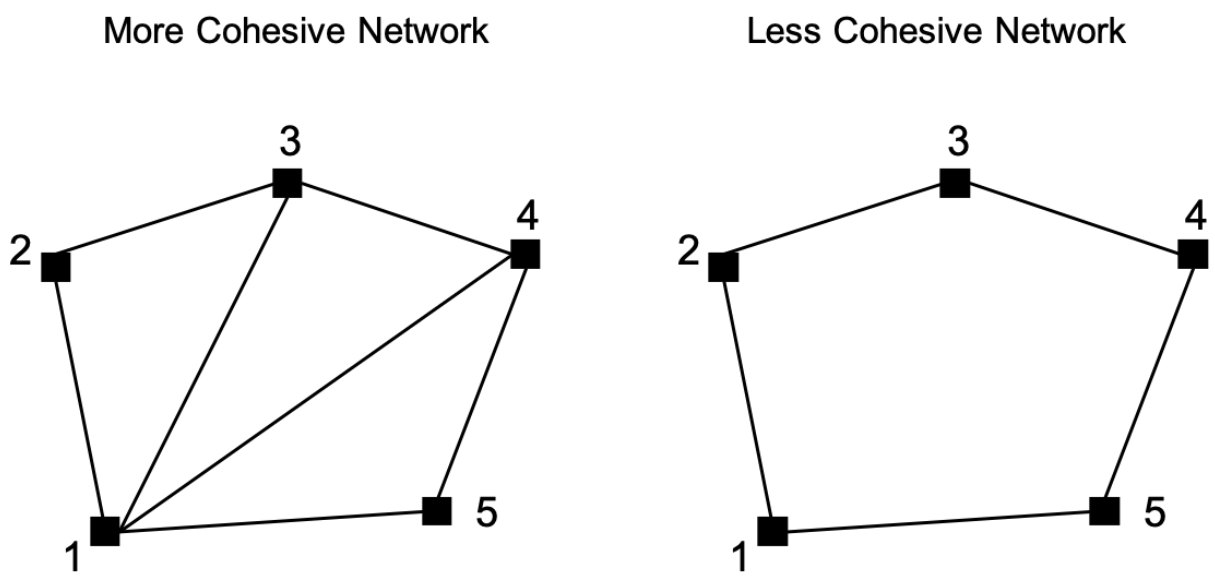

Figure 1.2. This is an example of two simple, hypothetical sociograms. Squares represent five different faculty (labeled 1, 2, 3, 4, and 5) and lines represent who these faculty talk to about teaching-related topics. For example, we can infer that faculty 1, in the more cohesive network, talks with faculty 2, faculty 3, faculty 4, and faculty 5 about teaching-related topics. In the less cohesive network, faculty 1 talks with faculty 2 and faculty 5 about teaching-related topics.

The sociograms we created for this study are called ego networks. Ego network sociograms are "comprised of a focal actor (called *ego*) and the people to whom [the] ego is directly connected," (Prell, 2012, p. 8). The focal actors in our network are our fourteen STEM faculty participants. The ego network also includes any person who is directly connected to these fourteen faculty. However, we decided that the directly connected actors could only include faculty who were also invited to take the survey, since we cannot make assumptions about network connections for people not invited to take the survey[4]. That said, during analysis we noted one person who was not offered the opportunity to complete a 2014 survey but who was still identified by five faculty as someone with whom they discuss teaching-related topics. Given

[4] For example, we cannot make assumptions about network connections to faculty members' partners or faculty at other institutions, since these people were not invited to take the social network survey.

the frequency with which this person was mentioned, we decided to include this person in our networks. In summation, our 2014 and 2017 networks include: 1) the fourteen faculty participants; 2) whom these fourteen faculty participants reported talking with about teaching and learning at this institution; 3) faculty who mentioned talking to one or more of our fourteen faculty participants; and 4) the relevant ties between these community members.

We assumed that when a person was listed on the survey as a discussant that each participant in the discussion contributed to the conversation, or we assumed that one person never simply talked *at* the discussant but rather talked *with* the discussant. So, we assume ties between faculty are nondirectional. Additionally, although some data were collected to determine the frequency of discussion, we did not assign a 'strength' to ties between faculty representing the conversational frequency of teaching-related conversations. Instead, ties were assumed to be a binary value, or as either existing in the network or not existing in the network.

To explain these decisions, consider the sociograms in Figure 1.2. Either a line exists between two faculty (and has a binary value of '1') or it does not exist between two faculty (and has a binary value of '0'). Furthermore, the lines are not weighted by frequency of discussion. This is because social network analysis uses equations to calculate network metrics. In mathematics, a '2' is twice as much as a '1,' but saying that discussions occurred around once a term (a potential strength of '2') is not mathematically twice as frequent as discussions that occurred less than once per term (a potential strength of '1'). As such, we represent a reported tie with the value of '1' and the absence of a tie with the value of '0.'

To look at how STEM faculty networks changed over the life of an initiative, we compared the 2014 and the 2017 networks. First, we wanted to see if there were changes in the cohesiveness of the network. Cohesiveness tells us something about how interconnected a

network is. Networks that are more cohesive, or more interconnected, are more likely to have shared understanding around teaching-related topics while less cohesive networks, or less connected networks, are less likely to have this shared understanding (Quardokus & Henderson, 2015).

For example, again consider the networks in Figure 1.2. The more cohesive network has a higher potential for shared understanding around teaching-related topics than the less cohesive network. This is because faculty 1 talks with everyone in the network about teaching-related topics, whereas the less cohesive network does not have any faculty member who talks to everyone about teaching-related topics. So, the less cohesive network is less likely to contain faculty who have a shared understanding of teaching-related topics. But these examples are only with five faculty; it becomes increasingly difficult to determine cohesiveness by simply looking at sociograms since networks are often larger than our examples, with more complicated ties between faculty. This is why we use social network analysis, which allows us to calculate different measures of cohesiveness to help us understand the extent faculty in networks are interconnected. Below, we report our methods for calculating network cohesiveness.

Before we calculated cohesiveness, though, we had to first explore if comparing the 2014 and 2017 networks was appropriate. Not surprisingly, the metrics used to compare network cohesiveness are affected by network size and response rate. Thus, we considered, and compared, the sizes and response rates of the 2014 and 2017 networks. We found that the two networks were relatively the same size: The 2014 network included 58 faculty and the 2017 network included 50 faculty. Also, the response rates were relatively similar: The 2014 ego network had a response rate of 86% and the 2017 ego network and a response rate of 78%. While 100% response rate is obviously preferred, around 80% response rate is the conventional ‘low

bar' for social network analyses (Henderson et al., 2018) and our networks are around this range. Due to the relatively close size of the networks and the reasonably high response rates, we determined that it was appropriate to compare the networks. We note, however, that size and response rate are still considered in our interpretation of results.

We next identified network metrics that were appropriate for measuring network cohesiveness, towards understanding the extent each network was interconnected. We used Prell's (2012) recommendation of calculating density, centralization, diameter, and average distance (heretofore referred to as 'average path length') to understand cohesiveness, since each of these measures provides a slightly different way to explore the extent a network is interconnected.

First, we calculated density. *Density* is a measure of how many ties a network has compared to all possible ties. In other words, it reports "the extent to which all the individual actors in a network are linked together" (Prell, 2012, p. 166-167). Density (d) is calculated by

$$d = \frac{L}{n(n-1)/2}$$

where L is the number of ties present in the network and n is the number of actors present in the network. Each actor could theoretically be connected to all other actors in the network (except to themselves), so the maximum number of ties a network can have is calculated by $n(n-1)/2$ (Prell, 2012). A high density score (maximum of '1') represents a network that is very interconnected, or cohesive, and a low density score (minimum of '0') represents a network that is less interconnected, or less cohesive. In Figure 1.2, the more cohesive network has a density of 0.7, while the less cohesive network's density is 0.5. The more cohesive network has a higher density because more of the ties that could possibly exist amongst five faculty are present in the network.

Centralization is a measure of the "extent to which one actor in a network is holding all the ties in that network" (Prell, 2012, p. 169). Centralization, like density, is also represented as a proportion. So, a network with a low centralization score would be one where the ties are distributed equally among all the faculty, and a network with a high centralization score would be one in which the ties were around one faculty member. Centralization scores depend on the degree centrality scores for the actors in a network. Prell (2012) explains that the degree centrality score (C_D) for an actor (i) is calculated by

$$C_D(i) = \sum_{j=1}^{n} x_{ij} = \sum_{i=1}^{n} x_{ji}$$

Where x_{ij} is the value of the tie from actor i to actor j (which is '0' if there is not a tie, or '1' if there is a tie) and n is the number of nodes in the network. Thus, Prell (2012) explains that the centralization score (C) is calculated by

$$C = \frac{\Sigma C_D max - C_D(n_i)}{max\Sigma C_D max - C_D(n_i)}$$

Where $C_D max$ is the largest degree centrality score across the set of actors, $C_D(n_i)$ is the degree centrality of actor n_i, and $max\Sigma C_D max - C_D(n_i)$ is the theoretical maximum possible sum of differences in actor centrality. In Figure 1.2, the more cohesive network's centralization score is 0.5 and the less cohesive network's centralization score is 0. The less cohesive network has a centralization of 0 because all of the ties are equally distributed among the actors.

Next, we calculated average path length and diameter (Wasserman & Faust, 1994). *Path length* is the number of ties by which two actors are separated. In Figure 1.2, the path length between faculty member 1 and faculty member 3 in the less cohesive network is 2 because the shortest path between them is through faculty member 2, which takes two ties. *Average path length* reports the average of the shortest path lengths between all sets of two actors. In Figure

1.2, the average path length of the more cohesive network is 1.3 and the average path length of the less cohesive network is 1.5.

Diameter is similar to path length and average path length: It reports the longest of the shortest path lengths between any two actors. So, a small diameter indicates that faculty are relatively connected to other faculty, because even the most disconnected pair of faculty have a small path length between them. A large diameter score indicates that faculty are relatively unconnected to other faculty, because the most disconnected faculty have a large path length between them. In Figure 1.2, the diameter of the more cohesive network and less cohesive network is 2. This is because the longest of the shortest path lengths between any two faculty is 2. So, while the diameter of the two networks is the same, the average path length, centralization score, and density indicate that the more cohesive network is, indeed, more cohesive.

Again, these four metrics (density, average path length, centralization, and diameter) represent different ways to describe how closely connected faculty are to each other, or different ways to measure the cohesiveness of the network. In this study, we calculated each of these four cohesiveness metrics for the 2014 and 2017 networks so we could compare the cohesiveness over time, or compare the extent faculty talked with others about teaching-related topics in 2014 and 2017. A network that shows high cohesiveness across every metric would indicate that the network is cohesive, whereas a network without consistent interpretations of cohesiveness across measures would be considered less cohesive. As argued by Quardokus and Henderson (2015), we expect that more cohesive networks are more likely to have shared understanding regarding teaching-related topics than less cohesive networks.

One more cohesion metric specific to this study was comparing the types of faculty ties for each of our participants in the 2014 and 2017 networks. Specifically, we counted the number

of ties each participant had to faculty within their unit and outside of their unit in 2014 and 2017. This helps us interpret the extent our participants' ties changed over the life of an initiative, in terms of the types of faculty participants talked with.

Limitations

We note various limitations in our research. To begin, a limitation of the social network data was that some participants reported talking to partners or others outside of the institution, but these people are not shown in the sociograms because they did not have a chance to take a network survey (as discussed in the methods, above) and because our study focused on understanding STEM faculty engagement in conversations in the context of an institution of higher education. Thus, these peoples' absence in the networks negates insight into how those not belonging to the community in the institution of higher education possibly contribute to teaching-related conversations. Future research could help illuminate the larger landscapes of faculty conversations concerning teaching, including those potentially happening at disciplinary conferences and national professional development opportunities. As well, other researchers have shown that family members can contribute to faculty members' constructions of teaching-related knowledge (Oleson & Hora, 2014), and it would be interesting to see future social network analysis research explore faculty members' more personal conversations as well.

Additionally, our research is based on a small sample size, with some claims voiced by only a few, or a single, participant(s). Furthermore, our study took place at one institution with one improvement initiative targeting select STEM disciplines. As such, we acknowledge the lack of generalizability of these data. While we hope that our paper helps raise reader awareness about some considerations for the design, implementation, and study of STEM educators' teaching-related conversations, particularly those created/fostered in faculty learning

communities by institution-wide improvement initiatives, we note that our results and implications may not be applicable in all contexts. Further research might be done using data from more faculty who engage in teaching-related conversations, to explore how different factors impact these conversations.

A last limitation concerns the authors' proximities to the initiative. The authors helped with the design of the initiative based on research data, with the third author specifically leading some initiative activities; it can be argued that such proximity is a bias threat. We have tried to reduce this bias by having others not affiliated the initiative, such as the first author's doctoral committee, read our study and provide feedback. We also argue that an insider perspective gives vital, in-depth knowledge about the initiative and the lives of the participants who were targeted by the initiative. As with many human endeavors, education improvement initiatives are complex, and we argue that to adequately comprehend how an initiative was planned and implemented, as well as the experiences of the participants in the initiative, researchers often may not have the luxury of being 'entirely removed' from influencing it.

Results

We start by presenting the results related to our first two research subquestions, which were informed by analyses of interviews with STEM faculty. Then, we present the results of our third research subquestion, which was informed by our social network analyses.

Specifically, we have organized findings by activity system components (i.e., 'rules,' 'community,' etc.). We note, however, that factors claimed by our participants arguably relate to multiple components of the activity system. For example, a participant might mention that they do not talk to others about teaching since they have a great deal of pedagogical autonomy with their upper-division teaching load. This suggests there is a 'rule' that faculty who teach upper-

division courses have pedagogical autonomy, and this has the potential to influence teaching-related conversations. It also suggest that there are community members who teach upper-division courses and community members who do not, which also has the potential to influence teaching-related conversations. While we acknowledge that sometimes codes relate to multiple components of the activity system, we do not believe our organization impacts the most important interpretations of our findings, which we convey in our discussion section.

Additionally, in our results section we make efforts to present findings substantiated by several participants before we present findings substantiated by fewer participants. This is not per any related decisions concerning the validity of claims, but is to both organize and more completely inform the reader about our findings.

Why do STEM Faculty, at an Institution of Higher Education, Engage with Community Members Around Teaching-Related Topics?

Participants offered information about how components of the activity system potentially influence STEM faculty engagement in the 'activity' of talking about teaching-related topics. Results exploring this research subquestion are shown in Figure 1.3.

Exploring the object through objectified motives and desired outcomes. Participants suggested motives for engaging in teaching-related conversations, or outcomes they desired from engaging in teaching-related conversations. Specifically, participants suggested that engaging in teaching-related conversations allowed them to compare teaching practices as well as find teaching-related support.

Comparing teaching practices. Participants (n = 5) spoke about meeting with others to compare teaching practices, or wanting to meet with others to compare teaching practices. For example, Alexis explained that talking to two other faculty about teaching-related practices has

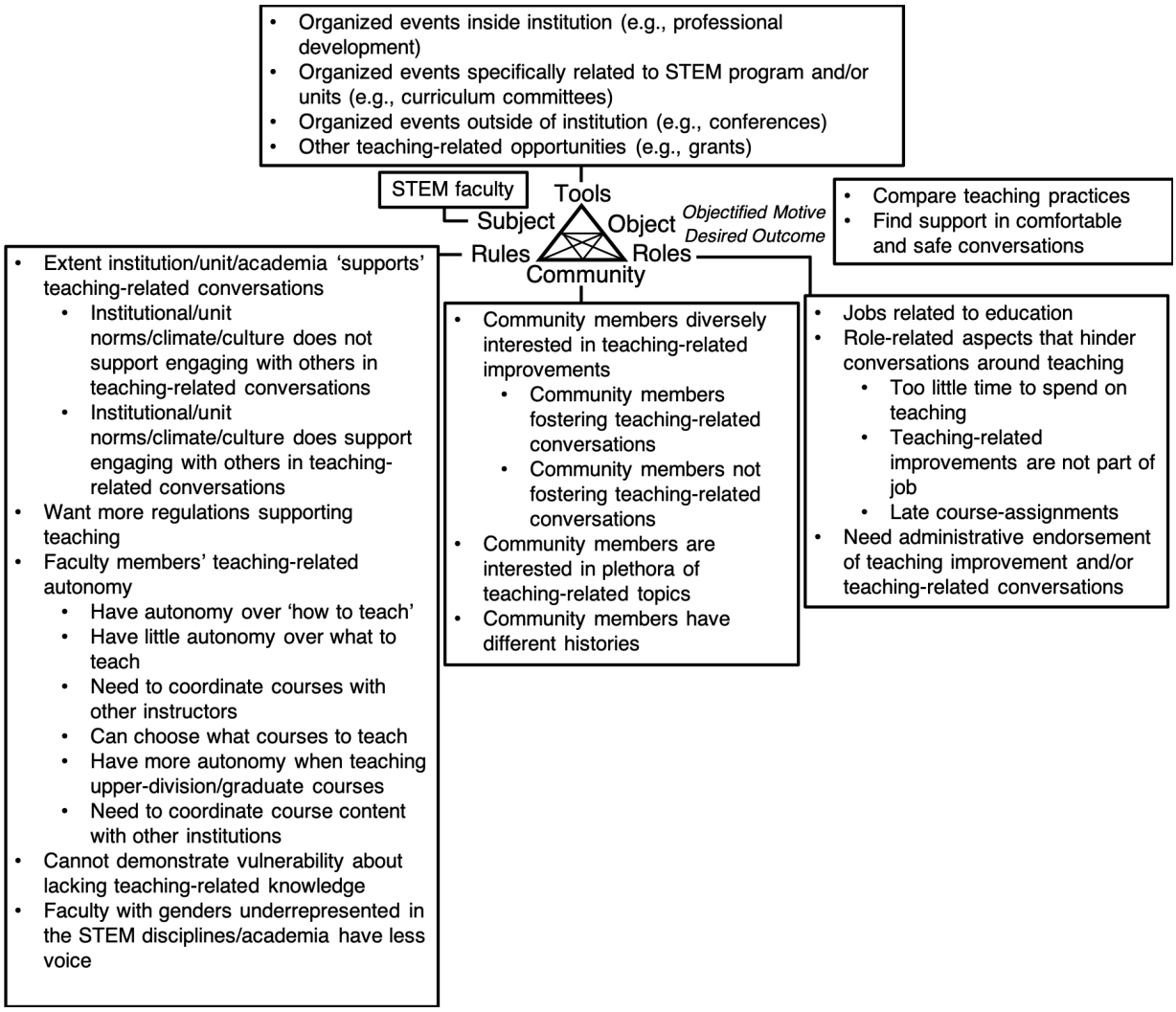

Figure 1.3. The components of the activity system that potentially influence STEM faculty engagement in the 'activity' of talking about teaching-related topics.

been "one of the most fruitful things because we look at how the other person delivers something and we say why did you deliver it that way, I would have delivered it this way, and we have conversations that illuminate[s] different ways to think about the delivery of content." Dallas also noted, "I think what it has done for me is once in a while we'll talk about a topic and somebody will show something the way they do something and show the students and talk about it and it'll be something that I've never thought of it that way before, and I do adapt those types of things," (although they also conceded, without elaboration, that "I think in general it doesn't

have a huge influence on my teaching"). These excerpts suggest that faculty might want to engage in teaching-related conversations towards learning about new teaching practices/experiences.

Find support in comfortable and safe conversations. Some faculty (n = 4) suggested they find support through teaching-related conversations and/or spoke about the value of engaging in teaching-related conversations that are comfortable and safe. For example, reflecting on bonding with others around teaching-related struggles, Ellery noted it was helpful to create a "space for people to feel comfortable reflecting on their teaching." Ellery also commented on how it was helpful to connect with others and discover that they have "been thinking about that too or if you're really stuck on something and they say 'yeah, I don't know how to do that either.' Sometimes that's very encouraging and that's also […] really the only way I know how to improve and be reflective on a day to day basis." Avery spoke about how cross-disciplinary conversations "provide encouragement and you're supported because you're not the only one and you're not worried about what if [inaudible] wrong, but you know it is a common goal for a lot of people." Similarly, Dakota commented on how the professional development they participated in, wherein they might talk about teaching-related topics with others, offered "a lot of support and a lot of information." Finally, when asked about what factors encourage interactions with others around teaching-related topics, Charlie succinctly stated, "I think personal relationships is what supports it." These excerpts suggest that faculty may choose to engage in teaching-related conversations to find teaching-related support, particularly if those conversational spaces are comfortable and safe places to talk about teaching.

Rules that potentially influence STEM faculty engagement in teaching-related conversations. Participants offered information suggesting aspects of being a STEM faculty

member that might regulate their engagement in teaching-related conversations, relating to 'rules' that influence teaching-related conversations in the activity system. These included: a) the extent the institution and/or unit supports teaching-related conversations; b) desire for more regulations supporting teaching; c) faculty members' teaching-related autonomy; d) the perception that faculty cannot demonstrate vulnerability about lacking teaching-related knowledge; and e) the perception that faculty with genders underrepresented in the STEM disciplines/academia have less voice in teaching-related conversations.

Extent institution/unit/academia supports teaching-related conversations. Participants offered varied perspectives about the extent the institution of higher education and/or their units supported teaching-related conversations. Specifically, participants talked about: a) ways the institution and/or unit does not 'support' teaching (n = 7) and b) ways the institution and/or unit 'supports' teaching (n = 4).

Institutional/unit norms/climate/culture does not support engaging with others in teaching-related conversations. Over half of our participants talked about there being a culture/climate[5] and/or norms in their units and/or the institution that might inhibit teaching-related conversations (n = 7), although they usually suggested this in more colloquial ways. For example, Charlie noted the cultural "element of like we don't talk about our teaching at the higher ed, it's just something that we do. We don't necessarily talk about that at our faculty meetings." Dana talked about how there was not "much communication about teaching" at the unit level, noting this was a "big flaw of the [unit]." Dallas offered a specific example of how unit (in)actions had shaped their perception of the unit's commitment to teaching:

[5] 'Climate' refers to how participants perceive specific elements of the institution of higher education, such as extent administrators support teaching-related conversations. As Walter, Beach, Henderson, and Williams (2014) explain, "Climate is more immediately accessible and malleable construct than organizational culture, as it can be changed through policy or other administrative and organization-member actions" (p. 1).

> The [unit] is somewhat I would say ambivalent to [talking about teaching-related topics]. They don't really care whether we do or not. One of the reasons why I believe that is I have requested to have a [discipline-specific] education resource room and I've said I would donate a lot of my [discipline-specific] education books to put in there so we could have a place where we could put really interesting research articles that we've read or just other articles and resources, a place for the [fixed-term faculty] and others, but more for the [fixed-term faculty] to be able to meet and talk about teaching and stuff and I really haven't got any movement on that.

Another example contributing to this category comes from Charlie's interview. "[I]t never occurred to [other faculty] that [teaching] could be something that they could be really proud of and talk about," commented Charlie, explaining a perception of "this weird institutional thing that happens" with respect to faculty members' lackluster enthusiasm towards talking about teaching.

Institutional/unit norms/culture/climate does support engaging with others in teaching-related conversations. Participants (n = 4) also spoke about how their unit and/or institution had a culture/climate or norms that supported teaching-related conversations, although, again, they often referred to these features in more colloquial ways. For example, Blair spoke about there being an "overall picture here" regarding motivations on the part of faculty to engage in best teaching practices and teaching improvements. Avery spoke about how their unit had administrative support and a longstanding history of curriculum meetings, explaining "a culture in the [unit that] we discuss teaching as well as other things, so there's a lot of local encouragement to do this." Elliott spoke about how the advancement or hiring of education-focused faculty encouraged teaching-related conversations. Finally, Alexis talked about how working at an institution that was supportive of teaching improvements/conversations around teaching helped foster teaching-related conversations. However, Alexis cautioned that this support

> depends on what [unit] and what [institution] you're in as to what sort of motivations you have to have these kinds of conversations to make these kinds of changes. [This institution] in general, and I don't have a lot to compare it to, I think is very supportive in improving education and getting together having conversations and spending some of your time actually thinking carefully about how you teach and how you could improve on that, but you see some variability inside different [units].

This indicates that some faculty felt that the institution or their units supported teaching, which could help educators engage in teaching-related conversations.

Want more regulations supporting teaching. Participants (n = 3) also talked about wanting more regulations that might support teaching and/or teaching-related conversations. Specifically, Ellery and Elliott desired more unit-based policies and Charlie wanted more institution-based policies, frameworks, or programs for teaching or teaching improvements. Specifically, Charlie noted they were really busy and thought that a more cohesive university vision regarding teaching-related improvement initiatives might help them use their time more effectively:

> [W]e've got all these things and all these different people are working on it, but it's almost like we're not focused enough to really figure out what it is we really want to do. So I feel like there needs to be some sort of master plan about all these education initiatives and that kind of includes [this initiative] and how we think about where we as an institution are and how we as an institution move forward and I feel like a lot of it hasn't been an institutional think tank, it's been kind of from the bottom up, which has value, but I think at some point we've got to get to that institutional level think tank where we can make some sense of all this stuff. Honestly, I have a lot on my plate and sometimes it's just overwhelming.

Faculty members' teaching-related autonomy. Participants also talked about the varying degrees of autonomy they had with teaching-related tasks. Specifically, faculty spoke about a) having autonomy over how to teach (i.e., pedagogy) (n = 12); b) having little autonomy over what to teach (i.e., course content) (n = 8); c) needing to coordinate courses with other instructors (n = 7); d) having the ability to choose what courses they teach (n = 3); e) having

more autonomy when teaching upper-division/graduate level courses (*n* = 2); and f) needing to coordinate course content with other institutions of higher education (*n* = 1). These suggest 'rules' related to teaching that have the potential to influence teaching-related conversations.

Have autonomy over 'how to teach.' Almost all participants (*n* = 12) spoke about having autonomy over how they teach. For example, Blake explained, "[H]ow and what we teach is fairly decided [by] us, the instructors."

Have little autonomy over what to teach. Many participants (*n* = 8) also spoke about having little autonomy over what to teach, or the content of courses. For example, Blair explained, "[With the introductory courses], not much [autonomy] for the curriculum. We have content curriculum to cover, our preparation for students continuing in the [STEM disciplines], understanding key physical concepts, pretty much dictates the curriculum."

Need to coordinate courses with other instructors. Many participants (*n* = 7) also spoke about needing to coordinate course curriculum with other instructors. For example, when asked about how much autonomy they have over what they teach and how they teach, Avery explained, "So basically what I teach very little [autonomy], because we discuss this and we have a lower division curriculum group that meets every three weeks and we talk about curriculum, what has to go on there, so basically we all agree on which parts go where."

Can choose what courses to teach. Some faculty (*n* = 3) also indicated they had autonomy over course assignments. For example, Drew explained that they had "flexibility in what I get to teach, yeah, lots of flexibility." Elliott credited their background as the founder of a STEM program as giving them lots of autonomy over what to teach, and Dana conceded that although they were "essentially assigned what I teach" they "do get […] preference to what I would like to teach."

Have more autonomy when teaching upper-division/graduate courses. A couple participants (n = 2) talked about having autonomy when teaching upper-division and graduate courses. For example, Drew explained, "For the most part like upper division courses and graduate-level courses I feel like I have a lot of autonomy in what I teach and how I teach."

Need to coordinate course content with other institutions. One participant, Alexis, noted that the curriculum they covered was constrained because, if curriculum was changed, "you've got about twelve or thirteen [institutions of higher education] that would change and shift as well." They explained further, "So in that sense I can't make much changes as to what particular topics we cover." This suggests that, according to Alexis, course content changes must be coordinated with other institutions of higher education, which could influence teaching-related conversations.

Cannot demonstrate vulnerability about lacking teaching-related knowledge. One participant, Ellery, spoke at length about how STEM faculty cannot express needing help with their teaching, or be open with others about how they lack teaching-related knowledge. Ellery viewed an existing "value judgment that can be implicit" in talking with others about evidence-based instructional practices: "[I]t seems to me that telling someone there's a right way to do it and you're doing it the wrong way is anathema [inaudible] interaction, and it's a hard thing to balance," they explained. Although they noted a need and desire for faculty communication around teaching-related topics, they felt faculty might be inhibited to engage in initiative-related conversations because they have "just a real vulnerability and sensitivity to judgement." They elaborated that this vulnerability might stem from a lack of recognition, across the unit, of the complexity of teaching:

> I think some of the disconnect is the imposter syndrome thing [inaudible] of you're younger or somehow a lower status it's really hard to believe that anyone

> else is as overwhelmed as you. You just, you know, do the [inaudible] job based on your research ability and that's great and then all of a sudden you find yourself in front of like four five college students you're supposed to teach [a STEM subject] and you're like oh shit, I don't know how to do this, and it's hard to admit. So acknowledging is a really hard thing and it's important to us, so much more important that we don't have time to...You know when you ask for directions and someone is like how did you end up here, and it's like come on dude, I admit it, I'm lost, help me. I'm not going to go through all the poor decisions I made [inaudible]. So really if you're a full professor [in this discipline] and you've been doing teaching for thirty years, traditional teaching, learning after thirty years that there's a full body of literature and research that kind of exists that could've made everything better is difficult.

Ellery commented that hiding a lack of teaching-related knowledge could be ameliorated by the unit "committing to some kind of shared framework of teaching and learning." Ellery explained that this "essential model" would normalize platforms for discussion around teaching-related topics, including social justice-related ones, so that "you can expect when you're discussing with somebody, you know what a learning outcome is, do you know why it's important, do you structure your course around them like you're supposed to, that kind of language." This could, Ellery speculated, make it so that STEM faculty had "less of a step [...] down in dignity" when admitting they lacked teaching-related knowledge. It would also validate newer faculty members' difficulties with teaching. Although this would be helpful, Ellery also suggested that using social science research to justify changes might not be respected. Ellery's extensive excerpts suggest there are 'rules' to being a STEM faculty member, which include hiding a lack of teaching-related knowledge and, perhaps, not taking social science research seriously. As Ellery summarized:

> [T]he privacy that we all kind of assume for our teaching is really protective for me. So sometimes the problem is like oh, I keep coming to class unprepared, I don't want to ask my boss, okay, you've got any advice on how to not be such a screw up. So there's a vulnerability element that I think tends to be the main thing that silences me, if there is something I would like to talk about with somebody.

Ellery's excerpts suggest that some STEM faculty may not want to be vulnerable in their lack of teaching-related knowledge: This may dissuade STEM faculty from participating in teaching-related conversations.

Faculty with genders underrepresented in the STEM disciplines/academia have less voice. Dana suggested another implicit 'rule' about gender and engaging in teaching-related conversations. Although Dana noted that they talk to other faculty about teaching-related topics, they admitted sometimes feeling dissuaded from contributing since others might not value their comments based on their gender:

> You have to realize too, I said I was a [tenure-track faculty member in a STEM discipline]. I have been here [a long time]. What do you think that makes me? You know, gender-wise, honestly, what do you think, okay, you know I've come into this profession and I've been an outsider. I'm not going to take something I do that's different than what other faculty members do and advertise it. I may be very successful at it, but if I advertise it there will be repercussions. I just don't want to go there anymore. I and the students know this is working really well, that's enough.

Dana raises the concern that their contributions will be dismissed because their gender is one underrepresented in the STEM disciplines and/or academia. This speaks to a 'rule' that faculty with genders underrepresented in the STEM disciplines and/or academia have less voice, and this 'rule' has the potential to influence which community members engage in teaching-related conversations.

Aspects of the community that potentially influence STEM faculty engagement in teaching-related conversations. Faculty also commented on community-related aspects that have the potential to influence their engagement in teaching-related conversations. Specifically, faculty mentioned working in a diverse community, consisting of members who foster teaching-related conversations and those who do not foster teaching-related conversations. Participants also indicated that community members were interested in a plethora of teaching-related topics

which could potentially influence teaching-related conversations. Finally, community members indicated having diverse histories with respect to engaging with others in teaching-related conversations. All these aspects have the potential to influence STEM faculty engagement in teaching-related conversations.

Community members diversely interested in teaching-related improvements. Faculty explained that there was a diverse array of community members, in terms of their interests in teaching and/or making teaching-related improvements. This included community members who fostered teaching-related conversations (n = 9) and community members who did not foster teaching-related conversations (n = 6).

Community members fostering teaching-related conversations. A little over half of our participants (n = 9) stated or implied that engaging with people who are interested in teaching, value teaching, or want to know how to implement teaching improvements helped foster teaching-related conversations. As Avery summarized:

> [Y]ou really need a group of people that themselves are interested and only when you have a critical mass there, and I think we do have a critical mass here, then more people will get on board. But if administration says this is what you've got to do, people say sure, they'll do it for a little bit, then it disappears. So you really need this local interest and I think a lot of places have that, so I'm not worried about it, but if it's not there for some reason, you cannot build it by force.

Other faculty, such as Briar, credited discussions about teaching to the discussant's interest in the same topic (i.e., "active learning"). Drew noted that an expanding interest in teaching helped foster conversations, explaining, "I think what encourages it is more and more people are becoming interested in improving instruction in the [unit], so that's really exciting."

Community members not fostering teaching-related conversations. Conversely, participants (n = 5) mentioned community members who did not foster teaching-related conversations, such as "lecture-type people," "bullies," faculty who were perceived as having

little teaching-related knowledge, and faculty who were uncollaborative. Reflecting on the initiative and who had been participating in initiative-related events, Alexis noted that they would "probably not have very much fruitful conversations with a traditional lecturer who's done that their whole life." Similarly, Briar noted:

> It's difficult to have those conversations with people who absolutely believe that standard lecture is the gold standard of teaching. So being open minded about different approaches is certainly encouraging it and the opposite is also true for those who are adamant that standard lecture is [...] it, it's difficult to have a conversation.

These excerpts suggest there are community members who are perceived as strongly identifying with lectures and/or are disinterested in broadening their pedagogical knowledge. These community members, our participants suggest, have the potential to inhibit teaching-related conversations.

Finally, Dana and Bowie spoke of potentially more problematic community members who have the potential to inhibit teaching-related conversations. Dana explained:

> There are some very antagonistic people, faculty members in my area [in my discipline]" who there was "no point in talking to them, so I don't. So I think if you have bullies in [a unit] it's going to really decrease the amount of interaction among faculty and I think that's happened in this [unit].

Bowie noted there was "so much ideological drive in pedagogy" that educators "cherry pick" evidence-based instructional practices. Bowie further explained that this set up situations where "proponents of standard lecture" and "flipped classroom people" meet, bring "their literature," and "yell at each other for a while and they go back to what they were doing. Some of us go, oh, I might incorporate some of that."

Community members are interested in plethora of teaching-related topics. Participants also offered evidence to indicate that community members were interested in a plethora of teaching-related topics. These were topics participants mentioned either talking to others about

or were topics they were interested in discussing. Some mentioned topics include: assessing student learning (*n* = 11); how to teach course content (*n* = 11); STEM education research (*n* = 9); student learning (*n* = 8); improving instruction (*n* = 7); active learning (*n* = 6); what content/material to teach (*n* = 6); online coursework (*n* = 4); student diversity/inclusion (*n* = 4); course logistics (*n* = 3); technology use in classrooms (*n* = 3); adaptive learning systems (*n* = 2); flipped classrooms (*n* = 2); developing curriculum (*n* = 2); creating educational videos (*n* = 2); large course sizes (*n* = 2); open source textbooks (*n* = 2); unprepared students (*n* = 2); backwards design (*n* = 1); dropout/fail/withdrawal rates (*n* = 1); duration of classroom activities (*n* = 1); course materials (*n* = 1); course policies (*n* = 1); student attitudes about STEM (*n* = 1); student studying (*n* = 1); supplemental instruction (*n* = 1); and faculty teaching training (*n* = 1). "Need is the ultimate encouragement," explained Bowie, commenting on what motivates their conversations with others around course content. "If I don't know how to do something I have to figure out how to do it. So I'll engage resources at that point and people out here are some of my best resources. So need frequently initiates any sort of this outreach activity."

Community members have different histories. Participants also offered information about histories with various community members (*n* = 5), which helped explain teaching-related conversations faculty have with others. For example, both Avery and Elliott credited their longevities at the institution as contributing to their teaching-related connections. "There's a whole bunch of history there," Avery explained, elaborating on their previous participation in a discipline-specific teaching preparation program and how this allowed them to become more aware of how "standing in front of the classroom and talk[ing] for fifty minutes is not very effective." Elliott also mentioned they had worked at the institution for many years, in different units. "I've interfaced real closely [with people in these different units]," they explained. "I've

consulted a lot. I bring a lot of that into the classroom." Simply having more time at the institution of higher education to meet community members, and engage in teaching-related conversations, could help faculty foster teaching-related connections.

Faculty also explained that sharing teaching-related experiences helped them make teaching-related connections, with community members they could potentially talk with about teaching-related topics. Specifically, Avery and Briar talked about having shared experiences with other faculty around the same course (Briar) or in the same teaching-related workshop (Avery), suggesting that those opportunities led to teaching-related conversations. For example, Avery explained:

> The biggest influence I think was a few years ago when the science education instructor and I, we co-taught a course there, not a course, but a workshop more for perspective [prospective?] middle school [STEM educators, especially those teaching topics relevant to Avery's discipline], and all the discussions, observations, how these people are working and analyzing, what goes well, how do we get to the right answers, what is science, and this person was much more kind of radical on some of the aspects than I was, but I realized hey, these are right approaches.

Finally, Elliott said they talk to a faculty member because they "developed a program" together and Alexis commented on being part of a cohort of new faculty, who started around the same time, who meet to talk about teaching-related topics. Longevity at the institution as well as simply sharing teaching-related experiences with different community members could help faculty engage in teaching-related conversations.

Roles potentially influencing STEM faculty engagement in teaching-related conversations. Faculty also suggested ways roles potentially influence teaching-related conversations. Specifically, faculty mentioned: a) nine education-specific jobs or positions they either engaged in or that others held that have the potential to influence teaching-related conversations; b) role-related aspects that hindered teaching-related conversations such as

lacking time, the perception (held by some community members) that engaging in teaching-related conversations or improvements was not part of their job, and receiving late course assignments; and c) having administrator support.

Jobs related to education. Participants mentioned a variety of education-related jobs that either they engaged in or others held that may help foster conversations around teaching-related topics. For example, participants (n = 4) talked about how having fixed-term faculty, or being a fixed-term faculty member, fostered teaching-related conversations: Dallas commented that "most of the [fixed-term faculty] are more interested in and apt to get involved" in collaborative education-related grants since "particularly for [fixed-term faculty], we do focus on education often more than a lot of the tenure track people." Similarly some faculty (n = 4) talked about how engaging in teaching related conversations and/or teaching-related improvements was part of their jobs. "I am in a situation where I've never been allowed to work in isolation in my classroom, I don't work in an isolated setting. Everything I do is on a giant team of people on all sorts of level[s]," explained Charlie. "I think for me that sort of forced me into this interactive state." Having faculty positions, or community member roles, specifically focused on education could help foster faculty conversations around teaching-related topics.

Furthermore, faculty (n = 3) talked about how having the role of course coordinator afforded teaching-related conversations. For example, Dane noted, "This past year I've been the coordinator for [a STEM course] so I interact with people teaching [this course] in a particular term." A couple of faculty (n = 2) also talked about how their roles as unit-wide professional development providers helped them work with faculty, which could instigate teaching-related conversations. For example, Charlie explained that they had "worked with faculty on their

professional development, which also allows me to do my own professional development at the same time."

Other participants mentioned specific jobs, or roles, that potentially influenced teaching-related conversations. For example, Bowie mentioned meeting community members through "doing academic outreach with students." Avery mentioned that their unit hired a community member to do lower-division work who they had "interacted [with] a lot" and implied that having a "separate person who's running the labs" helped foster conversations about lab needs. Elliott specifically mentioned talking with another faculty member about "what kinds of things work, what doesn't work" who was a "social justice leader" in education. Finally, Elliott commented on how the professional advancement of faculty committed to changing teaching practices encouraged teaching-related conversations.

Role-related aspects that hinder conversations around teaching. Faculty also spoke about aspects, related to their roles, that hindered conversations around teaching. Specifically, participants spoke about: a) having too little time to spend on teaching (n = 6); b) the thought (held by some community members) that engaging in teaching-related improvements was not part of the job (n = 4); and c) late course assignments (n = 1). These role-related aspects have the potential to hinder faculty engagement in teaching-related conversations.

Too little time to spend on teaching. Almost half of our participants talked about lacking time when it came to engaging in teaching-related conversations (n = 6). Bowie commented:

> I don't think there's any villain out there trying to stop this [interactions with others around teaching-related topics] from happening, so there's no evil [inaudible] preventing these things [interactions] from happening, but I think the biggest factor impeding me is my teaching schedule.

Charlie similarly stated:

> I think there's time and energy. I tried for several years to have these meetings where we all get together and talk about cool things people are doing in their classrooms and sometimes I'm really successful, and I like [inaudible] just don't have time, I just have too many other demands on myself and I can't make that sort of thing happen now.

This indicates that some faculty feel so busy that it is difficult for them to find time to engage with others in conversations about teaching, or engage in teaching-related improvements. This also suggests that their roles might not wholly support engaging in teaching-related conversations, since they feel they have too little time to engage in this activity.

Teaching-related improvements/conversations are not part of job. Faculty ($n = 4$) also suggested that some may feel that engaging in teaching-related improvements or conversations is not part of their job. This role-related perception has the potential to inhibit teaching-related conversations. As Elliott stated,

> There's no question we [our unit faculty] could improve significantly if we just start implementing best practices, let's start doing it, but the fact is we don't even have a requirement for all of our new teachers that are coming in embarking on a thirty year teaching career to prepare them for that. There's no formal requirement that they engage training along their development as a teacher.

Another example for this claim comes from Charlie, who succinctly stated, "I think a lot of faculty work in isolation." If faculty do not think it is part of their job to engage in teaching-related conversations or, as Elliott stated, if faculty have "a perception [...] that it's just not worth putting effort into improvement of teaching, they'll worry about that after they get tenure or after they get their research under control or whatever," faculty conversations about teaching could be inhibited.

Late course assignments. One participant, Drew, also felt discouraged to engage in teaching-related conversations since, in their unit, "sometimes instructors aren't assigned to teach classes, like they don't know what class they're going to teach until like a week before

classes start, sometimes two days before classes start. So with that, like how can you have meaningful conversations about the course before the term starts." This suggests that late course assignments, or belated teaching-related 'roles' given to STEM faculty, inhibit teaching-related conversations.

Need administrative endorsement of teaching improvement and/or teaching-related conversations. Almost half of our participants (n = 6) spoke about how having administrative buy-in, or endorsement, of improvement efforts and/or teaching-related conversations could help faculty engage in conversations around teaching-related topics. For example, Avery commented on how having supportive administrators fostered teaching-related conversations, stating, "There is a lot of encouragement from our dean to say 'hey teaching is important' and to support those objectives." Another example comes from Elliott, who commented on the need for administrator endorsement of a teaching professional development program for unit faculty, that might provide opportunity for teaching-related conversations:

> I think a lack of awareness is that probably we are going to need to, leadership in the college is going to need to make an investment and intervention to bring that about, that won't come about by...I believe it won't come about by getting a few NSF grants every few years. That will be great, we'll get research, get publications, students will, certain courses will be used as laboratories for exploring different kinds of things, but I think if we really want to be a [unit] where it's whoa, that [unit], they really get it, and all their assistant professors go through not only this boot camp when they get there, but it's through their careers these developments and [faculty peer teaching] and all this stuff going on and it's part of everybody's existence here, just as going to research conferences and having research group meeting and all that is, that will take intentional university commitment rather than thinking of it as oh, yeah, they do [this discipline-specific education] research over there, they got millions of dollars, they're fine. They can do their research, they don't need us.

Tools potentially influencing faculty engagement in teaching-related conversations. Faculty also suggested 'tools' that potentially influence their engagement in teaching-related conversations. Specifically, participants mentioned being involved in different organized events

where teaching-related conversations had the potential to occur, including those: a) inside the institution; b) specifically related to their STEM programs or units; c) outside the institution; and d) of unknown affiliation.

Organized events inside institution. Participants indicated they were involved in a myriad of teaching-related events, inside the institution, where they had potential to engage with others around teaching-related topics. For example, participants mentioned eleven different institution-related programs, centers, and/or offices that provided events related to teaching improvements or student success. The most numerously cited were the institution's teaching and learning center (n = 8), wherein almost half of the participants (n = 6) had participated in a peer-observation teaching improvement program. Other participants talked about engaging in teaching improvement opportunities offered by the institution's e-campus (n = 2) and their college (n = 2), as well as seven more institution-based teaching-related and/or teaching improvement-related opportunities (n = 6). These organized events inside the institution have the potential to serve as tools where STEM faculty can talk with others about teaching-related topics.

Organized events specifically related to STEM programs and/or units. Participants also talked about engaging with others around teaching-related topics in organized events related to their programs and/or units. Specifically, many participants mentioned collaborating with others around unit courses (n = 10) and while serving on unit committees (n = 2). For example, Dallas explained that they discussed courses with others in their unit: "We do a lot of course coordination here [in this unit]. I wouldn't say it [is] necessary great coordination, but it's something that we've been improving over the last couple years. So generally I meet at least once a week with the others teaching the course, or the courses I teach."

Organized events outside of institution. Faculty also mentioned being involved with opportunities outside of the institution where teaching-related topics had the potential to be discussed, including attending conferences/being part of professional organizations (*n* = 7); talking with others at a community college (*n* = 2), and attending a publishing company forum about technology and teaching (*n* = 1). For example, speaking about the value of conferences and how it influences teaching-related discussions, Charlie explained:

> I have structured and built this large community of [educators specific to my STEM discipline] in [this location of the US] that I consider my friends and my colleagues and I continue to go to these meetings and do this professional development because it gives me opportunities to interact with them and to improve my knowledge and to improve our knowledge together and it allows a much bigger impact than just what I'm doing in my classroom here. It also impacts what I do in my classroom here. So for me I find those interactions, which does involve some things like travel and going to meetings and doing these things, but I find them to be kind of the thing that allow[s] me to kind of connect my educator self with my science self and so I feel like I'm doing science on my education and allows me to really feel like I can improve and continually understand and improve the impact of what I'm doing in my classroom with my students, but also the impact of what we're doing across [this region of the US] on all our students. So for me that community aspect of that is really what drives me to continue to go back to these things over and over again and as far as doing the research in my classroom, asking my students the questions anyway, so if I can write an IRB and do my own research in my class then I'm going to be able to do something with that data eventually.

Other teaching-related opportunities. Faculty mentioned or suggested connecting with others in teaching-related opportunities other than the initiative of our focus, but with too little description to determine some characteristics of these, such as if they occurred within the institution, within their units/programs, or outside of the institution. Specifically faculty talked about participating in teaching-related professional development (*n* = 4); in education-related grants (*n* = 4); in education-related workshops (*n* = 2); and on an unknown education-related committee (*n* = 1). These are other opportunities where faculty may have met with others to talk about teaching-related topics.

How Has a Pedagogical Change Initiative Influenced STEM Faculty Engagement in Teaching-Related Conversations?

Above we detailed components of the activity system that had potential to influence STEM faculty engagement in conversations about teaching-related topics more generally. We now present results concerning how a comprehensive campus initiative potentially influenced STEM faculty engagement in conversations with others about teaching-related topics. We summarize these results in Figure 1.4.

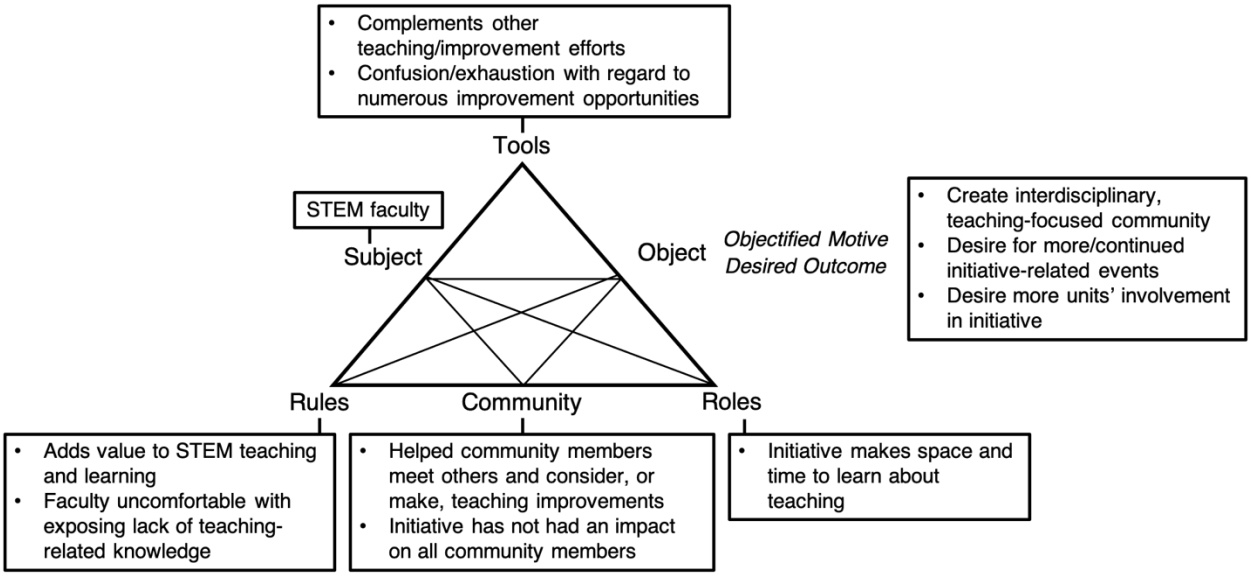

Figure 1.4. Ways a pedagogical change initiative influenced STEM faculty engagement in the 'activity' of talking about teaching-related topics.

Exploring the object through objectified motives and desired outcomes. Faculty offered excerpts suggesting the objectified motives for participating in initiative-related communities, with many participants speaking very highly of the way the initiative had helped create an interdisciplinary, teaching-focused community at the institution. Participants also spoke about wanting more initiative-related events, continued initiative-related events, and more units' involvement in the initiative.

Create interdisciplinary, teaching-focused community. Most participants (*n* = 11) spoke about how the initiative had provided a vital opportunity to connect with interdisciplinary community members at the institution, who were interested in education, suggesting that meeting these community members may have been a motive some participants had for engaging in initiative-related events. "I really enjoy getting to know faculty outside my unit," commented Charlie. "That's been really great with [this initiative]." Similarly, Blake commented:

> I certainly did meet new people or get a closer working relationship with a few people through the project and that certainly were here for a long time, so that gives us new people to talk to and perhaps collaborate with, perhaps write grants with, perhaps discuss things with. So that was another good thing.

Drew elaborated on how participating in the initiative had specifically helped them get to know others in different disciplines, stating:

> [B]eing part of [the initiative] it was really nice to talk to folks, like my grouping was with folks from [other STEM units] and that was really nice to kind of have these scheduled meetings to talk with people from other disciplines. I don't really have conversations with people from other disciplines now.

Additionally, Avery summarized:

> [T]hrough [this initiative] it's really nice to see all these things happening in other [units] and say hey, we're all working on a common thing. One thing I noticed for instance when we started with [a specific curriculum] seven or eight years ago students would come in and sit there with their hands crossed and say I'm not going to work, you have to talk to me, and now they're all working because they do it in other disciplines as well and we have seen an enormous culture shift among the students because they are used to things right now which ten years ago they were not.

Most participants indicated that the initiative provided a valuable opportunity to get to know more community members interested in teaching at the institution, helping create an interdisciplinary, teaching-focused community.

Desire more/continued initiative-related events. Participants (*n* = 5) also spoke about wanting more initiative-related events or seeing a continuation of initiative-related events. This

further suggests that a motive for engaging in initiative-related events was to get to know other faculty. “My biggest suggestion,” Dallas explained, “is more opportunities to just get together and talk about and share ideas about teaching and learning with other people in the [initiative].” Other faculty wanted to see different initiative-related events. For example, Alexis suggested having “big events where we’re just meeting people” and level-specific events “for beginners, for intermediate, and for advanced” faculty, with respect to teaching-related knowledge. Blair speculated the initiative could expand to include more “inter-institutional communication” through, perhaps, a summer “mini-conference” with “some presentations, some questions and answers, [...] some workshops.” In reflecting on the end of the initiative, Avery worried, “Without [the initiative] how are different [units], are they going to get isolated again, or keep working together, what can we do to keep that momentum going, and that’s my big question, what was the best way of doing that.” Blake also indicated that they wanted to see continued support for initiative-related events:

> I think to continue on with these sort of get togethers and even these [practitioner inquiry opportunities] I think would be great. I know the NSF grant has ended, but I think that is a relatively minor component of the total funding. So I’m hoping that somehow there will be support, maybe just internal support, but to continue those things, specifically I think those [practitioner inquiry program opportunities] were really good and I think that is continuing this year. I don’t know how that’s getting funded, maybe through the [campus STEM center], that was one, and sort of those meetings that we had on once a term basis, I’d like to see those continue.

Blake also spoke very highly of their initiative-related experiences, noting that they hoped the initiative continued:

> I don’t know if it came across, but it was a very positive experience for me and for the people I coordinate in [my discipline] and it really was. Every work space has programs and units that are a pleasure and always fun and intriguing and others that are less so, and this was one of the really positive things and it has been and hopefully it continues. Every time we hear something from the [initiative] and I go attend something, it is always enjoyable, fun, and often productive. So my hat’s off.

Desire more units' involvement in initiative. A couple participants (n = 2) also spoke about wanting the initiative to include more units, which could increase the STEM education-interested community involved in the initiative. Specifically, Charlie explained that "there are certainly a whole lot of other units out there that could benefit from participation in something like this." Blake corroborated, "I think there were five units we focused on and maybe expanding that a bit would be good too." This suggests that some participants wanted more initiative-related events that expanded the community members involved.

Initiative's influence on rules affecting STEM faculty engagement in teaching-related conversations. Interviews with STEM faculty suggested the extent the 'rules' of being a STEM faculty member, which potentially influence faculty engagement in teaching-related conversations, were affected by the initiative. This included excerpts suggesting that: a) the initiative added value to STEM teaching/learning and b) faculty might still be uncomfortable exposing a lack of teaching-related knowledge.

Adds value to teaching and learning. Participants (n = 3) talked about how they felt the initiative contributed to a positive image of teaching and learning at the institution, suggesting the initiative influenced the 'rules' around how teaching and learning was perceived. Charlie commented:

> I think there's this element that is not even an intentional part of [the initiative], but that is just giving a little bit of a profile to it and just raising the idea that it's awesome to have awesome teachers and I think that has come somewhat from the [the initiative] being there and the prestige of having this giant grant that comes along with that and also just the fact that we're talking to the deans and we're talking to the provosts and we're talking to those people about who's doing these best practices and I think that has raised the profile of the people who are taking the risks in some ways and I think that is a way to allow people some safety in that if they're being recognized for their risk and for the successes coming because of the risk hopefully, and that allows them some safety in taking some

> risks and also creates an atmosphere where we're talking more about teaching at our institution than we used to and I think that's an effect of [the initiative].

Avery also commented on how the initiative had added value to STEM teaching and learning at the institution, explaining how involving interdisciplinary faculty gave it a certain gravitas:

> I think the strong point about [the initiative] was bringing people together from different disciplines, have them talk to each other and realizing, hey, we have a common goal and we can look to each other for support, even if sometimes, say chairs, might find it strange or why do it, it's working, so you can really help each other to value what you're doing that's the right thing to do, even though someone at the administrative level may say well we need to save money and so we shouldn't do it. So you get some support and say yes, this is important, we have to spend the money on it. It's always about money of course at some point, but it helps the students learn. So I think to me … It's a very important thing the community building part that [the initiative] has done.

Faculty uncomfortable with exposing lack of teaching-related knowledge. One participant, Ellery, commented on how talking about the initiative "had a bit of a chilling effect on some conversations, because some people are uncomfortable with it or they have criticisms of it." They said they felt like there was an interest in their unit to talk more about "stuff" like "students and teaching and mentoring and some research and stuff," but that "[n]one of these people go to any of the [initiative] stuff." They further speculated:

> I'm not sure why that is, but my guess is just a real vulnerability and sensitivity to judgement, that for whatever reason, because of parallel positions or just I'm an amazing person, they don't feel judged in that smaller circle, so there's energy and motivation to engage. For some reason it doesn't transfer over to the large-scale thing. The only sense I can make of that is there's an association of uncomfortable exposure and judgement.

Ellery's excerpts suggest that the 'rule' of not confessing a lack of teaching-related knowledge may have been unaffected for some faculty, since some may have still felt uncomfortable participating in initiative-related events and potentially feeling judged for lacking teaching-related knowledge.

Initiative's influence on community-related aspects that potentially affect teaching-related conversations. Faculty provided excerpts suggesting ways the initiative had impacted community-related aspects that might influence teaching-related conversations. Specifically, participants spoke about how: a) the opportunity to engage in conversations with other faculty had helped community members consider, or make, teaching improvements, and b) the initiative did not have an impact on all faculty.

Helped members meet others and consider, or make, teaching improvements. Many participants (n = 10) discussed how the communities or opportunities to engage with other educators, fostered by the initiative, helped them, or others they knew of, make teaching improvements. Blake commented:

> So absolutely we are hearing about both things we may have heard of but no[t] very familiar or hearing about the implementation of new approaches and how they work, right, so that's been like key to us doing new things and I think it has led directly to me adding some of these components this year and other people in our [unit] doing the same over the past few years.

Charlie also reflected on engaging with other community members: "[M]uch like the way science works, it's like by having a community of collaborative individuals we end up being more creative by the end of it, so I think it's an incredibly good way to do it." Avery, Bowie, Blair, Dallas, and Blake talked about adding new curricular techniques to their classroom practice, or had seen new curriculum being added to unit courses, based on STEM faculty observing or becoming aware of other community members' successes or classroom changes. For example, Avery noticed people in their unit making teaching improvements, based on their knowledge of a practitioner inquiry fellow's success:

> If we look at our [unit] again, we want to look at our [unit] again, the one instructor who flipped his classroom, definitely there was a lot that was driven by what [the initiative] was doing and a lot of people that are much more traditional you can kind of see them listening, picking up things, and slowly moving in the

> same direction because they see how it works, you get this consensus which is slowly built and moving on there.

These statements about faculty picking up teaching-related practices, or becoming aware of teaching-related practices, demonstrate that the initiative helped community members consider or make teaching improvements. Blake nicely summarized this effect on the community:

> I guess one thing, I think I observed in a few places, both at sort of the get togethers we had every term, but also kind of on a presentation of maybe the [presentation by the practitioner inquiry participants], there were a few of those, I sort of observed the same kind of thing, people talking to each other, not me, but other people talking to each other who I don't think really talked to each other often, and I think I saw connections getting made that way. We had poster sessions. I see people getting together and discussing things. I know some of those people and I don't imagine they were ever discussing these topics before or would have.

Initiative has not had an impact on all community members. Participants (n = 8) also provided information suggesting that the initiative did not influence, or had a minimal influence, on some community members' conversations around teaching-related topics or teaching-related improvements. This suggests that the initiative did not have an impact on all community members. For example, Charlie explained, "I know people who think that's [learning about teaching in a community of collaborative individuals] not how they want to get engaged with this kind of stuff. So I don't know if that would engage everyone. It certainly is a great way to engage me." Alexis confessed to knowing faculty who had attended an initiative-related event and "walked away and they're like, 'I don't feel like, I didn't walk away with one thing that now I know is going to make me a better teacher, so what did I get out of it.'" Also Dana suggested that the initiative could not influence teaching-related conversations in their [unit]: "[O]ne thing is since I don't teach lower division [classes in my discipline], there isn't much communication about teaching at the [unit-]level and I think that's a big flaw of the [unit]. So because of that we're in this state for various reasons and I don't think the [initiative] is going to fix it."

Other participants, such as Drew, Briar, Dana, and Dane, indicated that the initiative had not strongly influenced their interactions with others around teaching and learning. For example, Briar noted, "I think everything that I've done I would have done anyway. But it has been good, I'm sure I've picked up things from hearing about what [other STEM units are] doing when you go to these meetings." Dana simply noted they "had not noticed [the initiative] at all" when asked if the initiative had any impact on their interactions around teaching. Similarly, Dane was unaware of the initiative, stating:

> I'm not sure all the people that teach at [this institution], teach STEM classes at [this institution] were even aware of [this initiative]. So find a way to increase awareness so that people know that there is this program that maybe they can try to participate in, or other instructional strategies.

Initiative's influence on roles potentially affecting teaching-related conversations. Faculty provided information about the extent the initiative may have influenced roles related to engaging in teaching-related conversations. Specifically, participants talked about how the initiative helped set aside a time to learn about teaching.

Initiative makes space and time to learn about teaching. A few faculty (n = 3) commented on how the initiative helped them efficiently learn about teaching by providing opportunities to collaborate with colleagues, suggesting that initiative-related opportunities catered to their busy roles as STEM faculty. "I think that I myself and probably lots of people in my position are not going to the literature frequently to look at the next published methodology or whatever, so we're getting a lot of this through interacting with our colleagues," commented Blake. Blair noted, "I don't want to work in a silo, I don't think I would be productive in a silo and I don't think that I have nearly the amount of time to go ahead and experiment and find results on everything, so it's wonderful being collaborative." Finally, Charlie commented on how engaging with a community of colleagues helped them learn about teaching:

> [H]aving a community of like-minded educators or people who know things, have ideas that I haven't thought of, or have tried things that might work for me, is really the best source of how I get ideas about how to effectively implement things that I might read about in the literature. So if I personally didn't have those communities of people, it would be much more challenging for me to dive in and do some of the things I've done, because I have a lot of barriers with six hundred people in my classroom. So I think for me having a community of people that I can talk to about these [teaching-related] ideas allows me to be better about it.

Initiative's influence on tools potentially affecting teaching-related conversations.

Faculty offered excerpts related to how the initiative had impacted perceived tools for engaging in teaching-related conversations. Specifically, participants talked about how the initiative complemented other improvement efforts, wherein faculty likely talk with others about teaching-related topics and expressed confusion and/or exhaustion with regard to the numerous instructional improvement efforts available.

Compliments other teaching/improvement efforts. Half of our participants (n = 7) mentioned that the initiative complemented other work or efforts through which they likely talked about teaching-related topics, suggesting the initiative had a certain synergy with other tools for engaging in teaching-related conversations. Charlie noted:

> [T]here's been a lot of publicity around our really wonderful teachers and our [evidence-based instructional practices] and all that stuff and I think that's synergistic with some of the other things happening on campus. I think there is change happening across our campus and I think there is big chunks of it that are related to the way that [the initiative] has happened.

Blake also mentioned "a few different venues where we are getting together in groups larger than just our [unit] and [the initiative] is probably the most important of those" and Blair talked about how they made connections through the initiative with faculty they would see at other events. Dallas summarized:

> I wanted to learn from opportunities from people in other disciplines. A lot of the people that were at least initially involved when I started were people that I knew about on campus and of course they're the people that are attracted to this kind of

> thing, that have already been doing a lot of the things that the grant would like to see happen in the classroom, the people that are going to volunteer or apply for grants are exactly the people that are at least already on that path, at least towards it if they're not already there to a certain extent and I don't mean there like a final place, but you know always thinking about engagement and things like that. I think everybody knows they can always improve.

And Alexis also explained how the initiative complemented other instructional improvement efforts:

> If there wasn't [this initiative], the density of events would have been potentially below a critical mass, meaning like the [institution's teaching and learning center] maybe there's one event a year or two events a year, so I wouldn't have seen these people as often, we wouldn't have come together and started forming this informal groups. Then I would have never also done the [practitioner inquiry program] and that has been a catalyst along with some grants that they helped guide me to, that basically started a whole new research group at [this institution] in [my unit] with educational data [...] so I really leveraged [my involvement in the practitioner inquiry opportunity], like I said four years ago none of this was happening, three years ago even none of this was happening…

Other words used to describe the initiative that indicate it complemented other instructional improvement opportunities included "another wheel in this whole program where things were running [...] and it increases the momentum going forward" (Avery) and a "catalyst that brought us together" (Alexis).

Confusion/exhaustion with regard to numerous improvement opportunities. Some faculty (n = 4) also expressed confusion regarding what was related, or not, to the initiative or exhaustion about all the numerous available tools to explore, and support, teaching improvements where teaching-related topics might be discussed. As Bowie noted, when questioned about their attendance at initiative-related events:

> Bowie: I think I went to a lunch or a dinner, there was food, and we had name tags and stuff. But I go to so many of those events that it's kind of …
> Interviewer: Blur together.
> Bowie: …yeah, blur together, especially because there's so many of the same faces at many of these events, so it's hard to differentiate what is an [initiative-related]

> event and what's not an [initiative-related] event sometimes because many of the same people attend.

Ellery corroborated, "There's a network of people that are important to me that I think I've been granted access to through [the initiative]. Other than that I don't really keep track of who's paying for the coffee at whichever thing I'm at." And last, Charlie expressed some exhaustion from the numerous opportunities to meet with others around teaching improvements:

> ...maybe I just get involved with too many things, but there have been so many initiatives at [this institution] recently, which is really wonderful, but I feel like they're all like pieces I feel like should be tied together and hasn't yet been done, at least in my mind, and that may be some of the like what the research team of the [initiative] is working on, but that hasn't been transparent to the faculty part of that team. So for me I feel like the institution could use a plan that allows them to see here's all these initiatives and how they relate to each other and here's where we should now go onto target, because we can't just keep targeting large, lower division, high enrollment courses in every initiative that we have, because I can only do so many things. That's how I feel today.

These excerpts suggest some faculty perceived so many available instructional improvement tools, wherein they might engage in conversations with others around teaching-related topics, that they either felt confused about what opportunities corresponded to which initiative or they did not know where to put their limited efforts.

How Have STEM Faculty Networks, Used to Talk About Teaching-Related Topics with Community Members, Changed Over the Life of an Initiative?

Above, we reported results that help us explore our first two research subquestions, or why STEM faculty engage with community members around teaching-related topics and how a pedagogical change initiative influenced STEM faculty engagement in teaching-related conversations. We now report the results from our social network analyses, which help us understand how STEM faculty networks, used to talk about teaching-related topics with community members, changed between 2014 and 2017. First, we present our sociograms which show the networks used to talk about teaching-related topics. Then, we present the results from

our cohesiveness calculations, which tell us something about how interconnected the faculty were in each network. Last, we present our results on who participants talked with (i.e., faculty within their unit or outside of their unit) in 2014 and 2017.

Sociograms showing faculty networks used to talk about teaching-related topics. We created sociograms to show the faculty networks used to talk about teaching-related topics. Again, these sociograms show: 1) the fourteen faculty participants; 2) who these fourteen faculty said they talk with about teaching-related topics at this institution; 3) faculty who mentioned talking to one or more of our fourteen faculty participants; and 4) the relevant ties between these community members. The sociogram from the 2014 data is shown in Figure 1.5. The sociogram from the 2017 data is shown in Figure 1.6.

Cohesiveness metrics. We determined how STEM faculty networks, used to talk about teaching-related topics, changed in cohesiveness, or interconnectedness, between 2014 and 2017. To understand cohesiveness, we calculated density, centrality, diameter, and average path length.

Density calculations. The density in the 2014 network was 0.053 and the density in the 2017 network was 0.062. This means that the 2014 network contains 5.3% of the potential ties available and the 2017 network contains 6.2% of the potential ties available[6]. We anticipate density might be most affected by the different sizes of the networks, since density depends on the number of ties and, thus, "larger networks (that is, networks with higher numbers of actors) can have a larger number of ties within them than smaller networks" (Prell, 2012, p. 170). The 2014 network, composed of 58 faculty, does have the potential for more ties than the 2017

[6] Again, if all faculty were connected to each other, the density value would be 100%

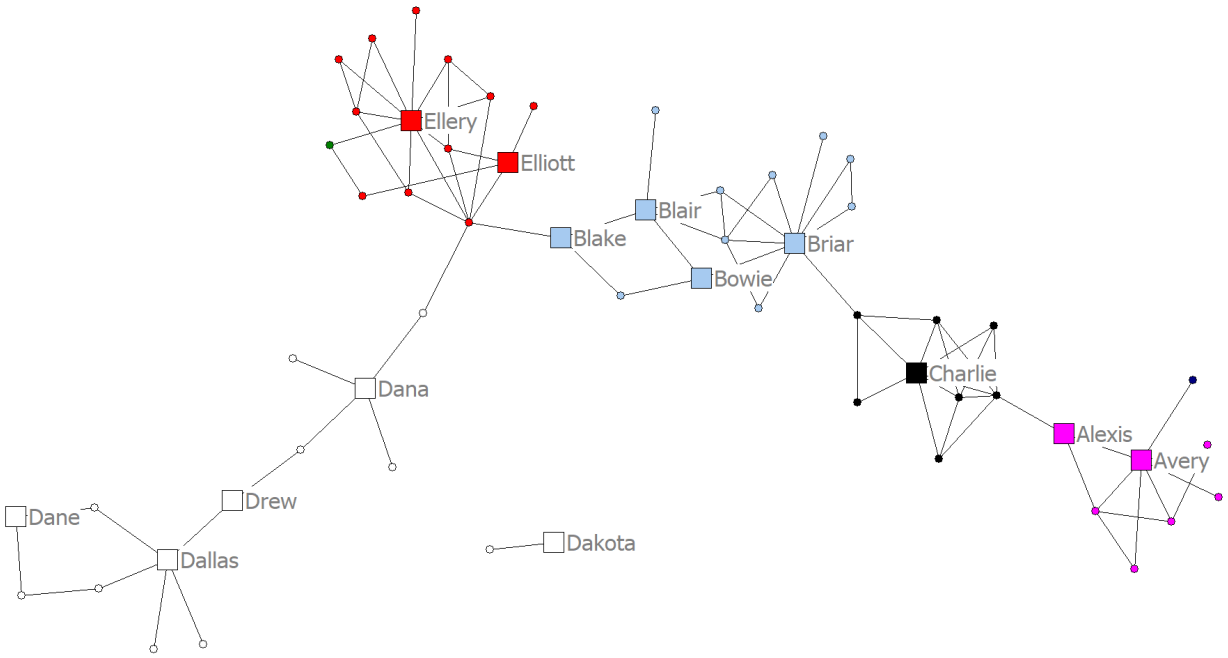

Figure 1.5. This sociogram shows the network of teaching-related conversations amongst faculty using data from the 2014 survey. Faculty are shown as squares and circles, where squares represent the fourteen participants in this study and circles represent participants not included in this study but who were identified as part of the network of teaching-related conversations. Lines represent ties between faculty, or they connect faculty who one or more reported engaging in teaching-related conversations with each other. The colors represent units at the institution of higher education.

network, which is composed of 50 faculty. That said, the density values of the 2014 and 2017 networks (0.053 with 58 faculty and 0.062 with 50 faculty, respectively) are very similar. So, although the 2017 network is a little denser than the 2014 network, it also has fewer potential ties that would likely contribute to an increase in density. For this reason, we conclude that the density has not remarkably changed between the two networks.

Centralization calculations. The centralization score on the 2014 and the 2017 network was 0.127. This indicates that there was no change in the extent ties centralized (or 'hovered around') any one faculty member. Also, in both years, ties between faculty were not centered around one faculty member. Rather, ties were relatively distributed throughout the network.

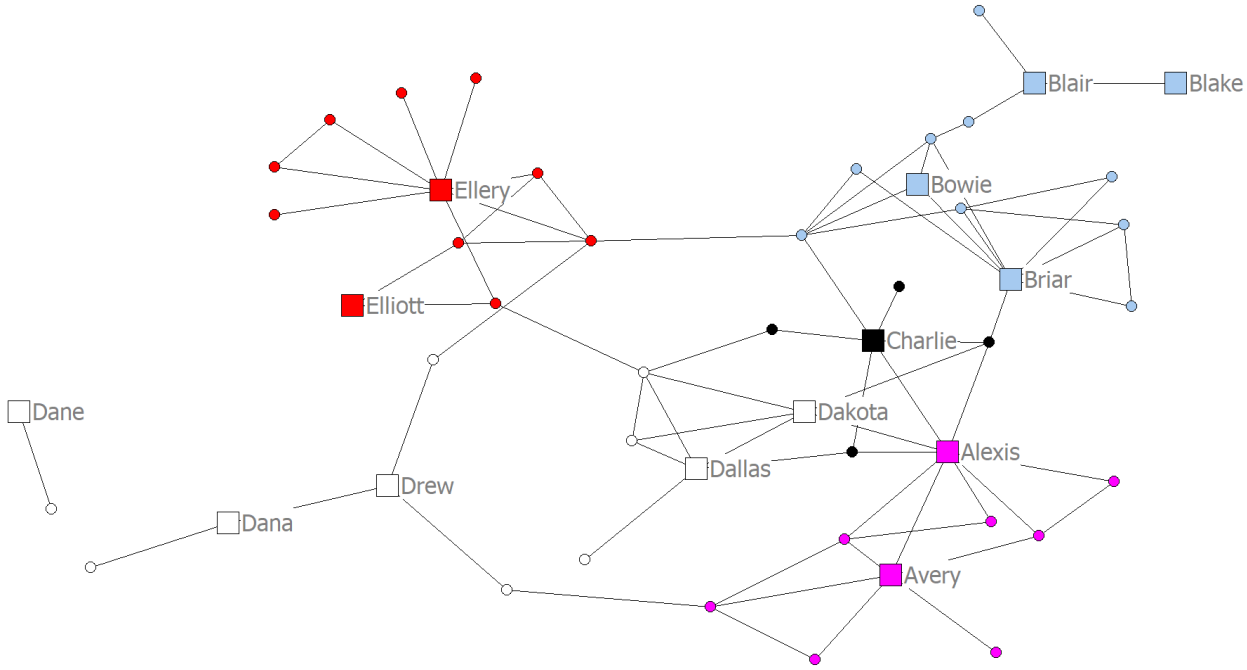

Figure 1.6. This sociogram shows the connections (lines) between faculty (squares and circles) used to talk about teaching-related topics in 2017. The colors represent units, large squares with names represent participants in this study, and small circles represent participants not included in this study but who were identified as part of the network of teaching-related conversations.

Diameter and average path length calculations. The diameter in the 2014 network was 17 and the diameter in the 2017 network was 9. The average path length on the 2014 survey was 6.522 and the average path length on the 2017 survey was 3.96. The changes in diameter and average path length are evident in the sociograms (Figure 1.5 and Figure 1.6) where it is visually obvious that the path lengths between any two faculty are shorter in 2017 than in 2014. The changes in diameter and average path length indicate that faculty are 'closer together' (or any given two faculty are connected by fewer ties) in the 2017 network than in the 2014 network.

We pause here to consider each networks' cohesiveness across all four measures. The density, which is generally the proportion of ties to total possible ties, did not noticeably change between 2014 and 2017. Also, the extent ties were centralized around one faculty member did not change. The diameter and average path length, however, noticeably changed between the

2014 and 2017 networks. This suggests that, by these metrics, the 2017 network is more cohesive than the 2014 network in that teaching-related social ties more closely link community members in 2017.

Types of community members participants talked with in 2014 and 2017. Last, we consider which community members, those within participants' units or outside participants' units, our participants reported talking to about teaching-related topics. Table 1.2 shows the results regarding the number of discussants STEM faculty said they talk to about teaching-related topics in 2014 and 2017, considering whether these conversations were with faculty within participants' units or outside participants' units.

Table 1.2.

Number of Community Members Participants Claimed Talking With in 2014 and 2017

Participant	Number of Ties to Community Members in Unit (2014)	Number of Ties to Community Members Outside Unit (2014)	Total Ties (2014)	Number of Ties to Community Members in Unit (2017)	Number of Ties to Community Members Outside Unit (2017)	Total Ties (2017)
Avery	6	1	7	6	0	6
Alexis	2	1	3	5	4	9
Blake	2	1	3	1	0	1
Blair	4	0	4	3	0	3
Bowie	3	0	3	3	0	3
Briar	8	1	9	7	1	8
Charlie	7	0	7	4	2	6
Dallas	5	0	5	4	1	5
Dakota	1	0	1	3	2	5
Drew	2	0	2	3	0	3
Dana	4	0	4	2	0	2
Dane	2	0	2	1	0	1
Ellery	8	1	9	8	0	8
Elliott	4	0	4	2	0	2

We found that all participants, in both 2014 and 2017, claimed talking with more faculty in their units than outside of their units. Six faculty reported talking only with people in their unit in 2014 and 2017. Additionally, four participants said they talked with more faculty outside of their unit in 2017 than in 2014, one participant said they talked with the same number of faculty outside of their unit in 2017 and 2014, and three participants reported talking to fewer faculty outside of their unit in 2017 than in 2014.

Discussion

Education researchers have called for greater opportunities for educators to learn about evidence-based teaching practices in collaboration with others in their institutional communities (Bouwma-Gearhart, 2012b; Henderson, Beach, & Finkelstein, 2011; National Academies of Sciences, Engineering, and Medicine, 2016). We investigated how STEM faculty engage in teaching-related conversations within the context of an institution of higher education with an ongoing teaching improvement initiative. Specifically, we explored why STEM faculty, at an institution of higher education, engage with community members around teaching-related topics. We also studied how faculty networks, used to talk about teaching-related topics with community members, changed over the life of an initiative. We used second-generation cultural-historical activity theory to help us understand how components of the larger system (i.e., rules, community, etc.), including those potentially associated with an improvement initiative, influence STEM faculty engagement in the 'activity' of talking about teaching-related topics. STEM faculty suggested system 'rules' (e.g., norms) that might influence engagement in teaching-related conversations, including the extent the institution/unit supports teaching-related conversations, participants' desires for more regulations supporting teaching, faculty members'

teaching-related autonomy, the perception that STEM faculty cannot demonstrate vulnerability about lacking teaching-related knowledge, and the perception that faculty with genders underrepresented in the STEM disciplines/academia have less voice in teaching-related conversations. Faculty also suggested community-related aspects that have the potential to influence teaching-related conversations, such as there being community members diversely interested in teaching-related improvements, community members interested in a plethora of teaching-related topics, and community members who have different histories with respect to talking with others about teaching. Faculty also suggested information about how professional roles potentially influence teaching-related conversations, hinting that faculty who hold jobs related to education may support teaching-related conversations. They also talked about role-related aspects that might inhibit teaching-related conversations, such as having too little time, perceiving that engaging in teaching-related conversations isn't part of a STEM faculty member's professional duties, and receiving late course assignments. Further, participants suggested that a lack of administrative support may hinder conversations. Participants also suggested the opportunities ('tools') they take advantage of to converse with others around teaching-related topics, such as participating in organized events inside the institution, those specifically related to their STEM program and/or units, as well as events outside of the institution. They also suggested they might meet with faculty around teaching-related foci in other teaching-related opportunities more difficult to locate with respect to the institution, such as education-related grant work. Finally participants offered their motives for or desired outcomes from engaging in teaching-related conversations, such as comparing teaching practices and finding teaching-related support in comfortable and safe conversations.

With respect to how an institution-wide, pedagogical change initiative influenced faculty members' engagement in teaching-related conversations, faculty suggested the initiative influenced some of the implicit 'rules' for engaging with others in teaching-related conversations. Participants explained that the initiative helped make space and time to learn about teaching, suggesting how the initiative might have fit within the 'roles' of busy STEM faculty. Participants also offered information related to how the initiative had influenced their relevant community, in that it helped community members meet others that could inspire teaching improvements, although participants also suggested that the initiative did not have an impact on all community members. Participants further suggested that the initiative complemented other teaching improvement 'tools' at the institution, where faculty have opportunity to converse about teaching-related topics. That said, some participants felt confusion or expressed exhaustion with respect to the numerous available 'tools' for teaching improvement at the institution. Furthermore, one participant suggested that faculty members might be uncomfortable exposing a lack of teaching-related knowledge in initiative-related events. Finally, participants offered information about their motives for or desired outcomes from engaging in initiative-related conversations, suggesting that the initiative helped create an interdisciplinary, teaching-focused community that they may have felt they lacked before. Some participants also desired more initiative-related events, continued initiative-related events, and more units' involvement in the initiative, further suggesting that the initiative spoke to faculty members' desires to grow their knowledge of, and connect with, the teaching-interested community at the institution of higher education.

To illuminate how teaching-related discussion networks changed over the life of an initiative, we used social network analyses to compare the cohesiveness, or interconnectedness,

of faculty networks in 2014 (shortly after the initiative was implemented) and 2017 (approximately three years after the initiative was implemented). These analyses revealed that the network density, or the proportion of ties to total possible ties, did not noticeably change between 2014 and 2017, suggesting that faculty were not necessarily talking to greater or fewer community members over the life of an initiative. Also, the extent ties were centralized around one faculty member did not change between 2014 and 2017, suggesting that no single faculty member dominated connections among all other community members. That said, the 2017 network did have a smaller average path length and diameter than the 2014 network. This suggests that teaching-related knowledge can be more efficiently shared throughout the community compared to when the initiative first started, since the path lengths between any two faculty are shorter than they were in 2014.

Finally, we were interested in exploring changes in which community members STEM faculty discussed teaching-related topics with in 2014 and 2017, considering discussants' unit affiliations. We found that many individual faculty experienced shifts, to different extents, in terms of who they talked with. In both 2014 and 2017, participants talked with more faculty in their units than outside of their units and six participants talked only with community members in their unit. Four participants talked with more faculty outside of their unit in 2017 than in 2014, and three participants talked to fewer faculty outside of their unit in 2017 than in 2014. This suggests that different faculty experienced different changes in terms of who they talked with, but also shows that there were no noticeable trends representing all faculty (e.g., not all faculty reported talking to more people outside of their unit in 2017 than in 2014).

In light of these findings, we now turn to discussing salient activity system tensions that might impact teaching-related conversations and propose implications for stakeholders.

Salient System Tensions Potentially Inhibiting Teaching-Related Conversations

Our results suggest some tensions in the activity system that might inhibit faculty from engaging in teaching-related conversations. These include: 1) STEM faculty members have autonomy with teaching practices; 2) community members have varied levels of interest in teaching-related improvements; 3) varied levels of support are given to STEM faculty to engage in teaching-related conversations; and 4) STEM faculty may lack inclusive and judgement-free spaces to talk about teaching. These tensions contribute to both our understanding of what might inhibit the 'activity' of engaging in teaching-related conversations and, when addressed, suggest affordances for faculty to engage in more of this activity.

STEM faculty members have autonomy with respect to teaching practices. Many participants reported great autonomy in terms of deciding how to teach, which may be particularly true for those teaching upper-division/graduate level courses. At the same time, some participants reported having little autonomy over what to teach, sometimes due to the need to coordinate courses with other instructors or institutions. This suggests that faculty might be more inclined to have conversations about course content, which might need to be aligned with other instructors or other institutions. This could be a tension inhibiting conversations specifically about teaching practices, since faculty have the autonomy to decide how to teach and thus may have autonomy regarding whether they want to engage in discussion about teaching practices, such as evidence-based instructional practices.

We speculate that conversations about teaching practices may also be more effort-intensive, since they might necessitate STEM faculty elucidate teaching and/or learning rationales to explain or justify how they teach. Considering that pedagogical training is likely varied amongst STEM faculty, faculty members might have different comfort levels in terms of

engaging in conversations about teaching practices, particularly if faculty perceive threats to acknowledging a lack of adequate teaching-related knowledge. This might be particularly true for faculty whose perceptions of institutional/unit climate, culture or norms leads them to conclude that teaching-related conversations are not supported. Thus, talking with community members about aligning course content may be an easier conversation in which to engage STEM faculty since it may not involve, or may limitedly involve, discussion of how to teach course content.

This tension, that STEM faculty have autonomy over teaching practices, provides insight into our social network findings. Specifically, in both 2017 and 2014, participants reported having more discussions with community members within their units than outside of their units. It is reasonable to expect that conversations with faculty within one's unit might be focused around aligning course content, because faculty might have to engage in coordination on these topics and faculty may be more comfortable having these types of conversations. Similar findings in previous research on this change initiative support this interpretation: STEM faculty members tend to talk about day-to-day needs and not necessarily system-level topics that influence teaching practice (Quardokus Fisher et al., 2019).

Community members have varied levels of interest in teaching-related improvements. Participants reported working in a community where colleagues were diversely interested in teaching-related improvements. For example, faculty spoke about engaging in teaching-related discussions with community members who were interested in teaching, valued teaching, or wanted to know how to implement teaching improvements. These types of community members, our participants suggested, seem more approachable for teaching-related conversations. Also, having a job related to education, or an associated 'role' focused on

teaching, might afford teaching-related conversations: If thinking about teaching, and working towards providing quality teaching to students, is a large part (or all) of a faculty member's formal role at the institution (e.g., as it might be for fixed-term faculty, or faculty specifically coordinating courses, etc.), a faculty member might be more inclined to seek out and participate in teaching-related conversations. Conversely, some members in the community were perceived as only being willing to engage in the teaching practice of lecture, possessing little teaching-related knowledge, and perhaps not even open to civil conversations about different teaching techniques. These types of community members, our participants suggested, inhibited teaching-related conversations.

Our 2014 and 2017 network data shows us who STEM faculty talked to about teaching-related topics, suggesting that those in the network might be community members who have 'traits' that welcome teaching-related conversations (e.g. they are interested in instructional improvement.) Furthermore, our 2014 and 2017 social network analyses show that this community became more interconnected over time. Specifically, our cohesiveness comparisons of the 2014 and 2017 network showed that average path length and diameter, which represents how interconnected faculty are, decreased. This suggests that teaching-related knowledge can be more expediently spread throughout the network compared to when the initiative was first implemented. In light of these findings, we wonder if the initiative, amongst a variety of other instructional improvement efforts, helped faculty who desired to engage in teaching-related conversations gain a better awareness of which community members they connect talk with about teaching. This interpretation is also lent support by the many participant excerpts speaking to how the initiative helped create an interdisciplinary, teaching-focused community. This

teaching-focused community, our results suggest, consists of more efficiently interconnected faculty who are open to and interested in talking about teaching.

Varied levels of support are given to STEM faculty to engage in teaching-related conversations. Our participants had varied perceptions about the amount of support they felt they had at their institution to engage in teaching-related conversations. In some instances, participants more generally indicated there being a 'culture' (e.g., working in academia) that inhibited teaching-related conversations, although specific aspects of culture were not often called out by participants. Other participants indicated more detailed and localized 'climate' or 'norms' (e.g., administrators not supporting teaching-related conversations) inhibiting conversations. This nuance is worth considering because factors associated with climate (e.g. certain administrators) are quicker and potentially easier to change than those comprising organizational culture (e.g. longstanding norms concerning faculty promotion) (Walter et al., 2014).

Furthermore, some faculty perceived working in roles that did not support teaching-related conversations. For example, some participants reported having too little time to spend on teaching, suggesting that other aspects of their roles might be privileged over teaching. Also, some faculty more explicitly suggested that teaching-related improvements/engaging in teaching-related conversations was simply not a part of their role at the institution of higher education. Last, one faculty member commented on how late course assignments, or belated notifications about teaching-related roles, inhibited teaching-related conversations. In particular, this latter example suggests that notifying faculty of teaching assignments earlier would help support faculty in engaging in teaching-related conversations.

Relatedly, our participants suggested that administrative support of teaching improvements and/or teaching-related conversations could help foster teaching-related conversations. This highlights the prominent role administrators play, who have professional roles with more power than most STEM faculty, in terms of supporting faculty members' engagement in teaching-related conversations. Faculty perceptions suggest that if administrators promoted/implemented policies, or even informally supported educators' engagement in teaching-related conversations and instructional improvement efforts (e.g., a dean saying that they support faculty members' engagement in teaching-related conversions) faculty might be more inclined to engage in teaching-related conversations.

When we consider these finding in light of our social network analyses, we note how density and centralization did not change between 2014 and 2017. For example, if density had increased in 2017, it might indicate faculty increased the number of discussants in their community with whom they interacted. But this was not the case. Indeed, relatively little change in density might be likely because, as our interviewees indicated, STEM faculty are busy and thus might be limited in the number of community members with whom they can connect. Additionally, STEM faculty might feel inhibited in expanding their teaching-related social networks because some might believe that engaging in teaching-related improvements is unsupported by their roles and some perceive working in a culture/climate that does not support engaging in teaching-related conversations.

STEM faculty may lack inclusive and judgement-free spaces to talk about teaching. A couple participants indicated that not all opportunities to talk about teaching were inclusive and judgment-free. One of our participants indicated biases that deterred them, a faculty member with a gender underrepresented in STEM and/or academia, from discussing their teaching

practices and experiences with community members. We are unfortunately not surprised by this result, as previous research has noted that educators with identities underrepresented in STEM often face discrimination or hostile work environments (National Academies of Sciences, Mathematics, and Engineering, 2018). This likely inhibits STEM faculty, particularly those with identities underrepresented in STEM and academia, from contributing to teaching-related conversations. Additionally, one of our participants provided information inferring a 'rule' that STEM faculty must hide teaching-related issues or a lack of teaching experience. This participant also speculated that this 'rule' might keep some community members from participating in the initiative. These 'rules' about which community members have voice in teaching-related conversations and how open participants can be in their sharing of teaching knowledge could inhibit faculty from participating in teaching-related conversations.

Considerations for Stakeholders Towards Fostering Faculty Communication Around Instruction

Looking across the results of our research questions and identified system tensions helps us suggest research-informed considerations for postsecondary STEM education improvement initiatives, unit leaders, and STEM faculty attempting to foster and/or engage in teaching improvements via learning communities, where educators can collaboratively share and learn about teaching-related topics. Specifically, we suggest stakeholders help: 1) uncover and attend to faculty members' interests in diverse teaching-related topics; 2) acknowledge that faculty may already be involved in diverse opportunities, wherein they engage with others around teaching-related topics; 3) create spaces where faculty can talk with community members about teaching-related topics; 4) create spaces for sharing that are inclusive and safe, towards fostering faculty participation; 5) develop the administrative support that may be necessary to help foster and sustain opportunities for faculty to talk with others about teaching-related topics.

Uncover and leverage faculty members' interests in diverse teaching-related topics. Our participants suggested that faculty are busy and have autonomy in terms of deciding how to teach. However, autonomy with respect to teaching practices might be a barrier towards engaging faculty in teaching improvement work, including those involving teaching-related conversations. In light of these considerations, it is perhaps even more important that initiative leaders, designers, and administrators cater to STEM faculty members' teaching-related needs and interests, which our participants indicated are plentiful and diverse, in instructional improvement opportunities (as also noted in Bouwma-Gearhart, 2012c; Bouwma-Gearhart, Lenz, & Ivanovitch, 2018; Oleson & Hora, 2014). If STEM faculty view communities, where they can converse with others around teaching-related topics, as relevant or useful with respect to their teaching-related interests they might be more likely to engage in these communities. Additionally, STEM faculty might consider forming their own learning communities, or engaging in conversations with other community members, who share an interest in exploring the same teaching-related topics.

Indeed, encouraging educators to bring their teaching-related experiences and expertise into conversations can be important towards helping educators think about how to improve teaching. Specifically, scholars have pointed to the importance of helping STEM faculty realize a "dissatisfaction with the teaching and learning goals established for students, beliefs about students and how they learn, and beliefs about the effectiveness of instructional practices" (Gess-Newsome, Southerland, Johnson, & Woodbury, 2003, p. 762 - 763). Faculty might develop a dissatisfaction with such teaching-related topics through making explicit their own teaching-related notions and broadening their knowledge of teaching through conversations with other educators. We discuss below, but also point out here, the importance of eliciting and responding

to teaching-related experiences, beliefs, and interests with a sense of curiosity and not judgement, so that faculty do not feel embarrassed if admitting they lack teaching-related knowledge.

Acknowledge that faculty may already be involved in diverse opportunities, wherein they engage with others around teaching-related topics. Also, our participants suggested they were involved in a diverse array of instructional improvement opportunities, including those within their units, in the institution, and outside of the institution, wherein they might engage in teaching-related conversations. Participants also spoke of how the initiative contributed to the 'momentum' of teaching-related improvement efforts underway at the institution, which also indicates that participants perceived many instructional improvements underway. One participant even indicated feeling exhausted per being involved in so many improvement opportunities and some participants expressed confusion about what teaching-related opportunities were part of this specific initiative. Given these findings, we assert it is important for initiative leaders, designers, and administrators, particularly those creating and/or fostering faculty communities, to think critically about synergizing faculty learning communities with other teaching-related improvement efforts. Specifically, initiative leaders and designers, and campus leaders/unit heads, might coordinate initiatives so that initiative strategies target different populations of faculty (e.g., fixed term versus tenure-track) teaching different educational levels (e.g., undergraduate versus graduate courses).

Relatedly, participants also talked about wanting to see more regulations supporting teaching, such as making explicit the institution's vision for teaching improvements, committing to a shared framework of teaching and learning, and requiring instructional professional development for faculty. Explicit regulations about teaching could help those creating

instructional improvement opportunities consider how to focus opportunities around unit and/or institutional goals as well as better identify instructional areas that need more support. Having more explicit regulations around teaching could also help faculty engage in teaching-related conversations inside and outside initiative-related communities, since it might help faculty perceive that teaching was valued in their unit/at their institution.

Calling on initiative designers and implementers to operate with intentionality and knowledge of the institutional system during initiative design and implementation has been suggested by previous researchers (Bouwma-Gearhart et al., 2018; Henderson et al., 2011). Our findings specifically suggest that one part of the institutional system to consider is the larger landscape of initiatives and professional development efforts available, wherein faculty might already invest parts of their limited time in teaching-related conversations. Administrators, instructional improvement designers and leaders, and STEM faculty should consider exchanging knowledge of these opportunities and visions for instructional improvement towards mapping the landscape of improvement opportunities and guiding further efforts.

Create spaces where faculty can talk with community members about teaching-related topics. Many participants spoke about how engaging in teaching-related conversations helped them compare teaching practices and find teaching-related support. Additionally, many participants spoke about how they felt the initiative provided important opportunities for them to engage in a disciplinary diverse community, consisting of educators from across the STEM disciplines, around teaching-related topics. This finding can be related to the decrease in the discussion network's average path length and diameter, which suggests that the network of faculty was more connected than before. Although we cannot directly link this finding back to the initiative, interview excerpts do suggest the initiative was an important part of the STEM

instructional improvement efforts that helped faculty meet and exchange teaching-related knowledge with STEM educators across the institution. These results suggest that many faculty want to have opportunities to connect with others about teaching-related topics, or would be interested in engaging in these opportunities.

In fact, several faculty members desired more initiative-related events and opportunities, with more units involved. This suggests that the specific desire to talk with other community members outside of one's unit may be a big draw for faculty on the part of their engagement in multidisciplinary, initiative-fostered communities. Relatedly, research has noted that creating opportunities for faculty to engage with others around teaching-related topics may be particularly important for faculty who feel departmentally isolated in terms of their interest in teaching-related topics. Participating in faculty communities can supply faculty with "energy, enthusiasm, encouragement, and affirmation" (Kezar et al., 2017, p. 253) that they may not get in their units. This suggests that initiative leaders and designers consider ways to build, sustain, and grow interdisciplinary faculty communities where educators can meet with STEM faculty across the institution who are interested in collaboratively learning teaching-related topics.

Some participants also offered statements about how the initiative communities had either contributed to their or others' effective uptake of novel pedagogical practices towards improving student learning. These results mirror those found in studies assessing participant benefits in national STEM initiatives: Gehrke and Kezar (2016) found that 70% of their study participants reported altering practices while involved in large-scale STEM communities. This suggests that engaging educators in faculty communities, where they might collaboratively learn instructional improvements, can be an effective way to improve postsecondary STEM education.

Also, as a few of our participants noted, engaging in teaching-related conversions could be an efficient way to learn about teaching, especially for busy faculty who do not have extra time to consult the literature. Marketing faculty communities as a way to 'efficiently' learn about teaching could be a useful way for initiative leaders, designers, and administrators to engage busy faculty in instructional improvement communities. If faculty believe that communities can help them efficiently address their teaching needs and effectively help them explore their teaching-related interests, they might be more inclined to participate.

Many participants' discussants changed (to various extents and for different participants) in 2014 and 2015, in terms of whether those discussants were within the participants' unit or outside of their unit. Social network analyses, specifically diameter and average path length calculations, show that the networks changed in such a way that teaching-related information can travel through the community by going through fewer people. This suggests that as interested faculty participate in opportunities to meet with other educators, the overall network of teaching-related discussions might decrease in cohesiveness. In other words, with more faculty talking with community members across units, teaching-related knowledge can be more expediently communicated across the institution.

Create spaces for sharing that are inclusive and safe, towards fostering faculty participation in teaching-related conversations. Our results also suggest that conversational opportunities for STEM faculty, where they might talk about teaching-related topics, must be spaces that are inclusive and safe. This means any faculty member can air genuine teaching concerns to respectful and helpful discussants. Therefore, initiative leaders, designers, administrators, and STEM faculty constructing opportunities that might afford teaching-related conversations should consider communicating explicit norms for sharing and reception. For

example one norm may be approaching others' comments and teaching-related experiences with curiosity, and not judgement. This may help faculty feel more comfortable sharing genuine teaching-related experiences and knowledge.

Another way to help faculty feel comfortable sharing is to explicitly acknowledge the difficulty of teaching as well the norms for pedagogical training and support provided to some STEM faculty throughout their graduate student years and employment. While lamentable that teaching-related training is varied amongst STEM faculty, this reality is one to handle delicately so as not to cause faculty push-back that might impede teaching improvement efforts. Faculty members who perceive a lack of teaching skills and knowledge as a personal failing, or perceive others judging these things as personal failing, may be less motivated to engage in teaching improvement efforts. Like others (Bouwma-Gearhart, 2012b), we suggest initiative leaders, designers, and administrators acknowledge and openly address this norm in teaching-related communities. If faculty know that teaching requires learning, is difficult, and that it is okay to struggle (in fact, struggling is part of an educators' growth) they might feel more comfortable admitting to and openly discussing teaching difficulties. Such explicit acknowledgements help serve as bases for safe professional development spaces for STEM faculty in teaching professional development at institutions (Bouwma-Gearhart, 2012b) as well as STEM faculty engaged in large-scale reform efforts (Kezar et al., 2017).

Develop the administrative support that may be necessary to help foster and sustain opportunities for faculty to talk with others about teaching-related topics. Our participants spoke about the importance of administrative endorsement of improvement efforts. This suggests that getting the 'buy-in' from administrators, who have greater positional roles, is very important in fostering and sustaining instructional improvement opportunities for faculty to talk with others

about teaching-related topics. This result echoes that found in previous studies, which have suggested the importance of engaging upper-level administrators in instructional improvement initiatives (Callahan, Pyke, Shadle, & Landrum, 2014; Gehrke & Kezar, 2016).

Specifically, administrators can help foster instructional improvement initiatives by offering support and recognition to STEM faculty working collaboratively to learn about instructional improvements. This support might manifest as modifying environments and structures to allow (and encourage) time for faculty to engage in teaching-related conversations and teaching-related improvements. For example, administrators in institutions or units could work to explicitly clarify (e.g., write into position descriptions) that time participating in teaching-related conversations (e.g., departmental course meetings) is expected as part of all STEM faculty members' duties. This would likely necessitate alleviating faculty time from other tasks, since our participants also lamented being too busy to spend time on teaching. Another example is unit administrators working with instructional improvement leaders and designers to create required pedagogical professional development opportunities for new faculty, as one of our participants suggested. Through such administrative support, STEM faculty might feel more inclined to participate in teaching-related discussions towards informing instructional improvements

Studying STEM Faculty Experiences in Instructional Improvement Efforts: Reflections on Combining Social Network Analyses and Interviews

We close our discussion with brief but critical thought about using social network analyses in addition to interviews with STEM faculty to take a systems-level approach to understanding how STEM faculty engage in teaching-related conversations. Specifically, our social network analyses illuminated how the teaching-related connections STEM faculty had with others created a larger network of discussions, and how this network changed in

interconnectedness over time. However, social network analyses did not illuminate STEM faculty members' rationales for engaging in teaching-related conversations; specifically, social network analyses did not tell us how STEM faculty members' perceptions of working at an institution of higher education with an ongoing improvement initiative influenced the 'activity' of engaging in teaching-related conversations. To understand that, we analyzed interviews with STEM faculty. We argue that this combination of methods has provided us with a more robust, yet effort-intensive, picture of how STEM faculty engage in teaching-related conversations at an institution of higher education with an ongoing instructional improvement initiative. For example, if we had limited our study to the social network analysis, we might deduce that faculty conversations around teaching-related topics had not changed much, as indicated by stagnant density and centralization values. However, our interviews suggest a more complicated picture — of STEM faculty working in a diverse community shaped by various rules and roles with the potential to impact teaching-related conversations. Furthermore, interviews helped us understand the tools available to STEM faculty for engaging in teaching-related conversations as well as their motives for meeting with others to talk about teaching.

Our interviews suggest that faculty want to engage in teaching-related conversations to compare teaching practices and find support in comfortable and safe conversations. Furthermore, our interview analyses suggest that the initiative helped them do this, via creating spaces for an interdisciplinary community of faculty to come together to talk about teaching-related topics. While it may not have influenced all faculty members' engagement in teaching-related conversations, those who participated in initiative-related events largely saw the initiative as very impactful towards adding value to STEM teaching and learning and helping community members meet others to consider and/or make teaching improvements. In light of these findings,

we suggest that combining social network analyses with interviews is a fruitful, albeit time-intensive, method for the robust study how STEM faculty engage in teaching-related conversations in light of an improvement initiative.

Conclusions

Our study sought to use both social network analyses and interviews to understand how STEM faculty engage in teaching-related conversations, a typical strategy of instructional improvement initiatives, within the context of an institution of higher education with an ongoing teaching improvement initiative. Specifically, we identified salient tensions that may influence STEM faculty members' engagement in teaching-related conversations and discussed these results in light of STEM faculty members' discussion networks. For example, STEM faculty members may have great autonomy with respect to teaching practices and this may inhibit them from participating in teaching-related conversations or cause them to primarily speak with others in their unit about aligning course content, but not about teaching practices. Further, STEM faculty may work in a community with coworkers who are variably interested in teaching-related improvements, meaning that some community members are easier to discuss teaching-related topics with towards instructional improvement than others. Our social network results showed that the discussion networks STEM faculty use to talk about teaching-related topics grew more interconnected over the life of an instructional improvement initiative, suggesting that faculty who chose to talk with others about teaching grew more interconnected. Our study also found that STEM faculty may have varied levels of support to engage in teaching-related conversations, from their institution, units, or as manifested in their professional positions. Feeling unsupported to engage in teaching-related conversations could inhibit faculty from pursuing and participating in opportunities to connect with others around teaching. Finally,

STEM faculty may not feel motivated to engage in teaching-related conversations since conversations are not always inclusive or allow faculty to be open about lacking teaching-related knowledge.

Our results and identified tensions help us communicate recommendations for stakeholders involved in the construction and support of faculty learning communities, where faculty can talk and learn about teaching-related topics towards informing instructional improvements. Specifically, we suggest that initiative leaders and designers consider creating spaces where faculty can talk with coworkers, across the institution of higher education, about teaching-related topics. Any discussions about teaching-related topics should be inclusive and safe to help faculty feel like they can air real teaching-related concerns and insights to respectful and responsive listeners. Our study also shows that STEM faculty members may have a diverse-array of teaching-related interests, which suggests it is particularly important for stakeholders hoping to engage faculty in teaching-related conversations to build off faculty members' varied interests and teaching-related knowledge. Those hoping to foster new faculty learning communities might also consider working with members across the institution, such as administrators, staff, and STEM faculty, to understand the diverse instructional improvement opportunities STEM faculty may already take part in. Finally, our study echoes the results of prior research in that it draws attention to the potential importance of administrative support towards fostering and sustaining opportunities for faculty to talk with others about teaching-related topics. We hope this study contributes to the important and growing body of research on how to meaningfully engage STEM faculty in instructional improvement opportunities, towards enhancing the undergraduate STEM education provided to our postsecondary students.

CHAPTER 3 — Second Manuscript

Exploring STEM Faculty Experiences in Practitioner Inquiry in Light of Their Professional Identity

Ellen Aster & Jana Bouwma-Gearhart

Introduction

Various stakeholders now call on institutions of higher education to improve undergraduate STEM education, towards creating a larger and more diverse body of graduates entering the STEM workforce (National Academies of Sciences, Engineering, and Medicine, 2016). These calls for improvement include teaching more STEM courses using evidence-based instructional practices, which research has shown help students best learn STEM concepts and skills (National Academies of Sciences, Engineering, and Medicine, 2018). Increasing the use of evidence-based instructional practices necessitates engaging STEM educators in meaningful instructional improvement opportunities, where they can be supported to learn these effective teaching methods. Notably, postsecondary STEM educators often have little to no pedagogical training. Limited pre-service faculty have participated in instructional improvement efforts during graduate school, and these trainings have historically been wide ranging in terms of focus and quality (Gardner & Jones, 2011).

There are numerous and varied improvement efforts underway at institutions of higher education that seek to enhance STEM faculty members' uptake and implementation of evidence-based practices (Henderson, Beach, & Finkelstein, 2011). Some of these efforts are *prescribed* in nature, in which the goals of what needs to be improved are planned and set by leaders, while other efforts are more *emergent*, where the goals and values of the initiative are shaped by faculty members' teaching-related knowledge and needs (Henderson et al., 2011). Improvement efforts may target *individuals*, educators' beliefs and behaviors directly, and/or may target the *environments and structures* thought to influence educators' actions around teaching (Henderson et al., 2011)

One strategy for improving STEM faculty members' pedagogical practices is to engage faculty in activities involving 'practitioner reflection.' This category of improvement strategy made up about a third of the almost 200 articles on postsecondary STEM improvement research reviewed by Henderson et al. (2011), suggesting it could be a prevalent change strategy. 'Practitioner reflection' occurs when educators "use their own knowledge/experience/skill to improve their instructional practices" (Henderson et al., 2011, p. 961). Reflecting on teaching thoughts (e.g., beliefs) and actions can help educators "surface and criticize the tacit understandings that have grown up around the repetitive experiences of a specialized practice [e.g., teaching], and can make new sense of the situations of uncertainty or uniqueness which [an educator] may allow [themselves] to experience" (Schön, 1983, p. 61). Providing opportunities for faculty to reflect on their teaching practices can help faculty recognize their pedagogical needs and ways to address them (Bouwma-Gearhart, 2012b; 2012c) including contradictions in their "stated teaching beliefs, goals, instructional practices, and student learning outcomes" (Gess-Newsome, Southerland, Johnston, & Woodbury, 2003, p. 763). Ultimately, faculty reflection on their teaching-related knowledge can be the basis for instructional improvements (Oleson & Hora, 2014).

One type of activity that promotes faculty engagement in teaching-related reflection is *practitioner inquiry*, where faculty identify a teaching-related problem of their interest/relevance to their practice, collect and analyze appropriate data, and use this data to guide instructional improvements. Practitioner inquiry has existed as multiple forms and titles across K-20 education levels, including 'action research,' 'teacher research,' 'self study,' 'the scholarship of teaching and learning,' and 'the use of teaching as a context for research' (Cochran-Smith & Lytle, 2009). Postsecondary STEM education scholars have documented and explored the

practitioner inquiry forms of ‘teaching-as-research,’ the ‘scholarship of teaching and learning, ‘action research’, ‘classroom assessment,’ ‘classroom research, ‘action learning,’ ‘classroom action research,’ ‘scientific teaching,’ ‘research-led teaching,’ and ‘teaching-based research’ (Bouwma-Gearhart, 2012d; Connolly, Bouwma-Gearhart, & Clifford, 2007). Generally, faculty engaged in practitioner inquiry: a) formulate a research question about their teaching practice; b) create a research plan that builds off previous knowledge; c) implement a research plan, studying changes to answer the research question (i.e., gather and analyze data); d) reflect on findings to inform pedagogical changes and potential need for further inquiry; and g) organize and share results (Connolly et al., 2007).

Practitioner inquiry is usually distinguished from discipline-based education research (Dolan et al., 2018). Specifically, the scholarship of teaching and learning (an international postsecondary form of practitioner inquiry) focuses on collecting and analyzing classroom-specific data, usually by educators in charge of those classrooms, towards curricular and instructional improvements (Dolan et al., 2018). Discipline-based education research (generally not thought of as practitioner inquiry, but also performed at the postsecondary level) concerns “research questions and hypotheses about teaching, learning, and ways of thinking in a discipline that extend beyond single classrooms and programs in order to yield original, generalizable, and mechanistic insights into educational processes and their effects” (Dolan, et al., 2018, p. 33).

Research has suggested that efforts to improve teaching, or professional development opportunities, can be complicated by faculty members as individuals, including their perceptions, proclivities, and motivations built upon their past experiences (Bouwma-Gearhart, 2012a; 2012c; Bouwma-Gearhart, Perry, & Presley, 2014). In an argument-driven review of research, Brownell and Tanner (2012) point out that biology faculty might struggle making pedagogical changes due

to their *professional identities*, or how they "view themselves and their work in the context of their disciplines and how they accrue status among their professional colleagues" (p. 341). Brownell and Tanner (2012) contend that "[i]f a scientist has a professional identity he or she feels could be put at risk in his or her discipline and among his or her peers by embracing innovative approaches to teaching, then professional identity becomes a critical barrier in efforts to promote widespread [pedagogical] change" (p. 341). Brownell and Tanner (2012) specifically postulate three interrelated points of tension between science faculty members' professional identity and engaging in instructional improvement: 1) many science faculty members have had training focused more on creating a 'research' identity than an 'educator' identity; 2) science faculty may worry that openly identifying as an 'educator' will confer them lower status amongst their science colleagues; and 3) the general culture around being a science faculty member may foster the notion that being an 'educator' is lesser than being a 'researcher.' We argue that these realities are likely true for faculty across the STEM disciplines: Even when STEM faculty aspire to be good educators, they may work with peers and in organizations that privilege the identity of 'researcher' over the identity of 'educator' (Robert & Carlsen, 2017).

While the research mentioned above is illuminative, we note underspecification of researchers' notions of professional identity, as well as under-exploration into the interaction of individuals' intricate professional identities and the complex contexts they exist in as professionals. After reviewing research on K-20 educators' professional identity, Beijaard, Meijer, and Verloop (2004) argue that professional identity can be described by four features: 1) it is shaped by educators cognition concerning the various social contexts they learn and act in, meaning that educators perceive expectations for how to appropriately act based on the contexts they work in but that they may "differ in the way they deal with these characteristics depending

on the value they personally attach to them"; 2) it is comprised of many 'sub-identities,' with different relevance in different contexts; 3) it is constructed and reconstructed as an educator engages in experiences towards informing who they are, as well as who they want to become; and 4) it is shaped by an educator's *agency*, meaning it is shaped by an educator's actions and the goals an educator pursues in light of available resources (p. 122). Professional identity is not merely a trait an educator 'has,' but also something an educator 'uses' to present and demonstrate belonging across varied contexts (Beijaard et al., 2004). In light of these considerations regarding STEM faculty members' professional identities, more empirical research on how instructional improvement efforts, such as practitioner inquiry, are shaped by (as well as shape) STEM faculty members' professional identities is timely and important.

Previous research on the interaction between professional identity[7] and practitioner inquiry has primarily focused on understanding the experiences of multidisciplinary faculty members in the scholarship of teaching and learning. This research has suggested that participating in the scholarship of teaching and learning challenges, and shapes, faculty members' professional identities because faculty are engaged in a new field of research (Marquis et al., 2017; Miller-Young, Yeo, & Manarin, 2017; Simmons et al., 2013) and faculty might change who they are as educators as a result (Miller-Young et al., 2017). Furthermore, research has shown that participating in communities while engaging in the scholarship of teaching and learning can help faculty build identities as scholars of teaching and learning (Marquis et al., 2017; Simmons et al., 2013), which might prompt faculty consideration of how their growing scholar of teaching and learning identities fit (or do not fit) within their departments and

[7] Specifically, Simmons et al. (2013) explores faculty members' "academic identities," but they define this as "the meaning one attaches to roles and tasks required within a particular institutional context" which seems similar to our notion of professional identity (p. 10).

disciplines (Miller-Young et al., 2017). While also insightful, these studies focus on faculty from a range of disciplines and positions, leaving us to wonder about other salient contextual factors and faculty realities, including those associated with different professional positions (i.e. tenure-track versus non) and different disciplines (i.e., STEM).

Studies have pointed out that STEM faculty members may have unique experiences while engaging in practitioner inquiry. Connolly et al. (2007) studied how STEM faculty members at one research university define teaching-as-research (one practitioner inquiry form) as well as what concepts they associate with the term. They found that some STEM faculty, especially those with less teaching experience, described their practitioner inquiry work using terms from their STEM disciplines. Other researchers have noted that STEM faculty at a public Canadian university struggled with the "culture [of education practitioner inquiry], experiential learning, personal reflection and [the] iterative process of moving backwards and forwards between [a] familiar STEM approach and a different way of thinking" (Kelly, Nesbit, & Oliver, 2012, p. 4). These findings relate to research on multidisciplinary faculty members' experiences in the scholarship of teaching and learning, which has made brief claims about how the scholarship of teaching and learning affects STEM faculty including: 1) STEM faculty may struggle with the subjective nature of the scholarship of teaching and learning (Miller-Young et al., 2017), and 2) STEM faculty may not feel confident doing more social science-oriented research that involves collecting data from human subjects (Marquis et al., 2017). Although this previous research helps us identify some factors that may be related to how practitioner inquiry interacts with STEM faculty members' professional identity, we need more research that specifically explores how practitioner inquiry interacts with the (re)construction of STEM faculty members' professional identity in relation to what research confirms is important to professional identities,

including educators' motivations and interests, what they value, and their agency in light of varying and diverse institutional/organizational contexts (Beijaard, Meijer, & Verloop, 2004). Generally speaking, the field would benefit from more research employing rigorous theoretical grounding on identity to orient analysis and interpretations.

As well we contend that an especially underexplored factor concerning the interplay of practitioner inquiry research and STEM faculty members' professional identity is professional position (e.g. tenure-track, instructor, adjunct positions). Mathany, Clow, and Aspenlieder (2017) found that higher education personnel of different professional positions face unique challenges to understanding how being a 'researcher' fits with practitioner inquiry work. Specifically, Mathany et al. (2017) studied how the scholarship of teaching and learning influenced the professional identities of tenure-line and non-tenure line faculty, graduate students, and staff (e.g., support specialists for students and faculty). They grouped faculty of tenure-line and non-tenure line positions into one group of faculty, but found different barriers for faculty, staff, and graduate students in terms of building a scholar of teaching and learning identity. Specifically, Mathany et al. (2017) found that faculty may be hesitant to identify as scholarship of teaching and learning researchers because this identity confers a lower status than a discipline-based researcher identity. Mathany et al. (2017) further found that staff worried that they were not scholarship of teaching and learning researchers since they did not "fit the traditional researcher profile," likely because their work focuses on student/faculty services, even though part of their motivation to participate in education practitioner inquiry was to legitimize their work (p. 8). (Graduate students, interestingly, were hesitant to identify as researchers at all, let alone in the newer field of scholarship of teaching and learning.) These results suggest that the intersection of practitioner inquiry and professional identity may be influenced by professional position, and

points to the need for additional research that considers practitioner inquiry experiences in light of participants' professional positions. In particular, faculty appointments outside of the tenure-line system are growing more prevalent (Gappa, 2008). This change in faculty positions warrants more research on how non-tenure track faculty experience practitioner inquiry in light of their professional identities.

We additionally contend that institutional/organizational context matters to how STEM faculty, of various professional positions, may experience professional identity in light of practitioner inquiry experiences. Institutions, their units, and their human participants, all play crucial roles in how professionals are identified, by others and themselves. Along with a noted lack of rooting in theory, we note a lack of research attending to the greater sociocultural contexts potentially at play at the intersection of postsecondary educators' identity and practitioner inquiry. In light of these needs, and others detailed above, we embarked on a study using Gee's (2001) analytic lens of identity to explore how STEM faculty, primarily fixed-term faculty working at a research university, experience practitioner inquiry in light of their professional identities.

Theoretical Perspective

We employed Gee's (2001) analytic lens of identity to explore how STEM faculty experience practitioner inquiry in light of their professional identity. Via this lens, *identity* is conceptualized as the kind of person someone is recognized as being in a given context. People thus have multiple identities that are constructed, to various degrees, through recognition by themselves and others in different situations. Identities are also historically-, institutionally-, and socially-constructed, meaning that identities change, and carry varied meanings across time and per influence of larger social systems. In modern capitalist societies, identities are also imbued

with different degrees of power: Some identities are thought of as inferior based on attributions by members of society concerning identity-associated "skill, intelligence, morality, or sufficient effort" (Gee, 2001, p. 113).

Gee (2001) offers four perspectives of identity. These include: a) nature-identity; b) institution-identity; c) discourse-identity; and d) affinity-identity. Note that these identity categories are not mutually exclusive: They "interrelate in complex and important ways" in "[b]oth theory and in practice" (Gee, 2001, p. 101). However, distinguishing between these types of identity helps us illuminate subtleties in how professional identities gain power and/or significance via different forms of recognition.

Nature-identity refers to characteristics or ways of being a person largely "developed from forces in nature" (Gee, 2001, p. 102). An example of a nature-identity is 'sibling.' Nature-identities, however, "always collapse into other sorts of identities" because they "gain their force as identities through the work of institutions, discourse and dialogue, or affinity groups," which are reflected in the other categories of identity (Gee, 2001, p. 102). For example, being a 'sibling' could be considered a 'fact' derived from nature (i.e., you and another person have one or more parents in common). But this 'fact' is one built on a definition that is given meaning by human communities. As well, being a 'sibling' extends beyond a definition purely defined by biological facts, since one could have non-biological 'siblings' or even consider a close friend a 'sister.' Thus, what it *means* to be a sibling is socially situated. As well, like all identity perspectives, nature-identity perspectives are more salient in some contexts than others. For example, a STEM faculty member being a half-brother may not be a noticeable part of their identity when they engage with colleagues at an institution of higher education. However, when

their brother asks them to give a research presentation at his place of business, being a sibling may be a very salient component of the faculty member's identity.

The second form of identity, *institution-identity*, derives meaning from institutional authorization or sanctioning. Examples of this type of identity include being (and being labeled) a STEM faculty member or a unit administrator (e.g., of a department, school, or college) at an institution of higher education, or being conferred a degree or award from an institution. Institution-identities can be perceived by an individual conferred them as "either a calling or an imposition" (Gee, 2001, p. 103). For example, a STEM faculty member may enthusiastically engage in activities associated with being 'STEM faculty,' such as research, scholarship, and mentoring of undergraduate and graduate students, viewing these as aligned to longstanding goals and interests. Conversely, a faculty member might view their department assessment 'administrator' role a burden, feeling it inhibits them from engaging in their disciplinary research and/or saddles them with annoying regulatory tasks.

The third type of identity is *discourse-identity*, which gains significance through interactions with 'rational[8]' individuals. Discourse does not just include dialogue (interchanges via conversation), but any 'interaction' with someone, such as talking about a person or treating someone a certain way. Example discourse-identities include being a 'good' undergraduate STEM instructor or an 'uncollaborative' STEM researcher. Just as with institution-identities, discourse-identities "can be placed on a continuum in terms of how active or passive" a person pursues them (Gee, 2001, p. 104). For example, coworkers might 'ascribe' a STEM faculty member a 'bad' undergraduate instructor because they only lecture using an overhead projector.

[8] Gee (2001) defines 'rational individual' as those interacting with someone for "reasons (or for what count as 'reasons' to them and others like them) and not because they are 'forced' to do this by ritual, tradition, laws, rules, or institutional authority (which would render the trait an I[nstitution]-Identity)" (p. 103).

Alternatively, a STEM instructor might 'achieve' the identity of being a 'good' STEM instructor since they work hard to improve their teaching and receive positive student reviews in end-of-the-term evaluations.

The last identity perspective is affinity-identity. *Affinity-identity* is derived via 'affinity groups,' or collections of people who share practices and participate in similar experiences. Specifically, affinity-identity is derived via the "allegiance to, access to, and participation in specific practices that provide each of the group's members the requisite experiences" (Gee, 2001, p. 105). For example, an affinity-identity that a STEM faculty member might have is being part of a practitioner inquiry group, where the faculty member shares the practice of conducting classroom research with other faculty. An affinity-identity might be institutionally-sanctioned, such as belonging to a STEM department or being part of a practitioner inquiry program in an institution-wide, teaching improvement initiative. It also might be more informally fostered, such as a group of STEM faculty having Friday beers to share experiences teaching lower-division courses.

Methods

Research Questions

Our study was guided by the research question, *How do STEM faculty experience practitioner inquiry in light of their professional identity?* To understand faculty members' experiences as practitioner inquiry participants at an institution of higher education, we employed a phenomenological research approach. This means we sought to describe the "lived experiences" of STEM faculty using their descriptions of what it has been like to participate in a practitioner inquiry program (Creswell, 2014, p.14). To this end, we conducted semi-structured

interviews with participants to understand the "meaning and depth" of their practitioner inquiry experience (Moustakas, 1994, p. 116).

Our research is also shaped by ontological and epistemological considerations. Specifically, our research is primarily rooted in a constructivist worldview, in which we assume that knowledge is shaped by culture and history and is created as people live and learn in social contexts (Creswell, 2014). Reality is also subjective, in that it varies from person to person (Creswell, 2014). These considerations mean that, in collecting and analyzing interviews, we co-construct knowledge with our participants towards describing the breadth and depth of participants' varied experiences.

Participant Sample and Research Setting

We purposively selected STEM faculty who were engaged in practitioner inquiry at an institution of higher education classified as a *doctoral university with the highest research activity* (Carnegie Classification of Institutions of Higher Education, n.d.). Participants were engaged in the third cohort of a voluntary practitioner inquiry program, which was developed and implemented by a larger, institution-wide comprehensive STEM education improvement initiative. Often, several faculty members applied to the practitioner inquiry program, as part of a team. The model for the practitioner inquiry program evolved over time, but the main components were largely unchanged. Faculty members (both tenure-track and fixed-term) were given a small research budget and mentor with experience in educational research with whom they were expected to meet regularly. Faculty pursued research, either as individuals or in groups, around a teaching-related problem of interest/relevance to their instructional contexts. Each year-long cohort engaged in a professional learning community that met four times during the academic year to help refine their research problems of focus, choose designs and methods

appropriate to their questions, and learn strategies for analyzing their data towards meaningful teaching-related conclusions they could act on. Each participating faculty member or team was expected to disseminate their findings both within the community of STEM faculty at the university and externally, either by presenting at a conference or by submitting an article to a peer-reviewed journal. The program was initially funded by a grant that was the impetus for the STEM teaching improvement initiative and the fourth cohort's work was supported by the institution of higher education.

Data Collection

The first author created a semi-structured interview protocol, meant to elicit faculty experiences with the practitioner inquiry experience and piloted this protocol with two social science faculty and one STEM faculty member who had been or were participating in the practitioner inquiry program (who were then not study participants). After each pilot interview, the first author made amendments to the protocol per interviewee feedback and the overall interview experience. Members of the first author's dissertation committee were also invited to provide feedback to the interview protocol. These measures helped us feel confident that the interview protocol might elicit answers useful to our research interest.

The recruitment script (Appendix C), interview protocol (Appendix D), and consent form were filed for IRB approval, which was secured. The finalized and approved protocol asked participants to share information about their: 1) faculty positions; 2) prior experience with research on teaching and learning; 3) motivations for applying for the practitioner inquiry program; 4) participation in program meetings; 5) practitioner inquiry progress; 6) perceived abilities to do practitioner inquiry work; 6) perceptions of whether practitioner inquiry work was research or scholarship; 7) perceptions of themselves as STEM education researchers; 8) benefits

of participating in practitioner inquiry work; 9) perceptions of the extent their participation would influence their STEM unit; and 10) additional takeaways from participating, not already covered in the interview. Since two members of the third practitioner inquiry cohort were working in a social science discipline (i.e., they were not STEM faculty), and had already participated in pilot interviews, the first author sent study invitations to the remaining 14 of 16 practitioner inquiry participants in the third cohort. The first author conducted interviews with 10 consenting interviewees (response rate 71%), which included eight fixed-term and two tenure-track faculty. Table 2.1 displays participant pseudonyms, their professional positions/titles at the institution, whether they expressed having prior experience with practitioner inquiry and/or educational research, and the number of years they had been an educator in their STEM field.

Because we do not want to assume gender identities, which was not a construct explored in this study, we gave each participant a gender-neutral pseudonym. Each one-on-one interview lasted about 15 - 55 minutes in length. A few participants initially perceived the interviews as being evaluative in nature, so the first author (i.e., interviewer) made sure to reassure participants, when applicable, that the interview was to help researchers understand faculty experiences doing practitioner inquiry work and that there were no ‘right’ or ‘wrong’ experiences or perceptions.

Table 2.1

List of Participants, Participants' Professional Positions, Participants' Prior Experience with Practitioner Inquiry/Educational Research, and Number of Years Participant has been an Educator in their STEM Field.

Participant	Professional Position	Prior Experience with Practitioner Inquiry and/or Educational Research?	Number of Years an Educator in their Field
Ryan	Fixed-Term Faculty	No	Less than 5 years
Taylor	Fixed-Term Faculty	Unknown	5 - 10 years
Sydney	Fixed-Term Faculty	Yes	Unknown
Quinn	Fixed-Term Faculty	No	Over 10 years
Peyton	Fixed-Term Faculty	Yes	5 - 10 years
Mickey	Fixed-Term Faculty	Yes	5 - 10 years
Logan	Fixed-Term Faculty	Yes	Over 10 years
Kendall	Tenure-Track Faculty	Yes	Over 10 years
Jordan	Tenure-Track Faculty	Yes	5 - 10 years
Frankie	Fixed-Term Faculty	No	Over 10 years

Note. We do not report participants' STEM disciplines to reduce the possibility of identifying participants.

Data Analysis

The first author employed both inductive and deductive analyses of interview transcripts. Specifically, the first author inductively coded interview transcripts using the open coding methods described in Auerbach and Silverstein (2003). The analyst read through the text of each interview, selecting sections of *relevant text* that related to the research question. The analyst then read through relevant text excerpts, sorting them into *repeating ideas*, or codes. The second author reviewed these emergent codes, definitions, and the first author's memos about the coding process. This peer debriefing continued during all steps of the coding process to enhance the validity of developed codes and limit the possibility of coding bias (Creswell, 2014).

These codes were the basis of a second round of coding, wherein the first author searched for additional evidence to support emergent codes, refute emergent codes, or modify emergent codes in light of new evidence (Creswell, 2014). The first author uploaded transcripts into Dedoose, a web application useful for coding media. Then the first author re-read interview transcripts and, keeping in mind codes developed previously, sorted text under codes, amended codes, or created new codes. As larger groupings of codes were made apparent, codes were grouped into parent codes. Similarly, related parent codes were grouped into grandparent codes. These larger codes helped the first author think about how interview excerpts answered the research question as well as reflexively contemplate the relationships between the interview data, research question, and Gee's (2001) framework of identity. This type of emergent design is common in qualitative research studies, where the research processes is continuously assessed and modified in light of new findings (Creswell, 2014).

Limitations

Like all research, our study is bound by limitations. First, while we believe interviews are useful in potentially eliciting rich data concerning how STEM faculty experience practitioner inquiry in light of their professional identities, we note the following limitations. For one, we cannot be sure to have elicited all relevant thoughts/experiences. Just because a participant did not mention something in an interview does not mean it was not an experience they had or a belief they held that could be potentially relevant to answering our research question.

Also, although we argue that generalizability was not a goal of this study, and should not be a goal of most small-scale qualitative research, we still acknowledge that our findings are based on a small participant 'sample size' and, thus, our study is limited in generalizability. Although our work is limited in generalizability, we believe our results might be illuminative

and/or interesting to the larger education research community, particularly to those interested in studying STEM faculty identity in practitioner inquiry or making efforts to design/lead practitioner inquiry programs for STEM faculty.

Finally, both authors have had various involvements in the improvement initiative. The first author has attended initiative-related events, occasionally helping take notes as well as contributing (and listening) to conversations related to ongoing initiative design. The second author has been involved in the design and implementation of the initiative. Both authors have been (and are) involved in various research projects related to understanding the experiences of STEM faculty in the initiative. While proximity to our research site, and participants, has the potential to result in biases, we believe our involvement in and research of the initiative also offers us an 'insider' perspective. By this, we mean that we have a rich understanding of the initiative which enables deep reflection on how STEM faculty experience the initiative. To curb biases, we review this paper with the first author's dissertation committee, who will be able to provide 'outsider' edits.

Results

Coding relevant to our research question, *How do STEM faculty experience practitioner inquiry in light of their professional identity?*, is shown in Table 2.2. Specifically, we found that many participants: a) wanted to engage in scholarship concerning education; b) identified as 'novice' education researchers; c) had beliefs concerning the appropriateness, comfort, and notions regarding the legitimacy of quantitative- and qualitative-based practitioner inquiry work; d) saw practitioner inquiry work as not formally part of their faculty position; and e) saw practitioner inquiry work as helping them build identities as scholars of education. We also found that participants: f) connected with other faculty around shared practices/interests in a

formal practitioner inquiry program; g) connected with a national STEM education research community; and h) expressed various extents of recognition from their unit and/or institution. We provide nuance and evidence, in the form of interview excerpts, for each of these categories in this order.

Table 2.2.

Codebook Informing our Research Question, "How do STEM Faculty Experience Practitioner Inquiry in Light of Their Professional Identity?"

Code	Definition	*n*	Example Excerpt
Wanted to Engage in Scholarship Concerning Education Participant describes aspects of their experiences or beliefs indicating that they want to engage in scholarship around education			
Want to Improve or Evaluate Teaching	Want to explore teaching improvements, broadly speaking, and/or evaluate if a particular pedagogical technique/curriculum is effective	10	I wanted a mechanism to look at what I was doing and to convince my co-instructor that there was some structure to it. That's one thing [reason why I applied to the practitioner inquiry program]. (Frankie)
Want to Understand/Improve Student Learning	Want to understand how students learn, towards creating more successful students	6`	I think that the thing that always motivates me is helping my students learn, and be more successful. But, I think that I figure out how to help them learn, and be more successful, by either collecting my own data, or using current literature. And so collecting my own data certainly helps, 'cause context matters. But also, just relying on the literature of best practice, and how that works for different people. (Peyton)
Engaged in/with Multiple Education Research Grants	Mention of engaging in one or more grant/funding opportunities, aside from the practitioner inquiry program, that are focused on STEM education research/improvements	5	And it's been the support from people and from some funding sources that made all that happen [collaborating with undergraduates on discipline-specific, STEM education research towards publication]... (Logan)
Planned to Engage in Scholarship Concerning Education 'Anyway'	Anticipated doing practitioner inquiry project 'anyway,' regardless of there being the practitioner inquiry opportunity and/or was already engaged in practitioner inquiry-like research prior to engagement in practitioner inquiry program.	5	Being an educational researcher I start with evidence based practices. When I learned about the opportunity to participate in the [practitioner inquiry program] I saw the potential to have some support for the work that I was already doing… (Mickey)

Being 'Novice' Education Researchers

Many participants identify as ‘novice’ education researchers.

Saw Themselves as a 'Novice' Education Researcher	Participant identifies as a ‘novice’ education researcher	6	It's definitely been super helpful [to work with a faculty member who’s done the practitioner inquiry program before], because even with the [practitioner inquiry] program, sort of a new field for me, so it's helpful to have someone who's done a little bit of this kind of thing before. (Ryan)
Lacked Knowledge of the Field of STEM Education Research	Participant has or implies having a limited understanding of the field of STEM education research, including knowledge of appropriate research methods	4	I was looking at some books that I could just go get from the library on building surveys and survey instruments, and there was a lot. There's so many books. And I was like, ‘I only got time to read one or two of these, which one do I go to?’ And if there was somebody that I could have gone to and said, ‘Which ones do you think would be most relevant to my type of questions and my type of assessment that I want to do?’, that would have been helpful. (Logan)

Beliefs Concerning Appropriateness, Comfort, and Notions Regarding Legitimacy of Quantitative- and Qualitative-Based Practitioner Inquiry Work

Participant beliefs concerning the appropriateness, comfort, and notions regarding legitimacy of qualitative and/or quantitative methods in practitioner inquiry work

Beliefs Concerning Quantitative Methods	Descriptions of practitioner inquiry work using quantitative methods, such as 'plots,' 'control groups,' 'experimental designs,' the 'scientific method,' 'statistical analyses' and/or definitions of practitioner inquiry work as being 'hypothesis-driven' or 'systematic.'	7	[I believe my practitioner inquiry work is research and/or scholarship because] when I think about research and scholarship research, I feel like it's coming up within a plan, experimental [de]sign, and then implementing it, and then collecting the data and analyzing it. That is what I do with the [practitioner inquiry] work, so that's the research. Then the scholarship part I think is how you develop your ideas for implementing the plan or designing the experiments, and then also how you summarize them and write about them afterwards. (Ryan)

Beliefs Concerning Qualitative Methods	Descriptions of qualitative methods in practitioner inquiry	3	I think I have gained a little bit some more confidence in doing things [i.e., practitioner inquiry] the way that I see that they need to be done as appropriate with the [qualitative] skills that I have and in focusing on questions that I think are relevant, and answering them in ways that I see they can be answered most effectively. The confidence comes in to play and because maybe there were some insecurity in thinking I had to incorporate the quantitative analysis of a certain kind in order to have a legitimate study. I'm kind of pushing back on that, some confidence in saying I can make decisions as a researcher based on the questions that I want to answer and it doesn't necessarily have to be dictated by a perceived view in this [STEM] field that only quantitative data is legitimate. (Mickey)

Practitioner Inquiry is Not Formally Part of Faculty Position

Being involved in practitioner inquiry is not necessarily part of a STEM faculty member's official duties

The Research Involved in Practitioner Inquiry is Not (or is Limitedly) Part of Position Description	Participant's position description provides little- to no-incentive to explicitly engage in practitioner inquiry	6	...and the [practitioner inquiry program] was very helpful in getting [a promotion], and I actually had lots of people who came to me during that time and kept asking me, 'This seems a little odd for somebody who's just a [fixed-term faculty] to have started engaging in so much of these other activities that are more like what a researcher would do and not a [fixed-term faculty member],' so I think it was very beneficial [getting my promotion]. (Jordan)
Too Little Time to do Practitioner Inquiry	The participant does not have time to do practitioner inquiry	5	I think it's like a long-going project [my practitioner inquiry work]. I'll be work[ing] on it for a long time. I want to, not that I'll have the time to, but I hope to. (Ryan)
Need Financial Support to Engage in Practitioner Inquiry	Money is needed to justify the time spent on practitioner inquiry	2	Probably I'll say the money. It's that I really wanted to do extra stuff. (Logan)

Need Mentorship/Support to Engage in Practitioner Inquiry	Participant expresses a need for mentorship/support to engage in practitioner inquiry	2	Being an educational researcher I start with evidence-based practices. When I learned about the opportunity to participate in the [practitioner inquiry program] I saw the potential to have some support for the work that I was already doing, and some recognition also that I was doing that work, and some funding for dissemination of knowledge, which is important to me as an educational researcher more broadly, and publishing, and mentorship within the program. (Mickey)

Practitioner Inquiry Work Helps Build Identity as a 'Researcher'

Participant shares experiences or beliefs indicating that practitioner inquiry work helps them build a 'researcher' identity

Publishing Practitioner Inquiry Work	Participant plans to or already has published practitioner inquiry work.	7	I think the final goal, which I didn't mention before was like write a paper on what we found through the [practitioner inquiry] program, and I did that along with the help of two mentors, one being the same [mentor spoken about previously], one being another person. (Ryan)
Publication Validates Practitioner Inquiry as 'Research' and/or 'Scholarship'	Practitioner inquiry could be considered 'research' and/or 'scholarship' if it is published.	7	I am not quite there but I'm confident that what I have will be...Somebody will publish it [my practitioner inquiry work] and somebody will find it interesting. I'm confident that if you come back to me in six months I will say, 'Oh, here's my badge, see? I did make the club [of researchers].' (Logan)
Want/Need/Received Validation or Recognition from STEM Education Research Community to be a 'Researcher'	Participant wants, or has received, validation of being a 'researcher' from a larger, national STEM education research community (or national, disciplinary-specific STEM education community)	6	Ryan: That was nice, and yeah, I mean it's always good to get positive feedback [on my practitioner inquiry work]. That's helpful, especially when you don't really feel like you know what's you're doing but you're doing it. Interviewer: Yeah, yeah. It's like positive feedback from being accepted at conferences and that sort of thing... Ryan: Yeah, and from people you haven't met before.

Building/Being Part of Disciplinary Research Group/Team around Practitioner Inquiry Work

Evidence of participant building or working in a small research group, such as working with colleagues from their disciplinary unit and/or engaging undergraduates/graduate students in practitioner inquiry work.

Working on Practitioner Inquiry Project with Faculty in Same Unit	Participant explains that they worked on their practitioner inquiry project in collaboration with one or more faculty in the same unit.	6	Kendall: I think it's kind of the collaboration [that's been most meaningful about participating in practitioner inquiry], because me, even when I did it before, we did the training of the [undergraduate peer-instructors] in collaboration with a couple of other folks. So me, and this other faculty, were working together on this, and we actually...even though the third one wasn't on the [practitioner inquiry project], she also kind of joined us, and helped. Interviewer: Oh, okay. Kendall: So I think how it kind of increased collaboration is good. Interviewer: Okay. Were you collaborating mostly with people in your [unit], or outside, or...? Kendall: Mostly in.
Engaging Students in Practitioner Inquiry Work/STEM Education-Related Research	Participant explained that they engaged one or more undergraduate and/or graduate students to help them with the practitioner inquiry work or with other STEM education research-related work	4	And so I do feel that [during my practitioner inquiry work] I went from collecting to going through a process, to engaging graduate students and undergraduates and managing them, and going through that whole process. (Jordan)
Presenting at Conferences	Participant and/or participant's practitioner inquiry team member has presented talks and/or posters on practitioner inquiry project at conferences	5	We were able to go to three conferences and will be able to publish using the [practitioner inquiry program] funds. (Taylor)
Want to 'Return' to Research and/or Engage in Scholarship Concerning Education	Participant explains that they wanted to 'return' to research via engagement in scholarship concerning education	4	Yeah. I think so [noticed benefits from participation in the practitioner inquiry program]. It has personally kept me feeling like I'm still connected to thinking about important things. I mean, instructing is great and I do a lot of fun planning, but there's some...when you go to graduate school research is what it's all about. It's kept me connected to that even though it's not a huge part of my job description. (Frankie)

Redefining Fixed-Term Faculty Roles to Include Education-Related Research	Beliefs and/or perceptions of education-related research being a useful part of fixed-term faculty duties	3	And what I feel like are a new class of [fixed-term faculty] that didn't exist 20 years ago, [fixed-term faculty] were often like a stepping stone thing or they...I was the first PhD [fixed-term faculty member] that we had, and so, you have these people that now have their PhD, they are trained in research, they are capable of doing a lot more. They do want to be career educators, but they also want to be interested in education research, and I think creating a structure for that class is incredibly important because without it, it's just not going to happen. (Logan)
Practitioner Inquiry Work 'Practically' Informs a Classroom	Practitioner Inquiry work has roots in action research, practice-based research, and/or is 'practical' by making changes to a specific course or curricular tool	6	Kendall: [...] but maybe the [practitioner inquiry program] was kind of inspiring me that you don't have to do some huge thing. You can do a small thing. Interviewer: Mm-hmm. Small thing, meaning like a classroom? Kendall: Yeah, it was just one [paper written about a classroom change, unrelated to the practitioner inquiry program]. It was really one assignment that was kind of unique, and was built to elicit some other things, and I got IRB around that assignment, and wrote a paper on it, so...to have the students responding to that assignment, and their work products, and things like that. Interviewer: That is cool. Kendall: I mean, it was a [conference] paper, it wasn't an archival journal, but ... Interviewer: Mm-hmm, mm-hmm, okay, cool. So maybe your experiences...so what I hear you saying is maybe those experiences doing the [practitioner inquiry] stuff helped you sort of reframe... Interviewer: Yeah, that it [practitioner inquiry-related work] could be a little bit smaller, and smaller in scope.

Connecting with other Faculty around Shared Practices/Interests in Formal Practitioner Inquiry Group
Participants engage in a formal institution-wide, multidisciplinary STEM practitioner inquiry program where they share interests and practices with other STEM educators.

Enjoyed Belonging to a Group of STEM Faculty at the Same Institution who Share an Interest in Improving STEM Education	Participants enjoyed belonging to a group of STEM faculty, from different units, where faculty could collaboratively explore practitioner inquiry and connect around shared teaching-related interests/improvements (e.g., with other STEM faculty, STEM education faculty)	7	Exposure is a big one [salient benefit of participating in practitioner inquiry program], just meeting all these people. (Logan)

Presenting Practitioner Inquiry Projects at Institution-Wide, End-of-Year Poster Session(s)	Participant presented their practitioner inquiry work at one or more end-of-year poster session(s) for other practitioner inquiry participants as well as the institution's larger community	5	… I think I've been to most all of the [initiative events] and the [practitioner inquiry] events and the poster sessions […] so I presented [in the poster session(s)]. (Logan)
Initiative/Practitioner Inquiry Designers/Leaders Helped Participants with Practitioner Inquiry	Participants received help with practitioner inquiry through encouragement or assistance from practitioner inquiry designers/leaders	5	So we met with [this initiative leader/designer]. [They were] really supportive. [They] just helped us figure out what we should be asking, where did it fit in the overall, you know, like, 'What do we already know about this kind of thing', and then we needed to do the IRB training and so, staff at, I mean the, I don't remember, the [initiative] staff, I'm sure I'm not gonna... [name of initiative leader/designer]... and what's [their] name? Interviewer: Maybe [name of initiative leader/designer]? Speaker 2: [Affirmative]. Helped us sorta figure all of that out, and do our training. We got lots of emails from them, cause I had never done that training before. (Quinn)
Appreciated Belonging to a Group of Faculty 'Figuring Out' Practitioner Inquiry Together	Participant appreciated being part of a community of STEM faculty who were 'figuring out' how to do practitioner inquiry work together	3	[W]hat I've really valued most about the [practitioner inquiry program] is the interactions with the other [practitioner inquiry program participants]. And having the opportunity to talk about what we're doing, and different things about how they're getting their IRBs, and how I'm getting my IRB, and how we're actually...what we're thinking about, and the different ways that we're teaching, and really just thinking about how all of us are working to innovate and improve our teaching, and the data that's working with all of our students. And so for me, those faculty interactions, and the colleagues that I've met across units that I wouldn't have met otherwise, have been really valuable. And yeah, I mean, maybe in my confidence, but more so just my knowledge is almost what it is, right? About how to do research, and how to do it at this institution, and what the pathways are to get the data that you [want to] collect for your students, I think, has been really valuable. (Peyton)

Connecting with a National STEM Education Research Community	Participants' practitioner inquiry work helped them connect with others in a national STEM education research community.	3	Ryan: Also, I think maybe biggest thing that I got from [practitioner inquiry program] and the conferences like creating relationships with other people that I wouldn't have otherwise. Across campus, for example, other [units]. Interviewer: With people who were participating in the program. Ryan: People that were participating in the [practitioner inquiry program] or just people I met at the conference that I have connections with now. That's always a good thing.

Recognition from Unit and/or Institution

Extent participant feels their practitioner inquiry work will be/has been recognized by their unit and/or the institution (includes informal recognition as well as formal recognition)

Thoughts about Unit and/or Institution Recognizing Practitioner Inquiry

Thoughts about unit and/or institution recognizing, formally or informally, participants' practitioner inquiry work

Practitioner-Inquiry Work Counts as 'Part of Puzzle' Towards Promotion	Participating in the practitioner inquiry program has, on its own, not had an effect on promotion and tenure, but it is part of a larger puzzle of efforts towards promotion and tenure	6	Logan: I sailed through [a promotion], I expect to sail through [another promotion] next year. [Practitioner inquiry work is] part of this giant thing but it's like I can't strip apart the [practitioner inquiry work] and say it's the reason I would get that. Interviewer: Right. It's a piece of the larger...of your larger involvement. Logan: It's a piece of the larger involvement.
Unit Values Practitioner Inquiry Participants/Faculty Focused on Education (Not Related to Promotion and Tenure)	Evidence of unit valuing contributions from practitioner inquiry participants and/or faculty focused on education, not connected to promotion and tenure	4	Ryan: Then the other mentor that I was talking about doing some efforts with her, [they're] the leader that part is been trying to, I don't know, communicate it with other [fixed-term faculty] and... Interviewer: [The developed curriculum?] Ryan: Yeah. Interviewer: Okay, cool. [Have they] been pretty successful? Do people seem to want to do that too? Or do think it's kind of... Ryan: I think just this last year, it's been mostly been communicating about it. We haven't like presented a plan yet. Interviewer: Gotcha. Ryan: So we haven't said, 'Here's piece of paper. Do this.' Interviewer: So kind of raising awareness. Ryan: Yeah, definitely. I think raising awareness it's been good.

Practitioner Inquiry Strengthens Case for Promotion and/or Tenure	Participant affirmation that the practitioner inquiry work helps for promotion and tenure.	2	And so [Logan] said, 'Oh, this really helped me get my [promotion]' so we started talking. I was like, 'Oh, wow. We've been here the same amount. I didn't even know I could go up for [promotion].' [Logan] said, 'Yeah, you might want to think about the [practitioner inquiry program] when it comes out,' and so [Logan's] actually the person who told me about it, so when I saw the letter come through, the email come through about this program and apply, since I had already heard of it through [Logan], I was like, 'Hm. I'm going,' and I knew [one of the initiative leaders/designers]. I thought, 'Mm, I'm going to apply for that as well…' (Jordan)
Unit Updated Position Descriptions to Include Practitioner Inquiry-Related Work	The unit updated practitioner inquiry participant's position description to include practitioner inquiry-related work	2	The other thing that's happened recently, that's not totally related to the [practitioner inquiry] program, we talk about confidence and what that builds in you, is they're now hiring me an assistant, and so that I'm gonna move into this more assessment based role, and a lot of that is based on my now expertise in doing, evidently, evaluation and assessment. Some of that came from [my practitioner inquiry work], but some of that came from other places, for sure. And so my [unit] is moving me into a slightly different role, and bringing in some support to help me do my current job, and so yeah, my position is shifting. And some of that's [from the practitioner inquiry work], some of that's the fact that I just got this new grant. But whatever, so all of that stuff. (Peyton)
Unit Placed Discipline-Specific Education Researcher on Tenure-Track	The unit placed a faculty member in a tenure-track position, focused on discipline-specific education research.	2	Although I do have to say one person in our [unit] did get put on the tenure track and she is really big into education. So, I think there is a value for it. (Frankie)
Unit Adopted Practitioner Inquiry Model	The participant's unit has adopted the practitioner inquiry model for unit faculty	1	...we, in our unit [...] just issued our own. Well, we kind of...action research or like a professional learning community. Kind of called for proposals to our faculty and [unit], and we kind of based it on [the initiative] part, and so...so that, I feel is really good, because we had eight proposals for work, that encompassed [half of the faculty in our unit]. (Kendall)

Funding for Scholarship Around Education/Practitioner Inquiry Work	Unit and/or institution gave funds recognizing scholarship around education and/or to continue practitioner inquiry work	1	I'm sure it's [the practitioner inquiry program] helped me leverage certain grants and funding. I've done very well in the last three years, I've gotten nine grants, all internal from [this institution…]. All of those [grants and teaching awards] kind of stemmed from the [practitioner inquiry program...]. It was like you get one thing and people are like, 'Okay, maybe this person does have something to offer', and so, they give you another shot. And then all of this sort of builds and builds and builds until you look back and you're like, 'Wow, there's a lot that's happened and we've created something here.' What one piece was the most important piece, I don't think I can point to any one thing. (Logan)

Thoughts about Unit/Institution Not Recognizing Practitioner Inquiry Work

Participants' thoughts about how unit and/or institution has not recognized practitioner inquiry work

Does Not Believe (or is Unsure if) Practitioner Inquiry Matters for Promotion and/or Tenure	Participant does not believe participation in the practitioner inquiry program will matter for promotion and/or tenure, or is unsure if it will matter for promotion and/or tenure.	5	Interviewer: Okay, great. Have you noticed, or to what extent do you expect your participation in the [practitioner inquiry] program to influence your faculty position/promotion and tenure? Ryan: I have no idea. Interviewer: Okay. Ryan: I would hope that doing the little research and scholarship that has done would be a positive thing for a promotion. But I also I'm not the one who propel[s] the decision-making power.
Struggled in Gaining Recognition from Administrators/Unit and/or Institution	Participant has struggled in feeling like their practitioner inquiry work is recognized by administrators, their unit, or the institution.	4	Quinn: [sigh] scholarship...I mean, if we publish anything out of it, I guess I will think of it that way. You know, if something comes out of it that's useful to other people, and not just myself, I probably will start thinking of it as scholarship. Research, it's so funny because I...this is terrible, I don't want this to be on tape. Interviewer: Oh, do you want me to turn it off or? I can do that, too, if you'd like. Quinn: I mean, I just think there's a-- I can say it in another way. There's a very, big divide between structural faculty and research faculty on our campus. And this is not unique to [this institution]. And so, I think I have really, because of the way that I'm seen and treated here, I really don't ever think of myself as a researcher because no one else sees me that way. So, yeah, I don't.

Practitioner Inquiry Might Help Get New Position	Participating in practitioner inquiry might help get a new faculty position, one that offers more recognition of practitioner inquiry work	3	...it's pretty hard to be a full-time [fixed-term faculty member] and actually do research that would maybe give me publications in the field, what then which will allow me to move up the chain, maybe even get into a tenure track position here or somewhere else. (Logan)

Note. The column '*n*' shows the number of participants whose excerpts contributed to a code.

Wanted to Engage in Scholarship Concerning Education

Participants suggested wanting to engage in scholarship concerning education, since they specifically mentioned: 1) wanting to improve or evaluate teaching; 2) wanting to understand/improve student learning; 3) engagement in/with multiple education research grants; and 4) planning to engage in scholarship concerning education research 'anyway,' regardless of the practitioner inquiry opportunity.

Want to improve or evaluate teaching. Every participant (n = 10) suggested that they were motivated to explore teaching improvements, broadly speaking, and/or evaluate if a particular pedagogical technique/curriculum is effective. For example, when talking about their goals for practitioner inquiry work, Ryan explained, "...the other goal I had was to actually use those practices that were already written about and try and develop materials for my specific courses, and then implement those materials, and then collect data on if they actually worked or not."

Want to understand/improve student learning. Participants (n = 6) indicated they wanted to understand or improve student learning. For example, Ryan fondly recounted a positive student comment, from someone previously enrolled in a course they had modified in their practitioner inquiry work. The student had applied for a job and received a job offer, using skills taught by Ryan. Ryan noted this "was always nice to hear because that's a big way you can make a difference in student's lives," suggesting that Ryan is invested in helping their students

learn. Another, more explicit example comes from Peyton, who said, “I think that the thing that always motivates me [to change my teaching] is helping my students learn, and be more successful. But, I think that I figure out how to help them learn, and be more successful, by either collecting my own data or using current literature.”

Engaged in/with multiple education research grants. Half our participants (*n* = 5) mentioned engaging in one or more grant/funding opportunities, aside from the practitioner inquiry program, focused on researching or improving STEM education. For example, Jordan talked about receiving a grant “the year before” the practitioner inquiry program, “so I’d already gone down a path of starting to apply for grants and thinking about getting back in the research game and not just teaching.”

Planned to engage in scholarship concerning education ‘anyway.’ Half of our participants (*n* = 5) also mentioned that they planned to engage in practitioner inquiry-related projects ‘anyway,’ regardless of there being the practitioner inquiry opportunity. For example, Ryan succinctly stated, “I was going to do these things anyway, but having the program helped to a schedule and gave me the motivation to finish it and actually write about it.” Some participants even mentioned that they were currently engaged in practitioner inquiry-like work, such as Mickey who said, “When I learned about the opportunity to participate in the [practitioner inquiry program] I saw the potential to have some support for the work that I was already doing.”

Being ‘Novice’ Education Researchers

Participants also offered evidence to suggest that they identified as a ‘novice’ STEM education researchers. Specifically, participants made statements about being a ‘novice’ STEM

education researcher and statements about lacking knowledge of the research field of STEM education.

Saw themselves as a 'novice' education researcher. Over half of our participants (*n* = 6) indicated that they saw themselves as a 'novice' education researcher. For example, Quinn explained:

> I feel like most of what I've accomplished is just in my own learning. You know, what's required to do this kind of research. I sort of had a vague idea, and I knew a little bit cause I read a lot of research as a grad student but I didn't -- I haven't been through the process [of doing STEM education research] so that was just, for me, a really big learning curve…

Similarly, when asked to what extent they saw themselves as a STEM education researcher in doing their practitioner inquiry work, Taylor succinctly responded, "Beginner." When prompted for more information, Taylor explained, "I have had very little practice. I've spoken at a few conferences, presented a few posters, but all within the last two to three years. I'm in the process of learning the field, which is good."

Lacked knowledge of the field of STEM education research. Participants (n = 4) also suggested that they lacked knowledge of the field of STEM education research, including methods, which further lends support for their identities as 'novice' STEM education researchers. For example, Sydney explained that it had been interesting to experience "[h]ow hard it has been to...explain what we're doing." Upon prompting, Sidney explained that their practitioner inquiry team was "going to a conference in November to try and make sure we understand where the field is. Not that we haven't done our homework, but sometimes going and talking to people is different." This indicates that Sydney felt they lacked knowledge of STEM education research. Another example is Logan, who wished that the practitioner inquiry program

provided specific "support from people that are very skilled in particular sub-fields," such as quantitative analyses in STEM education research. Logan elaborated:

> [T]he people that were there to support me they add a very broad bit of knowledge that helped me get started, but it quickly got narrowed down to where their [i.e., practitioner inquiry program leaders/designers'] expertise was not going to be much use, and it didn't look like there was a structure [in the practitioner inquiry program] even to help you find the more detailed people [or experts in specific social science methods].

Beliefs Concerning Appropriateness, Comfort, and Notions Regarding Legitimacy of Quantitative- and Qualitative-Based Practitioner Inquiry Work

Many participants (n = 7) described using quantitative methods in their practitioner inquiry work while only a few participants (n = 3) talked about using qualitative methods. These results suggest that many participants (although notably not all) identify with and felt more comfort in using quantitative methodologies, which many had experience with, and saw as indicative of practitioner inquiry being (legitimate) research. In comparison, qualitative methods were viewed by some participants as less understood/mastered (at least initially) and potentially recognized as less legitimate.

Beliefs concerning quantitative methods. Many participants (n = 7) explained their practitioner inquiry work using quantitative methods: Mentions included using 'plots,' 'control groups,' 'experimental designs,' the 'scientific method,' and 'statistical analyses.' Further, some participants saw practitioner inquiry work as being 'hypothesis-driven' or 'systematic.' For example, Logan talked about making "plots," saying:

> [N]ow I'm working on four papers, one of them I think is real research, I think it's...Why is it real research, because it has plots. I'm a [STEM person] so I guess for me it's not research unless it has a plot. I know that's not true. My [partner's] a social scientist, so I have to be careful. [My partner] like[s] plots though.

Another example is Frankie who, when elaborating on whether they saw their practitioner inquiry work as 'research' or 'scholarship,' explained, "if I were solely a researcher and had a

control group and could spend 50% of my time on the project, that would be more robust. I would consider that more scholarship." Later in the interview Frankie noted that their practitioner inquiry work was based on "square things as far as doing research," such as "validity, reliability. There are methods and they are based on other research, and there's some system to what I do and how I ask questions."

Beliefs concerning qualitative methods. A few participants (n = 3) talked about how practitioner inquiry work related to the collection or analysis of qualitative data. For example, Frankie noted that their confidence had not really changed while doing practitioner inquiry work, since "I've, in the past, have done qualitative research and similar stuff. So I'm not sure that it [practitioner inquiry work] has necessarily shifted that." Mickey also commented that they were comfortable using qualitative data collection methods and analyses, since they had also used these methods before. Mickey explained:

> [M]y background [is more in the social sciences]. In exploring how the process has gone, I think I have gained a little bit some more confidence in doing things the way that I see that they need to be done as appropriate with the skills that I have and in focusing on questions that I think are relevant, and answering them in ways that I see they can be answered most effectively.

Mickey added that they were initially hesitant in using qualitative methodologies:

> [M]aybe there were some insecurity in thinking I had to incorporate the quantitative analysis of a certain kind in order to have a legitimate study. I'm kind of pushing back on that, some confidence in saying I can make decisions as a researcher based on the questions that I want to answer and it doesn't necessarily have to be dictated by a perceived view in this field that only quantitative data is legitimate.

Taylor corroborated Mickey's suggestion about the legitimacy of quantitative data in STEM disciplines, explaining, "As a scientist, we collect quantitative data. That's what we do. Qualitative data is still new to me. I know it exists, I know it's useful but that was some of my

first exposure to what exactly that means and what exactly it is and how to use it effectively and function."

Practitioner Inquiry is Not Formally Part of Faculty Position

Participants offered claims suggesting that doing education research, such as through practitioner inquiry, was not formally a part of their STEM faculty duties. Codes supporting this claim include: a) statements about research, or practitioner inquiry, not (or limitedly) being included in position descriptions; b) having too little time to do practitioner inquiry; c) needing financial support to engage in practitioner inquiry; and d) needing mentorship/support to engage in practitioner inquiry.

The research involved in practitioner inquiry is not (or is limitedly) part of a position description. Over half our participants (n = 6) suggested that the research involved in practitioner inquiry was not (or was limitedly) included in their position descriptions. For example, Frankie reflected, "It's kept me connected to that [i.e., research] even though it's not a huge part of my job description." Similarly, when asked about how they felt their participation in practitioner inquiry might influence their unit or program, Sydney explained that practitioner inquiry was "not part of my position description. I mean, I think it gets me kudos (from my unit), but that's about all."

Too little time to do practitioner inquiry. Perhaps partially related to the reality of such work not being part of their position descriptions, participants (n = 5) also talked about having too little time to engage in practitioner inquiry. For example, Logan succinctly stated, "[I]t's pretty hard to be a full-time [fixed-term faculty member] and actually do research that would maybe give me publications in the field…" Mickey also noted:

> [B]ecuase of the demands of our [fixed-term faculty] positions I think to have some official kind of designation that we are this year working with [the

> initiative] is important to show our [unit] in order to make sure that we can devote time and to have motivation [to continue practitioner inquiry work].

Additionally, Ryan noted, “I think it’s [my practitioner inquiry work] like a long-going project. I’ll be work on it for a long time. I want to, not that I’ll have the time to, but I hope to.”

Need financial support to engage in practitioner inquiry. A couple participants (*n* = 2) stated that they needed financial support to do practitioner inquiry. For example, Jordan commented, “[s]o, I would like to continue with it [the practitioner inquiry research], and I have a lot of students who are very interested in helping with it, I just don’t have any funding for it anymore. My funding ran out, so if [my graduate student is] not doing it, it’s either got to be me or [the graduate student], and so I don’t know what to do about that.” Logan also noted:

> We could talk about equity in the university and how much they pay [fixed-term faculty], but it's pretty hard for you to say, ‘I'll just take summer off and I'll work on this research,’ something I'm not going to get any pay for and it's not part of your job description whatsoever. Yes, it might help facilitate you going up to a different job description, but that's even tough to tell if that's going to happen ever. I can't take a quarter of my yearly salary away to do this, and so, you need some buyout time to do these types of things, or to justify the overtime. Okay, I'm not going to be home as often because I'm working on this other stuff. I think that's pretty important. It's important no matter where you're at, you need the financial support.

Need mentorship/support to engage in practitioner inquiry. A couple participants (*n* = 2) also claimed needing mentorship/support with their practitioner inquiry work. For example, Mickey commented that they worked in a unit where:

> ...there’s got to be a lot of pragmatism involved in how we're developing our educational practices and what gets valued is results a lot of the time and so it can be a stretch or it can be, can seem less rewarding to engage in a survey development, additional, or writing a paper in my position without having at least mentorship, somebody kind of helping along the way or it would it be really nice, which I think was available to us last year were some potential support in the form of a research assistant or to have a consultation at least with somebody.

Logan concurred, “You need the support of people who know how to do these types of research or know how to do IRB, who can point to the right literature.” These excerpts suggest that two participants felt they needed mentorship or support with their practitioner inquiry work, hinting that this was because it was not part of their positional duties.

Practitioner Inquiry Work Helps Build Identity as a ‘Researcher’

Participants also suggested that practitioner inquiry work helped them build identities as ‘researchers.’ Participants detailed this in diverse ways: a) publishing practitioner inquiry work; b) feeling validated as a ‘researcher’ or ‘scholar’ through publication of practitioner inquiry; c) wanting/needing and/or receiving validation or recognition from STEM education research community to be a ‘researcher’; d) building/being part of a disciplinary research group or team around practitioner inquiry work; e) presenting inquiry work at conferences; f) desiring to ‘return’ to research and/or engage in scholarship concerning education; and g) calls for redefining fixed-term faculty roles to include education-related research.

Publishing practitioner inquiry work. Many participants (n =7) detailed plans to, or instances of, publishing their practitioner inquiry work. For example, Jordan stated that they had

> ...papers, outstanding papers, in both of those [i.e., papers on research presented at two initiative-related, practitioner inquiry poster sessions], so that was kind of nice, to be able to present what we were publishing, and I should let [one of the initiative leaders] know we got another publication out of this.

Taylor similarly commented that “[w]e’ve got a deadline for the paper by the end of fall. That was our goal, to get a paper ready using the [practitioner inquiry program]...”

Publication validates practitioner inquiry as ‘research’ and/or ‘scholarship.’

Relatedly, participants (n = 7) also explained that their practitioner inquiry work could be considered ‘research’ and/or ‘scholarship’ if it was published. For example, when asked if they considered their practitioner inquiry work to be ‘research’ and/or scholarship, Jordan explained:

> Well I would have to say it would be research. I guess, so if you want to distinguish scholarly research from just regular research, maybe like how great of an acceptance rate you're getting published. We've had a little harder time with some certain parts of it, getting within that 30%. The action research ones, those papers that have been published in the 50 to 70%, so I don't know how scholarly that is, right, but it was still research.

Want/need/received validation or recognition from STEM education research community to be a 'researcher'. Over half our participants (n = 6) mentioned wanting, needing, or receiving validation from the STEM education research community to be a 'researcher,' including from a larger, national STEM education research community and/or a larger, discipline-specific STEM research community. For example, Peyton explained:

> [Y]ou know, it's interesting, I see myself as a[n] education researcher in different ways, in different contexts, and so when I go, for example, to [a STEM education conference specific to my STEM discipline], I don't feel like I'm an education researcher there, because many of the faculty there are truly in [discipline-specific, STEM education research] tenure track positions, I'm very much not that. But here on this campus, when I'm here, I see myself as a [discipline-based education researcher]. It's very funny, right? And I very much see myself as doing education research, and some of it has to do, like as a [fixed-term] faculty, it's harder for me to do publication, versus really, like I can present at conferences really easily, and things like that, and so it's kind of this...it's more about the people around me's expertise. I think that broadly, my colleagues at those meetings would also consider me a [discipline-based education researcher] in some sense, but I think that there's an element of everything that I do that's practice based. As opposed to research based. And so I think about this IRB table that I've seen recently, [about] what is research, right? And my job description doesn't have that in it. I mean, it does, it has five percent [scholarship]...

Building/being part of disciplinary research group/team around practitioner inquiry work. Participants also offered excerpts to suggest that they had built or worked on practitioner inquiry projects as part of a small research group or team. This included working with colleagues in the same disciplinary unit on their practitioner inquiry projects (n = 6) or engaging undergraduate and/or graduate students in practitioner inquiry work (n = 4).

Working on practitioner inquiry project with faculty in same unit. Over half our participants (n = 6) mentioned working on their practitioner inquiry projects with faculty in their unit. For example, Ryan explained:

> I think the most meaningful thing would have to be the working relationship I've developed with the people I've worked with on the [practitioner inquiry] program [in my unit], so the two mentors [...t]hree altogether like I...I spent more time working with them and communicating with them, and so, that's the best thing.

Engaging students in practitioner inquiry work/STEM education-related research. Participants (n = 4) also mentioned engaging students, both undergraduates and graduates, in practitioner inquiry work or other STEM education-related research. For example, Ryan explained that "over the summer I had, using the [practitioner inquiry money], I had a student basically based on the data, how I'd been analyzed before, I had them go through the next set of data and try and do it the same so we can do a comparison." Another example comes from Jordan, who spoke about how they:

> ...have some grad students who've gotten really interested in wanting to study [the] quality [of some discipline-specific STEM content], so I think if I just get these graduate students who are interested, I might not even have to pay them. They could be a teaching assistant, but just for their research. I already have all the data that they could look at, so I'm sure that this year will...well, it's not out of my mind that I want to do any of this.

Presenting at conferences. Half of our participants (n = 5) spoke about presenting results of practitioner inquiry work at conferences. These included the interviewee, or the interviewee's practitioner inquiry partner(s), presenting their practitioner inquiry results via talks and/or posters. For example, when asked about their current goals for practitioner inquiry work, Kendall explained, "[W]e did write a [discipline-specific STEM education conference] publication on that, and gave that," likely referring to giving a presentation.

Want to 'return' to research and/or engage in scholarship concerning education.

Participants (n = 4) talked about how participating in practitioner inquiry provided opportunity for them to 'return' to research. For example, Sydney commented:

> I keep telling myself I need to get back into doing more and more research, more STEM education research, so I feel like when I took this job...I've done education research before, and some things happened in my...I've had a non-linear career path, too. I'm here now, I've learned a lot about this specific job that wasn't part of my sub-training, obviously. I keep saying to myself, as soon as I get a minute, I need to get back into that research stuff.

Similarly Jordan, when asked about what motivated them to apply for the program, mentioned receiving a grant the year before and "so I'd already gone down a path of starting to apply for grants and thinking about getting back into the research game and not just teaching…"

Redefining fixed-term faculty roles to include education research. A few participants (n = 3) offered information about how education-related research should be, or was a useful part of, fixed-term faculty members' duties. For example, Mickey noted:

> [M]y position description involves finding innovative ways of teaching and being in kind of an unconventional or newer type position. I think there's a lot of benefit that can come from evidence-based practice research. There's a lot to do in terms of laying foundations for a new program really. In our [unit…] the [...] curriculum is fairly new. I mean there have been, I shouldn't say that whole [...] curriculum is fairly new, but I'm a newer element and as a formal instructional element in the program and I'm really trying to figure out and navigate what's the best way that I can contribute to the program, and what are the program needs, and how can educational objectives and [the curriculum] be most effectively integrated into the program. That's all kind of from the ground up, at least in my experience of the way that we're doing it right now.

This suggests that Mickey was interested in incorporating "evidence-based practice research" in their 'newer' position as a fixed-term faculty member. Another example is from Peyton, who commented that the practitioner inquiry program supported fixed-term faculty in doing research:

> [O]ne of the things that I, especially the first round, that I really valued, was that I was able to bring this tenure track [STEM faculty member…] sort of into this idea, the scholarship of teaching and learning, and that [they were] able to have

> some support around that, and support around [their] ideas about changing [their] classroom. I think that was really great. But I also think that there's not a lot of, for instructional faculty, there's not a lot of opportunity for engagement in that kind of way. At least I don't think there was before the [practitioner inquiry] program. And it's been really great to have, I think, to give faculty. Like I said, I'm not sure I needed it as much as some people, but to give faculty that kind of support. To help them figure out how to ask the questions that they've always wanted to ask in their classrooms.

Practitioner inquiry work 'practically' informs a classroom. Over half our participants (n = 6) indicated that practitioner inquiry was 'practical' in helping to change a specific course or curricular tool. For example, when asked about whether they saw themselves as a STEM education researcher in doing practitioner inquiry work, Frankie affirmatively responded, qualifying, "It's just a very practical approach to it [STEM education research]." Jordan also discussed at length their troubles publishing their research, noting:

> I don't know that action research is really well-known [in my discipline-specific education community]. We've actually had a couple comments, reviews on some papers, that say, 'This seems like action research,' or we've said it, and 'we don't really think action research is a good thing.'

These excerpts also suggest that Frankie and Jordan, as well as other participants, categorized their practitioner inquiry work as more 'action research' or 'classroom-based' than, perhaps, 'generalizable' education research applicable to a broader community.

Connecting With Other Faculty in Shared Practices/Interests in Formal Practitioner Inquiry Group

Participants talked about how they had engaged in an institution-wide, multidisciplinary STEM practitioner inquiry group where they shared interests and practices with other STEM educators. For example, participants offered excerpts explaining that they: a) enjoyed belonging to a group of STEM faculty at the same institution who share an interest in improving STEM education; b) had presented practitioner inquiry work at institution-wide, end-of-the-year poster sessions; c) had received help with practitioner inquiry from initiative or practitioner inquiry

designers and/or leaders; and d) appreciated belonging to a group of faculty 'figuring out' practitioner inquiry together.

Enjoyed belonging to a group of STEM faculty at the same institution who share an interest in improving STEM education. Many participants (n = 7) explained that they enjoyed belonging to a group of STEM faculty, from different units, during their involvement in the practitioner inquiry program. Participants said this provided them with opportunities to, for example, collaboratively explore practitioner inquiry projects and connect with others around shared teaching-related interests/improvements. For example, when asked if they noticed any benefits from their participation in the practitioner inquiry program, Sydney explained, "I think it's been good to talk to colleagues who have done the same type of research." When asked if these were just colleagues in Sydney's unit, Sydney elaborated:

> Or [even other STEM units]. There's a [STEM faculty member in another unit] that we talk to, who is really helpful, and another [STEM faculty member in another unit]. I think that...just seeing what other people are doing is nice. Even if it's not the same filed...know that what...When we started, what we were doing was so far out there, that seemed so far out there, then we started talking to other people who were doing similar things. Ours was still a little far out there for [our discipline], but it was nice to see that other people were doing stuff too.

Similarly, Taylor explained that "[t]he sharing of ideas [was most valuable]. 'What are your interests?' 'What are your big problems and concerns?' Was more valuable in terms of trying to figure out who are our students and what challenges are they facing elsewhere." When prompted to explain whether Taylor was referring to faculty in their unit or outside of their unit, Taylor clarified:

> Outside of our [disciplinary unit] which is often. You get kind of myopic. Stare and try to fix your part without really trying to think about, 'Well, they're going to take this for one or two terms and then a whole bunch of other things and we have no control over them.' So it's...I think it's important for students for us to do this. I think...sure, teaching is a large percentage of all of our job descriptions, but that sometimes gets taken for granted. I think in terms of student success and having

> them...I think educational best practices, why in the world would we do things that we know are not--suboptimal--and vice versa. Why wouldn't we try things if we saw the data very clearly showed that they are great? Why wouldn't we try and see if we could help our students?

Presenting practitioner inquiry projects at institution-wide, end-of-the-year poster session(s). About half of our participants (*n* = 5) mentioned presenting their practitioner inquiry projects at the end-of-the-year poster session for other practitioner inquiry participants as well as the institution's larger STEM faculty community. For example, Frankie stated, "I presented my [poster] work at the most recent [practitioner inquiry meeting]."

Initiative/practitioner inquiry designers/leaders helped participants with practitioner inquiry. Half our participants (*n* = 5) mentioned receiving encouragement or help from practitioner inquiry designers/leaders. For example, Taylor explained that it was helpful "[j]ust having people that we can run things by as well so if we have questions about things there was a dedicated person." When asked about what was most meaningful to them about their participation in the practitioner inquiry program, Frankie stated, "I think trying out a new idea, talking to [initiative leaders/designers], showing up at the poster night, and having a celebration and talking ideas. That's been the best! I mean that, and that's why I did it."

Appreciated belonging to a group of faculty 'figuring out' practitioner inquiry together. Participants (*n* = 3) also talked about how they appreciated participating in a community of STEM faculty who were 'figuring out' how to do practitioner inquiry work together. For example, Taylor explained:

> I think even though it was designed to do it once and then go forth and multiply, I see it as a valuable, as meeting deadlines, sure and keeping on with it, but just in terms of interacting with the other faculty, the poster sessions, and even before that when we were just discussing ideas and spit balling, 'What are you doing, what are we doing?' That was, I think, probably the most valuable thing that I'll take from that.

Logan shared a similar feeling of appreciation for the practitioner inquiry group's support, stating:

> ...talking with, commiserating with other member[s], [practitioner inquiry members], that are sort of doing the same thing, practicing without a license, and hearing them, 'Yeah, I didn't know what any of that was either' or 'I still don't know what any of that is.' It makes me feel like, okay, I'm not a complete idiot, I'm not expected to definitely know what all of these things are.

Connecting with a National STEM Education Research Community

Faculty also suggested that practitioner inquiry had helped them connect with others in a national STEM education research community (n = 3). For example, Taylor explained that practitioner inquiry funds allowed them to "go out and meet other people beyond our university that are also interested in similar things. We've met several people that are doing [the type of curriculum Taylor is studying]. We've talked about, 'Well, what are you doing?'" When asked if Taylor was referring to just others in their discipline, they elaborated:

> [In my disciplinary field of] education as well as general education in other fields as well. We've met some colleagues [in other STEM fields] and they're all, sometimes dating back into the nineties and the eighties. They've been doing this for a while so they have a number of tricks and things that they do that were kind of neat that we'd like to try, and vice versa.

Recognition from Unit and/or Institution

Participants also offered excerpts about how they felt their practitioner inquiry work would be/has been recognized by their unit and/or institution. This included statements about both formal and informal recognition. We first present participant thoughts about the unit and/or institution recognizing practitioner inquiry work and then present thoughts about the unit/institution not recognizing practitioner inquiry work.

Evidence/thoughts about unit and/or institution recognizing practitioner inquiry. Participants conveyed how their practitioner inquiry work was recognized, formally or

informally, by the unit and/or institution. This included: a) perceptions of practitioner inquiry work being 'part of the puzzle' towards promotion/tenure; b) examples of the unit valuing practitioner inquiry participants/faculty focused on education (not related to promotion and tenure); c) statements that the practitioner inquiry program strengthens case for promotion and tenure; d) claims that the unit updated position descriptions to include practitioner inquiry-related work; e) statements about a unit (or units) placing a discipline-specific education researcher in a tenure-track position; f) explanations of a unit adopting the practitioner inquiry model for its faculty; and g) evidence of continued funding for scholarship around education/practitioner inquiry work.

Practitioner inquiry work counts as 'part of puzzle' towards promotion. Over half our participants (n = 6) suggested that participating in the practitioner inquiry program had, on its own, not had an effect on promotion and tenure: Rather, practitioner inquiry work was part of a larger puzzle of efforts towards promotion and tenure. For example, Peyton stated,

> I do think that for me, participating in things like this certainly...I never had any doubt when I went up for promotion that I would get promoted, you know what I mean? I had done my job more than enough in some ways, right? And part of it is my participation in things like [the initiative] and the [practitioner inquiry] program. I feel like it really shows that I've gone above and beyond in my caring about my students, and my doing my scholarship, in improving my teaching over time [...] I think that in my case it helps make the case that I am working in the right direction for my students. I think lots of other people make that case too.

Also Kendall, when asked about the extent they felt their practitioner inquiry participation mattered for promotion and tenure, answered, "I think it's...I don't know. Maybe a little helpful in that it adds qualifications."

Unit values practitioner inquiry participants/faculty focused on education (not related to promotion and tenure). Some participants (n = 4) also suggested that their units valued contributions from practitioner inquiry participants and/or fixed-term faculty, focused on

education. For example, Frankie talked about how they "get out there and talk about my ideas and I think they're catchy, even if I'm not directly talking about the [practitioner inquiry program], the stuff I come up with because of the [practitioner inquiry work]." When asked if they thought their ideas were catchy to those in their unit, Frankie responded, "Yes," although they later conceded that they felt they would have "a bigger effect if I present it at a conference of other universities who are doing similar stuff." Jordan, who recently received a tenure-track position as a disciplinary-specific, STEM education researcher but was previously a fixed-term faculty member, noted:

> ...to have everybody supportive of this new [disciplinary-based education research] area for me here, has...It's blown me away. To be honest with you, I'm actually blown away how many professors have come to me now with ideas that they want to...collaborations that they want to do for education purposes.

Practitioner inquiry strengthens case for promotion and/or tenure. A couple participants (n = 2) were more certain that involvement in the practitioner inquiry program would strengthen cases for promotion and tenure. For example, Peyton explained:

> [I]f someone were to come up to me and ask me to do an external evaluation of someone's promotion packet that I knew from the [practitioner inquiry] program, I would absolutely say yes, because I would know that it would be a fairly straightforward, presumably, I don't know if that's true or not. So I think that it does help in that way, and I think it would help other instructors in that way, even more so than me. 'Cause I'm in a unique situation, in that I do a lot of other scholarly work, and [practitioner inquiry] is a small piece of that.

This suggests that participating in the practitioner inquiry program may help for promotion and/or tenure, especially if the promotion/tenure packet is reviewed by a previous practitioner inquiry participant who understands the merits of the experience.

Unit updated position descriptions to include practitioner inquiry-related work. A couple participants (n = 2) talked about how the unit had updated practitioner inquiry participants' position descriptions to include practitioner inquiry. This is an example of the unit

formally recognizing practitioner inquiry work. For example, Ryan noted that they had "worked with my [unit] head to update [my position description] at the end of last school term, academic school year." They later elaborated that this "did include that kind of had aspect of the [practitioner inquiry work]. Yes."

Unit placed discipline-specific education researcher on tenure-track. A couple of participants (n = 2) talked about how their unit had recognized STEM faculty members' commitments to education by offering a faculty member, or two faculty members, opportunity to be (a) tenure-track STEM education researcher(s). It was difficult to discern if these two participants were talking about the same faculty member or two different faculty members. For example, Jordan talked about how the practitioner inquiry program "gave me the confidence" to apply to a tenure-track faculty position in their unit, focused on STEM education research. It's interesting to note that, prior to Jordan's start, they "had our director and everybody ask every single full or associate professor if they were on board [with Jordan's tenure-track STEM education position] before I said yes." Frankie also noted that their unit had just placed someone in a tenure-track position who was "really big into education."

Other mentions of unit and/or institution recognizing practitioner inquiry work. One participant, Kendall, explained that their unit had implemented a practitioner inquiry program for its own faculty, based off of the model for practitioner inquiry built by the initiative. Another participant, Logan, talked about how their unit and/or institution had supported them via funds to continue scholarship around education and/or continue practitioner inquiry work.

Thoughts about unit/institution not recognizing practitioner inquiry work. Participants also suggested ways their units and/or institution had not recognized, formally or informally, their practitioner inquiry work. These included mentions about: 1) not believing (or

being unsure if) practitioner inquiry matters for promotion and/or tenure; 2) struggling to gain recognition from administrators/units/institution; and 3) ideas about how practitioner inquiry might help get a new position.

Does not believe (or is unsure if) practitioner inquiry matters for promotion and/or tenure. About half our participants (n = 5) expressed concern that their practitioner inquiry work did not matter for promotion and tenure or were unsure if it mattered. For example, Logan said, "It might help facilitate you going up to a different job description, but that's even tough to tell if that's going to happen ever." When asked about the extent they expected their participation in the practitioner inquiry program to matter for promotion and tenure, Mickey stated, "I would say no." Mikey elaborated, "[practitioner inquiry is] professional development for me. I think that the benefit to meet professionally is mostly in my aspirations, larger aspirations, not necessarily in my current position."

Struggled in gaining recognition from administrators/unit and/or institution. Participants (n = 4) also explained that they had struggled feeling like their practitioner inquiry work was recognized by administrators, their unit, and/or the institution. For example, Franke noted, "I know my [unit] head didn't show up [to the practitioner inquiry poster session]. It was highly advertised, but getting that buy-in? I think the energy is there but, I don't know how to [...] It seems like it would be awesome if there would be more [unit] heads interested." They continued explaining that they went to a smaller, more teaching-focused institution as an undergraduate, and that their:

> ...experience [there] was way different. Education was so important. Here, it's important to the students, the undergraduates, especially, but it's something that we constantly need things like this program, [the practitioner inquiry program], to continue to give it importance, I guess...

Practitioner inquiry might help get new position. A few participants (*n* = 3) explained that doing practitioner inquiry might help them get a new faculty position, one that offers greater recognition of practitioner inquiry work. For example, Mickey noted that, "the fact that I'm publishing or that I'm engaging in IRB-approved research, no [it will not influence my promotion and tenure]. That's not gonna influence my current position, but it may help me to obtain a different position — if I choose to do in the future."

Discussion

There has been a national push to improve STEM education at institutions of higher education, via initiatives that provide opportunities for faculty to learn evidence-based instructional practices. One set of strategies for improving STEM faculty members' pedagogical practices are activities eliciting 'practitioner reflection.' One type of activity that promotes faculty engagement in 'reflection' is *practitioner inquiry*, where faculty self-identify a teaching-related problem of interest and then collect and analyze relevant data to inform instructional improvements. We know that faculty of different professional positions and from different disciplines may experience practitioner inquiry differently, but we have too little research on how STEM faculty and their larger professional contexts, concerning position type and type of university for instance, influence practitioner inquiry experiences. Furthermore, we need more research on how professional identity is influenced by (and influences) engagement in instructional improvement efforts, such as practitioner inquiry opportunities. Our research concerned how STEM faculty, primarily fixed-term faculty, experience practitioner inquiry in light of their professional identities.

STEM Faculty Sought Opportunity to Actively Build Discourse-Identities as Scholars of Education Through Practitioner Inquiry...and Did So

Our results suggest that our participants, who were primarily fixed-term faculty, may have participated in the practitioner inquiry program to build their identities as scholars of education. Specifically, participants suggested they wanted to engage in education research and be recognized as someone doing this; this can be seen in interview excerpts about wanting to improve or evaluate teaching, understand/improve student learning, being engaged in multiple education research grants, and planning to do scholarship around education regardless of there being a practitioner inquiry program. We interpret these results as indicative of faculty actively attempting to build a discourse-identity of 'STEM education researcher,' via active pursuit of opportunities related to STEM education research as well as how they talked about wanting to improve teaching and student learning during the interview.

Our results also suggest that participants were at least somewhat successful in building their discourse-identity as a scholar of education via the practitioner inquiry program. For example, participants were engaged in groups, involving discourse with students and unit peers towards completing practitioner inquiry work and/or education research. Furthermore, participants presented practitioner inquiry projects at conferences and were also publishing results from their practitioner inquiry projects. These suggest participants were engaged in efforts to be seen by others as scholars of education, towards meeting a typical goal of 'returning' to research. Publication and receiving positive feedback on their research efforts, from a larger STEM education research community, were important in helping them feel like legitimate researchers. A few participants even mentioned how fixed-term faculty positions should include education research as official effort towards this end. Again, we interpret these

results as indicative of our participants' construction of discourse-identities as scholars of education, achieved through interactions with and recognition from others.

That said, despite these many accomplishments, many participants were still careful to couch themselves as 'novice' education researchers. This was evident in how participants talked about their level of expertise with respect to education research and their knowledge of the field of STEM education research. Although participants actively pursued identities as scholars of education, they were aware, and were careful to acknowledge, that they were beginners learning a new field, potentially per their discourse with novel enough experts/expertise (rooted in the education sciences).

Building a scholar of education identity through practitioner inquiry work might have been, for some participants, a bid for greater recognition from their units and/or institution, since research is so highly privileged in STEM disciplines and academia. This may be an especially attractive potential for fixed-term faculty members, who are not typically charged with doing as much, if any, research per their official position. A couple of interviewees even pointed to evidence of recognition of their education-related inquiry work by their larger departments/colleges. For others, it remains to be seen if their research achievements and growing a discourse-identity via interactions (including publications and presentations) with others in the field of STEM education translate into recognition by their units/institution. These results suggest that STEM faculty engaged in practitioner inquiry had different perceptions of, and experiences with, how relevant their scholar of education identity was as a part of their professional identity.

Exploring Tensions in How Practitioner Inquiry is Conceptualized: STEM Faculty Members' Transition from Affinity-Identities as STEM Faculty to Discourse-Identities as Scholars of Education

Even though many participants suggested they wanted to build an identity as a scholar of education through practitioner inquiry, participants sometimes appeared conflicted about how to describe their practitioner inquiry work, perhaps because practitioner inquiry involved novel conceptions of inquiry/research and methods in comparison to those familiar to and practiced by STEM faculty. For example, some participants seemed to struggle with the boundaries or delineations between 'research' and 'practitioner inquiry work.' Sometimes participants described practitioner inquiry as 'practical,' involving 'action research,' or being 'classroom-based,' which suggests that practitioner inquiry work focuses more on studying a localized educational context than generating generalizable results. This is in contrast to conventionally-defined discipline-based education research, which researchers have suggested is more generalizable (Dolan et al., 2017). When taken in light of participants' indicated desires to build identities as scholars of education, these statements about practitioner inquiry work may illuminate a tension in how participants understand practitioner inquiry work: Is it practitioner inquiry 'only'? (How) could it qualify and be recognized as education research??

Additionally, most participants described their practitioner inquiry projects in terms of quantitative methods. This suggests that participants may have built their notions of practicing practitioner inquiry around familiarity and norms concerning 'research' and the methods used most often in their STEM disciplines. These results are is in line with previous research, which has suggested that STEM faculty likely draw on disciplinary experiences to conceptualize practitioner inquiry work (Connolly et al., 2007). Relatedly, one of the participants using qualitative methods for their practitioner inquiry project specifically expressed concern about

how their qualitative work would be received by a STEM audience, indicating that STEM faculty may not want to utilize qualitative methods in their practitioner inquiry projects per concerns regarding peer recognition of their work's worth and legitimacy. However, education-related research can use quantitative, qualitative, or mixed-methods. This illuminates a tension in how participants think about 'legitimizing' practitioner inquiry work: Is practitioner inquiry work legitimate (enough) if based on methods other than quantitative ones?

Per our data and what we know about faculty life at research universities, we can contend that STEM discipline-based organizations serve as bases for prominent affinity-identity for STEM faculty members, with certain practices/norms shared with associated faculty. As a result, the tensions we note above seem even more salient to STEM faculty members' construction of identities as scholars of education via their practitioner inquiry experiences. For example, STEM faculty are likely accustomed to research conclusions being generalizable and using a more constrained breadth of methods in investigations. They may be less used to the idea that research findings may be more constrained to localized meaning, and related methods more pragmatically applied per the problem at hand. Furthermore, they may be less used to problems involving humans as research subjects, which might benefit from qualitative methods often utilized in the social sciences. Overall, STEM faculty may lack typical affinity-identity affiliations with communities employing and knowledgeable about methods used in the social sciences and, thus, might be less comfortable with qualitative research. This suggests that participating in practitioner inquiry may challenge and afford STEM faculty engagement in practices outside of their affinity-identity as STEM faculty, perhaps changing how they view their professional identities as they become more adept at understanding different conceptualizations of research and using different methods. Through practitioner inquiry, STEM faculty may have to recognize

and reconcile tensions in their understanding of research and methodology, which may be different than notions fostered in the development of their professional identities as STEM faculty.

The Importance of 'Scholar of Education' as an Affinity-Identity: Providing Support and Recognition for STEM Faculty Members' Education-Related Research

Our participants also suggested that they cultivated affinity-identities as scholars of education in the practitioner inquiry program, as they interacted with others who shared similar values and interests and engaged in parallel experiences based on comparable practices around teaching improvement. Shared experiences and practice work included doing the 'steps' of practitioner inquiry (e.g. posing a meaningful question, gathering and responding to relevant student data), participating in end-of-the-year poster sessions, receiving help/support from initiative designers/leaders, and collaboratively 'figuring out' practitioner inquiry. Furthermore, a few participants offered information about connecting with STEM education researchers (including those STEM discipline-based) on a national level via their practitioner inquiry work. Thus, participants seemed to foster more local (institution) and cosmopolitan (national) affiliations, that faculty at research universities may crave for both their professional development as well as notoriety in their local and national disciplinary fields (Bouwma-Gearhart & Bess, 2012)[9]. This suggests this practitioner inquiry program, somewhat institutionally-sanctioned itself, helped participants grow in their institution- and discourse-

[9]Gouldner (1957) observed that faculty function within, and are recognized by/as part of, two latent social groups, *locals* and *cosmopolitans*. Orientations and rewards of these groups differ, with locals being recognized for their work in more immediate work environments. As detailed in Bouwma-Gearhart and Bess (2012), at research universities, like the one of our study, tenure-track faculty members are often recognized as/by other *cosmopolitans*, reaping rewards (including social capital towards promotion and tenure) associated with more (inter)national academic groups, largely those doing and validating the worth of disciplinary research.

identities, per what it afforded them in fostering their affinity-identities concerning inquiry into teaching and learning that they deemed meaningful and practical. This finding is important, since it suggests that building affinity-identities as scholars of education through the practitioner inquiry program helped STEM faculty expand/grow their professional identities.

STEM Faculty Members' Bid for Professional Recognition: Identifying Inconsistent Institutional and Discursive Recognition for Practitioner Inquiry Participants

Although various efforts allowed participants to be seen as scholars of education, largely through interactions with others and certain practices that might help them be recognized as that 'kind' of person, participants indicated a notable tension to professional identity development concerning the extent their efforts were recognized by their institution and/or units. Participants talked about how the practitioner inquiry research they were doing was not (or was limitedly) a part of their professional position and mentioned having too little time to do practitioner inquiry work. Furthermore, participants talked about needing financial backing and mentorship to do quality practitioner inquiry work, further suggesting that scholarship around education was not a substantial part of their formal duties. This suggests barriers to doing practitioner inquiry work per the formal institution-identity that STEM faculty brought to the experience.

Relatedly, participants also detailed mixed experiences concerning the amount of recognition they received from the institution or their units regarding their practitioner inquiry efforts, impacting the confluence of their institution- and discourse-identities. Specifically, some participants thought that their unit and/or institution recognized their practitioner inquiry work as indicated by statements that practitioner inquiry work was 'part of the puzzle' towards promotion and tenure consideration (a form of institutional sanctioning, or institution-identity), and mentions of how the unit values practitioner inquiry participants/instructional faculty (largely via treating them a certain way, or discourse-identity). Additionally, some participants offered

evidence of the privileging of their practitioner inquiry work in their case for promotion and tenure, for instance describing their unit(s) updating position descriptions to include practitioner inquiry work, or noting how a unit placed a STEM education researcher in a tenure-track position (both institutional authorizations). One participant even spoke about their unit adopting the practitioner inquiry program model and another participant spoke about their unit providing funding for this type of work, which are also forms of institutional sanctioning, which could help participants perceive practitioner inquiry as being part of their professional identity.

On the other hand, some participants felt less confident about the institution and/or units recognizing their practitioner inquiry work (as an institution-identity). Specifically, some participants expressed beliefs (or expressed uncertainty) about the extent practitioner inquiry work mattered for promotion and/or tenure (policies and practices associated with institution-identity). Others spoke of interactions with administrators, or perceptions of their unit/institution, that made them feel not recognized (associated with discourse-identity). A few participants even thought their practitioner inquiry work might be of more value in a different professional position, perhaps at another institution of higher education (if associated with a different institution-identity).

Thus, participants offered mixed perceptions about how their practitioner inquiry work was recognized, or might be recognized, by their units and/or the institution of higher education. These results suggest that, even though participants may have wanted to be seen as scholars of education (as mentioned above), and worked hard to cultivate this identity through practitioner inquiry, they may not have received recognition for their work (via discourse or institutional sanctioning) from those at their institution of higher education and/or units. Regardless of recognition and affiliation elsewhere, recognition from local professional colleagues seemed an

important contributor to how STEM faculty construct and understand their professional identities as scholars of education.

Towards Transitioning to Implications for Stakeholders: Considering Participants' Antecedent Professional Identities

Many of the results we highlight above are notably tied to what Choi, Bouwma-Gearhart, and Ermis (2019) term professionals' *antecedent identities*, or how professionals are recognized, by others and self, as a certain type of person as they enter into new experiences that may impact their professional identity. Notably, the majority of our participants entered into the practitioner inquiry experience of our focus with the institution-stipulated identity of 'fixed-term faculty member' (i.e., non-tenure track faculty member) for which engaging in inquiry was not part of their formal position descriptions/distributions of effort. Through their work in the program, they participated in research activities and discussions with other faculty, evolving their professional identities via discourse concerning a new field with different norms, knowledge, and practices. Further, they affiliated with a local group focused on practitioner inquiry and even disseminated their efforts via conferences and publications, allowing them affiliation with larger relevant scholarly groups. As argued above, these efforts largely evolved their professional identity in terms of Gee's (2001) discourse- and affinity- perspectives.

These efforts were all in light of many participants having mixed feelings about the extent their practitioner inquiry efforts would be recognized by their units and/or the institution of higher education. For some practitioner inquiry participants, efforts seemed rewarded as capital associated with key discourse- (e.g. praise from others in their unit) or institutional-identity (e.g. a new formal position) perspectives. For other participants, these seemingly crucial local (e.g. institution- or unit-based) recognitions were less obvious. And the disparity of these local recognitions must be considered, in terms of growing faculty members' professional

identities to include practitioner inquiry researchers with an expertise in education scholarship. These findings, cumulatively, suggest considerations for various stakeholders who could support STEM faculty in engaging in, and finding meaningful experiences from, practitioner inquiry. Given the focus and findings of our project, which detailed how STEM faculty engage in practitioner inquiry in light of their professional identity, we aim our recommendations at those designing and implementing practitioner inquiry programs.

Leverage motivations of practitioner inquiry participants. It may be useful to designers and leaders of practitioner inquiry opportunities to consider STEM faculty members' motivations to participate in practitioner inquiry. Our study suggests that fixed-term faculty might be motivated to participate in practitioner inquiry to 'elevate' their professional identities by including more research, or to be seen (as a discourse-identity, via interactions, or institution-identity, as per more formal positions/titles), by the key stakeholders within local and cosmopolitan groups of (often disciplinary) relevance to them as something greater than 'just' educators. Participants seemed to indicate the rationale, 'If I am recognized as a scholar of education I might garner greater status among important colleagues,' which is a practical consideration and aspiration in the world of academia. As Brownell and Tanner (2012) have argued:

> [When science faculty have] extra time in the day, we may more likely spend that time on research activities that raise our status with professional colleagues and are aligned with our professional scientific identity [...] teaching reform may, unfortunately, trivialize any teaching incentives that are developed. If scientists have professional identities that are predominantly research identities, then a *Nature* report or *Science* article will always be viewed as higher status than a departmental, university-wide, or even a national teaching award. Giving incentives for teaching will likely only have positive effects if we, as a scientific community, somehow begin to value those incentives to the same degree as research-based incentives. (p. 343)

Selling engagement in practitioner inquiry as an opportunity to publish and engage in the discourses and practices of a national education research community may be a motivating recruitment strategy for STEM faculty. This seems an important characteristic of faculty success in terms of such experience, in allowing for elevating/securing notions of their professional identity that align with local and disciplinary norms for academics. Also, while STEM faculty often desire to make teaching improvements, external factors and assumptions (including the nature of teaching and teaching improvement) impede their actions towards this; negating some of these factors may be key to get STEM faculty participation in activities that can help them accomplish their pedagogical goals (Bouwma-Gearhart, 2012b).

Help participants understand differences and nuances concerning 'practitioner inquiry' and other forms of inquiry. Although many of our participants wanted and succeeded, to a seemingly meaningful degree, to build their identities as those able to and recognized as performing inquiry concerning teaching and learning, difficulty understanding the differences between practitioner inquiry and discipline-based education research may have gotten in the way. This might be due to participants' entering into a new field by doing practitioner inquiry, with different practices and new notions of 'research.' This concern was perhaps heightened per participant desire to disseminate practitioner inquiry work via publications and presentations, and the fact that the program strongly encouraged participants to do so. In light of this finding, we recommend that practitioner inquiry program leaders and designers consider some of the boundaries (and blurred lines) between practitioner inquiry and other forms of inquiry, such as other types of (often more generalizable and theory-based) discipline-based education research, when planning and implementing practitioner inquiry opportunities for STEM faculty. For example, practitioner inquiry program leaders and designers might consider explicitly helping

faculty understand these nuances and explore assumptions and realities concerning these differences. As well, if the goal of a practitioner inquiry program is to encourage publication and presentation of findings, practitioner inquiry program leaders/designers should consider supports they might provide for participants to explore journals accepting of practitioner inquiry research, which may be less generalizable than that desired by many discipline-specific education journals.

Help participants develop competence in social science methods. Many of our participants spoke about their practitioner inquiry research as using more quantitative analyses than qualitative analyses. In addition, as one participant alluded to, faculty using qualitative analyses may feel uncertain about how their projects will be accepted by a STEM audience arguably representing a different affinity community with different methodological norms. This suggests it is important for practitioner inquiry programs, working with STEM faculty, to spend some time teaching faculty about different methods in ways sensitive to the reality that faculty may not feel competent or comfortable in utilizing or understanding them. Providing information on methods, and pertinent learning theories, has also been suggested in research on multidisciplinary faculty engagement in the scholarship of teaching and learning (Miller-Young & Yeo, 2015) and may be particularly important for STEM faculty given the disciplinary differences between STEM and more social science-oriented research (Kelly et al., 2012). Structuring lessons to broaden STEM faculty members' knowledge of methods should be supportively crafted to minimize faculty perceptions "of ignorance because 'all of a sudden you're not an expert'" (Kelly et al., 2012, p. 4) which may trigger "feelings of being an imposter" (Simmons et al., 2013, p. 13) and inhibit growth as a scholar of education. Disciplinary 'brokers,' with education scholarship knowledge and social capital in the STEM disciplines, may help STEM faculty consider and take up relevant methodologies and

frameworks (Bouwma-Gearhart, Perry, & Presley, 2014). Other research has suggested that practitioner inquiry opportunities can provide faculty with opportunities to be "published in areas and in formats new to them," suggesting that STEM faculty may gain a greater awareness of the field of STEM education by engaging in qualitative methods (Marquis et al., 2017, p. 14). Such efforts may help STEM faculty build affinity- and discourse-identities important to the rigor and meaningfulness of their inquiry and to the larger communities of STEM education researchers they wish to engage with.

Offer interdisciplinary practitioner inquiry programs where STEM faculty can find missing local affinity communities. Engaging in a multidisciplinary group of STEM faculty seemed to help participants expand their professional identities to include practitioner inquiry research. Providing spaces for faculty to connect with others around shared educational interests has been shown to be an effective way to help faculty build practitioner inquiry identities (Marquis et al., 2017; Simmons et al., 2013). Specifically, many of our participants mentioned that engaging in the practitioner inquiry group, with other STEM faculty across the institution as well as initiative leaders and designers, was meaningful and/or impactful. Participants suggested this group helped them feel supported in their practitioner inquiry work as well as helped them connect to a larger STEM community of educators who care about teaching. Practitioner inquiry program leaders and designers should consider engaging STEM faculty in such groups, somewhat institutionally sanctioned, where they might cultivate discourse- and affinity-identities as scholars of education through support and collaboration with others who can help them do practitioner inquiry and recognize their hard work. Furthermore, practitioner inquiry program leaders and designers should consider providing opportunities, funding, and support to participants so that they might share their work with larger communities (via, for example

university presentations, conference presentations, and publication). This is an especially important finding, considering that some participants did not feel like their units or institution supported or recognized their practitioner inquiry research: Indeed, practitioner inquiry programs may serve as a "second home that allows [faculty] to maintain a sense of self worth where otherwise [they] might have faced criticism" (Simmons et al., 2013, p. 15).

Work with practitioner inquiry participants and administrators towards more institutional recognition. Our participants shared mixed feelings about the extent that their scholar of education identities had been (or would be) recognized by their units and/or the institution (indicating concerns with related discourse-identity and institution-identity). Practitioner inquiry participants' concerns about the extent their research mattered for promotion and/or tenure has been noted by other researchers (Marquis et al., 2017). Furthermore, some participants suggested that they would like to see more administrative involvement in or support of the practitioner inquiry program of our focus. No doubt, those holding professional positions with more power could help support these programs and participants through formal (e.g., funding or recognizing practitioner inquiry work in promotion and tenure, towards institutional authorization or institution-identity recognition) or informal (e.g., showing up to practitioner inquiry poster sessions and publicly praising work towards discourse-identity recognition) means. Designers and leaders of practitioner inquiry programs might consider ways to engage relevant administrators in conversations about ways to formally recognize/validate practitioner inquiry towards heightened institution- and discourse-identity for participants. Previous research has also suggested it important to find ways for faculty engaged in the scholarship of teaching and learning to receive recognition for their work in their departments and the institution (Marcketti, VanDerZande, & Leptien, 2015; Marquis et al., 2017). This has also been echoed in

research on professional development for STEM faculty, which indicates that "support of significant others such as senior departmental colleagues, institutional provosts, and national science bodies" helps secure faculty engagement in teaching-related professional development (Bouwma-Gearhart, 2012b, p. 568).

Part of the lack of recognition experienced by those who participate in practitioner inquiry might be attributed to the difficulty of evaluating STEM education research on the parts of STEM units, which have a longstanding tradition of evaluating discipline-specific research and might struggle to evaluate education-related inquiry. Dolan et al. (2018) explains that discipline-based education researchers, specifically, publish in a variety of media unfamiliar to their STEM departments, such as (discipline-specific) education research journals and practice-oriented journals, towards varied audiences including practitioners, professional development programmers, curriculum and textbook developers, and policymakers. A similar reality exists for practitioner researchers who broaden their professional identities by participating in practitioner inquiry, which may be unfamiliar to those performing their disciplinary-situated professional reviews. This suggests the importance of practitioner inquiry program leaders collaborating with unit administrators towards establishing norms of judging the 'worth' of practitioner inquiry. It might be particularly challenging for STEM administrators to be open to learning about and working towards review standards for practitioner inquiry, since they may come from backgrounds and units that have historically undervalued qualitative methods and inquiry regarding teaching. This suggests that practitioner inquiry program leaders and designers should consider identifying and partnering with leaders that are respected among STEM faculty, who can serve as brokers of relevant knowledge and commitments concerning practitioner inquiry and other attempts towards teaching improvements (Bouwma-Gearhart, Perry, & Presley, 2014).

Garnering administrative, unit, or institution support could be essential in helping practitioner inquiry participants feel that their hard work and, on the part of our participants, extra hours are worth it. This is especially important when we consider comments made by a few participants, who indicated that their practitioner inquiry work, while maybe not recognized at this particular institution, might help them get positions elsewhere. This suggests institutions of higher education might lose these valuable educators, who are so committed to improving their teaching and helping students learn, if they do not recognize their scholarship concerning education (via institution- and discourse-identity means).

Conclusion

Our study explored how STEM faculty, largely fixed-term faculty, experience practitioner inquiry in light of their professional identity. We found that many of our participants sought to use their practitioner inquiry experience to broaden their professional identities to include identity as scholars of education. Indicative of one who does/demonstrates publication and presentation of research, identity as scholars of education was thought to be respected by the research-intensive institution within which they worked. Participants provided additional information to suggest that their scholar of education identities were shaped by their disciplinary notions of research and methodologies, which suggest tensions concerning how to legitimize scholarship in education. We also found that faculty identities as scholars of education can generally be facilitated by participating in a supportive group of other STEM faculty engaged in practitioner inquiry.

These results suggest implications for those leading and designing practitioner inquiry programs. Specifically, our study points the importance of engaging participants in lessons on the differences and nuances concerning practitioner inquiry and other forms of inquiry as well as

helping STEM faculty learn about methodologies relevant to their projects and research goals. Our study also suggests that practitioner inquiry program leaders and designers consider leveraging the motivations of practitioner inquiry participants, who might be specifically interested to participate to broaden professional identities towards including education scholarship. Practitioner inquiry program leaders and designers might also consider engaging STEM faculty in multidisciplinary, supportive practitioner inquiry groups as well as work with administrators towards conferring recognition to STEM faculty engaged in practitioner inquiry. While our research holds little generalizability for other STEM faculty, of other positions across universities, we argue that such efforts may help provide meaningful and supportive practitioner inquiry opportunities for STEM faculty of our focus — those with fixed-term positions at research universities. Recognizing practitioner inquiry work as constituting a valuable part of fixed-term STEM faculty members' professional identities could be of great importance towards recruiting and retaining this growing group of faculty, who are importantly employing research-confirmed means in their instruction to help students persist and find success in STEM courses.

CHAPTER 4 — Conclusions

Main Findings and Recommendations for Stakeholders

Both my studies broadly study STEM faculty members' experiences in learning communities fostered by a comprehensive, STEM education improvement initiative at a research university in the United States. My two dissertation studies contribute to the growing field of research on how STEM faculty experience change initiatives, particularly those intending to foster STEM faculty members' uptake of evidence-based instructional practices via their learning with other educators. Specifically, my first study explores how STEM faculty engage in conversations with others about teaching-related topics, as well as how these are influenced by an institution-wide improvement initiative creating communities where faculty can discuss, and learn about, teaching-related topics. My second study focuses on understanding STEM faculty members' experiences, primarily fixed-term faculty, in a practitioner inquiry program. Specifically, this study explores how these STEM faculty experience practitioner inquiry in light of their professional identity. Notably, the practitioner inquiry program in this study is one of the communities created and sustained by the same initiative as that in my first study.

Results and implications from first dissertation study. My first study takes a systems-level approach to understanding how, why, and with whom STEM faculty engage in teaching-related conversations within the context of an institution of higher education over the life of an initiative. The results of this study stem from the robust combination of both social network analyses of who STEM faculty talk to about teaching-related topics and interviews with STEM faculty. Specifically, this study used cultural-historical activity theory to illuminate how working at an institution of higher education potentially influences teaching-related conversations as well as how an initiative has impacted STEM faculty members' workplace perceptions and

experiences towards engaging in teaching-related conversations. Cultural-historical activity theory is particularly useful since it helps identify tensions that might inhibit teaching-related conversations.

Tensions that might inhibit STEM faculty members' engagement in teaching-related conversations were explored in light of social network findings. For example, STEM faculty may have great autonomy with respect to teaching practices, but not with respect to content, and this may inhibit them from participating in teaching-related conversations. Considering this finding in light of our social network analyses suggests that faculty might be more inclined to discuss aligning course content with community members in their units, since participants reported talking to more people in their unit than outside of their unit about teaching. Furthermore, STEM faculty may work in a community with coworkers who are variably interested in teaching-related improvements, meaning that some community members might be easier to discuss teaching-related topics with towards instructional improvement than others. Our social network analyses suggest that faculty networks, representing with whom faculty talk about teaching-related topics and likely composed of community members open to these types of conversations, grew more interconnected over the life of an instructional improvement initiative. This suggests that teaching-related knowledge can be more expediently moved throughout the network. Our study also found that STEM faculty may perceive varied levels of support to engage in teaching-related conversations, from their institution, units, or as manifested in their professional positions. Finally, STEM faculty may not feel motivated to engage in teaching-related conversations since conversations are not always inclusive or allow faculty to be open about lacking teaching-related knowledge.

These results suggest implications for those designing and sustaining opportunities for STEM faculty, where they might discuss teaching-related topics, such as administrators and initiative designers/leaders hoping to use faculty learning communities as a strategy to foster instructional improvements. Specifically, we suggest that such stakeholders consider creating spaces where faculty can talk with community members across the institution of higher education about teaching-related topics, particularly connecting those faculty interested in engaging in conversations about teaching improvements. Any discussions about teaching-related topics should be inclusive and safe to help STEM faculty feel like they can air real teaching-related concerns and insights to respectful and responsive listeners. Our study also suggests that STEM faculty may have a diverse-array of teaching-related interests, so it is particularly important for those hoping to foster faculty conversations/communities to make sure opportunities elicit and build off of the varied interests and teaching-related knowledge of STEM faculty. Those hoping to foster new faculty learning communities might also consider working with members across the institution, such as administrators and STEM faculty, to understand the diverse instructional improvement opportunities STEM faculty may already take part in. Finally, our study echoes the results of prior research in that it draws attention to the potential importance of administrative support towards fostering and sustaining opportunities for faculty to talk with others about teaching-related topics.

Results and implications from second dissertation study. My second study explored how STEM faculty experience practitioner inquiry in light of their professional identity. Uniquely, this study focused primarily on understanding the experiences of fixed-term faculty participating in a practitioner inquiry program. Specifically, we used Gee's (2001) analytic framework of identity to help us understand the different ways professional identity of fixed term

STEM faculty at a research university may evolve and, specifically, how their identity as scholars of education might be constructed and recognized. The results from this study suggested that many STEM faculty sought to use their practitioner inquiry experience to broaden their professional identities, towards including scholar of education. Being a scholar of education, and doing research, might be more respected by the research-intensive institution STEM faculty worked at, even though our participants also indicated that their practitioner inquiry work was variably recognized by the institution and units they worked in. Participants also provided information to suggest that their practitioner inquiry identities were shaped by their disciplinary notions of research and research methods, and that participating in a supportive group of STEM faculty doing practitioner inquiry helped support their growth as scholars of education.

These results suggest implications for those leading and designing practitioner inquiry programs. Specifically, our study points to the importance of engaging participants in lessons on the differences and nuances concerning practitioner inquiry and other forms of inquiry as well as helping STEM faculty learn about methodologies relevant to their projects and research goals. These incorporations, our study suggests, may support STEM faculty in broadening their professional identities to include scholarship concerning education. Our study also suggests that practitioner inquiry programs and designers consider leveraging the motivations of practitioner inquiry participants, who might be specifically interested to participate in such programs to broaden their professional identities towards including education scholarship. Practitioner inquiry program leaders and designers might also consider engaging STEM faculty in multidisciplinary, supportive practitioner inquiry groups as well as work with administrators towards conferring recognition to STEM faculty engaged in practitioner inquiry. These supports

can further help STEM faculty feel like practitioner inquiry, recognized as education scholarship, can be a respected part of their professional identity.

Looking Across Results: The Importance of Providing, and Supporting, STEM Faculty Members' Engagement in Collaborative Learning Opportunities Towards Instructional Improvements

Looking across my two studies, I am struck by the felt importance, on the parts of many participants, of having spaces available that recognize and cater to their instructional improvement interests and, specifically, opportunities to explore those interests amongst a community of STEM faculty with shared interests. As my first study found, faculty may have multiple teaching-related interests that they wish to explore with others. Interdisciplinary groups, specifically, may be particularly important for STEM faculty who do not find enough community in their home departments/programs, and especially for fixed-term faculty who, with the bulk of their work focused on teaching, perhaps receive too little recognition for their teaching-improvement efforts from their units. If faculty are to engage in instructional improvement opportunities, institutions and faculty organizations (e.g. colleges, departments) must provide faculty with meaningful opportunities where their teaching-related interests and experiences are heard, their efforts to improve instruction recognized, and where they can benefit from the experience and expertise of others. We must mitigate feelings, and norms, of doing the difficult task of teaching alone. In particular, research across both studies suggests collaborative learning opportunities should be spaces where all STEM faculty can have their ideas met with curiosity, carefully negating the more typical judgement that is perceived in academic debates and discourse. Ideally, these are spaces that meet their teaching-related questions and struggles with empathy and offer sound strategy towards relevant, evidence-based improvements. These should

also be spaces that celebrate the teaching-related successes of STEM faculty so dedicated to improving instruction and helping more students successfully learn STEM concepts and skills.

Furthermore, I am also struck by the importance of faculty agency and the support from those with greater positional power at institutions of higher education, in terms of the success and impact of education improvement initiatives and experiences. The impact of STEM faculty mobilizing and supporting one another without obvious higher- administration support was indeed impressive in both studies. Yet the experiences of our participants also suggest that administrator support may be necessary to help faculty feel that their efforts are most worthwhile, inclusive of the formal recognition from others in positions of power that professionals need and crave. If institutions of higher education are going to make it a mission to improve undergraduate instruction, they should consider putting effort into strategies to build from faculty vision, as well as recognize, formally and informally, the improvement efforts STEM faculty engage in. This might necessitate cultivating recognition and respect for STEM educators, even amid a culture that may privilege research over teaching.

Furthermore, my research draws attention to STEM faculty as persons who have teaching improvement interests and motivation to engage with others to learn about instructional improvements. STEM faculty want to engage in these efforts, even in light of some environmental and structural barriers. My studies suggest ways to help support STEM faculty in engaging in these conversations and communities, towards learning about instructional improvements to better the education provided to STEM students. In particular, my studies contribute to our growing knowledge of the experiences of fixed-term faculty, who are becoming more prevalent on campuses across the nation and who, my research suggests, want to learn about and engage in instructional improvements, and to build professional identity as those who

know how to ensure and inform these efforts. Thus, I hope this dissertation contributes to efforts to raise awareness of and support those faculty working at institutions of higher education who put effort, often above and beyond the norm, into improving instruction.

Brief Reflections on Using Second-Generation Cultural Historical Activity Theory as a Lens for Exploring Faculty Engagement in Instructional Improvement Opportunities

I used second-generation cultural historical activity in my first study, primarily as a heuristic tool for organizing findings and communicating analyses. However, I had some difficulties using cultural-historical activity theory. My reflections on these difficulties, which I detail below, may be useful for future researchers employing cultural-historical activity theory towards understanding how organizational aspects influence people's experiences.

First, I found it sometimes difficult to communicate the concepts of second-generation cultural-historical activity in the results and discussion. For example, some of the concepts in cultural-historical activity theory, such as 'object' and 'division of labor' (the latter of which I changed to 'roles,' upon the advice of a committee member) are 'clunky' to weave into explanations and interpretations. I wonder if this difficulty might be partially attributed to translating concepts from the language(s) cultural-historical activity theory was first conceptualized in, as noted in Foot (2014):

> [I]t must be noted that discussion of the components of an activity system and their relationships to one another is challenging for Western, especially English-speaking audiences. The most obvious problems arise because of differences between lexicons, translations, and cultural concepts. The English language has no direct translation for the concepts of "activity" or "object" as they are used in Russian or German, the languages in which activity theory was first articulated (p. 9).

As an example, Foot (2014) explains that Western audiences may think of an 'activity' as a linear sequence of "behaviors," whereas cultural-historical activity theory conceptualizes 'activity' as a "process-as-a-whole," consisting of "human collectives rather than individuals" (p.

9). While I do not think I had this specific problem concerning the definition of 'activity,' it is possible that my use of other concepts from cultural-historical activity theory may have been impacted by a lack of understanding original definitions. Granted, the way theory is used in research is not wholly attributable to a researcher's interpretation: Rather, how theory is used is a complicated process shaped by many factors, including the way theory is communicated in writings as well as the research focus. As a researcher, my understanding of cultural-historical activity theory has largely been shaped by the documents and books I have read as well as the varied ways I have learned about cultural-historical activity theory over my years as a graduate student. Thus, I wonder if other researchers have employed cultural-historical activity theory in slightly different ways due to the difficulty of translating theory-relevant concepts as well as variedly interpreting how to 'best' use those concepts.

Another difficulty related to using cultural-historical activity theory is that it can be quite a 'malleable' theory, meaning it can be used in different ways to illuminate different social phenomena. For example, when I first learned about cultural-historical activity theory in a graduate-level Learning Theories course, I learned that it was a *learning* theory. As a learning theory, cultural-historical activity theory can be used to help a researcher understand how a subject uses mediating artifacts to interact with an object: This process of learning is shaped by the context the subject is in, including the rules, community, and division of labor. However, in my first dissertation study, I wanted to more broadly illuminate how faculty use tools to engage in teaching-related conversations as well as how their perceptions of the context they work in influence this activity. Undoubtably, faculty using tools to engage in teaching-related conversations provides potential for faculty learning – but because faculty learning was not an explicit focus in this paper we were careful to never infer that learning occurred/was occurring.

Thus, because cultural-historical activity theory can perhaps be employed in many different ways — as a learning theory and as a heuristic tool for understanding how a context potentially influences activity — it can be challenging to 'know how' to 'correctly' use it.

Furthermore, my use of cultural-historical activity theory was complicated by the fact that many interviewees did not necessarily identify concepts (such as 'rules' or 'community members') that have the potential to shape the activity of engaging with others in teaching-related conversations. Rather, participants often identified aspects that *might influence* concepts, such as community member *traits* that might influence teaching-related conversations. For example, my first study found that members of the community might be differently interested in, or open to, engaging in teaching-related conversations/improvements. This finding suggests there is an *aspect* of some community members (i.e., varied levels of interest in teaching-related conversations/improvements) that might influence teaching-related conversations, but does not exhaustively define *who* makes up the community (i.e., administrators, fixed-term faculty, tenure-track faculty, etc.). If my goal was to more completely list all the community members, rules, and ways labor is divided, I would have needed to use other forms of data collection (such as observations and artifact analyses). These additional types of data collection would perhaps have helped me better understand the professional titles of those who make up the community, how labor is formally divided (and defined) by the organizations faculty work in, and what the explicit rules/expectations are for being a STEM faculty member. However, this would have shifted the focus of my first study to be less on what faculty members *perceive* as influencing teaching-related conversations and more on how does working in an institutional context potentially influence-teaching related conversations. I believe my first study usefully unveils STEM faculty members' *perceptions* of aspects that have the potential to influence teaching-

related conversations, which may be covered/minimized if other forms of data are collected and analyzed. Understanding how faculty vary in their perceptions provides unique and important insight towards constructing and fostering instructional improvement efforts in ways knowledgeable of faculty members' felt experiences and rationales.

Future Research Directions Inspired by this Research

Reflecting on my dissertation work helps me offer suggestions for future related research, that I believe would contribute novel knowledge to a growing base concerning instructional improvement initiatives and the realities of postsecondary STEM faculty.

Future research might also focus on understanding the experiences and rationales of other stakeholders who might engage in, or be affected by, similar instructional improvement opportunities, further illuminating how a larger system functions and interacts with initiatives. Researchers might explore, for instance, how administrators engage in (or do not engage in) instructional improvement opportunities, including their rationales for their level of support of STEM faculty engagement in instructional improvement work. Additionally, it would be interesting to know more about the experiences of graduate students, including how and why instructional improvement opportunities are engaged in (or not) by graduate students. Furthermore, because our study was limited to interviews, it would be fascinating for future research to employ other data collection techniques such as observations to better understand how STEM faculty engage in teaching-related conversations as well as what those conversations look like.

Furthermore, research on STEM faculty members' engagement in practitioner inquiry, and notably their development and recognition as scholars of education, could benefit from more research on how they make teaching and learning changes to undergraduate courses. While we

assume, in our study, that STEM faculty were making improvements to their courses based on interviews, observational research or case studies of STEM faculty engaged in practitioner inquiry that more closely analyzes the incorporation of research-confirmed instructional improvements in classrooms would contribute to our growing knowledge of how practitioner inquiry influences STEM faculty members.

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APPENDICES

Appendix A: STEM faculty interview protocol, for exploring how STEM faculty engage in teaching-related conversations at an institution of higher education with an ongoing teaching improvement initiative.

Introductory Script

Thank you very much for taking the time to talk with me today. As the email mentioned, I am a member of the evaluation team for the [initiative] which intends to foster connections between STEM faculty members and to encourage active learning in lower division STEM courses. I will be asking some questions specifically related to the [initiative] as well as some general questions regarding your approach to curriculum, teaching, and learning.

Is it OK if I record this conversation?

Questions

1. I'd like to know more about your position at [the institution]. Specifically:
    a. What is your official title?
    b. What classes did you teach this academic year, 2016-2017?
    c. Have your teaching responsibilities changed since last interviewed for this project?
    d. How much autonomy do you have over what and how you teach?

2. Do you interact regularly with any others concerning issues of teaching and learning?
    a. [If yes], please provide detail regarding those interactions: including
        i. Who?
            1. Are these people in your discipline/department/program?
        ii. how often?
        iii. regarding what specifically?
    b. What encourages or discourages these interactions?
    c. Have these interactions had impact on how you think about or approach teaching and learning? Please explain how/why.
    d. Has [this initiative] influenced these interactions in any way?

3. I'd like to hear about your engagement with the [initiative]. Specifically:
    a. What has been your affiliation with the [initiative]? What activities have you attended?
    b. Have you noted any impact of [the initiative] on you?
    c. Have you noted any impact of [the initiative] on others?

4. Please describe any evolution in your teaching practices over the last couple of years that you can attribute to improvement initiatives or professional development activities. [If not mentioned, probe for specifics via questions a and b.]

   a. Have any university or departmental initiatives or teaching professional development opportunities impacted this evolution?
   b. Has [the initiative] influenced your evolution in any way?

5. I'd like to hear about your assessment practices while teaching.
   a. To what extent do you collect data/information about student learning?
   b. Are your teaching practices informed by data/information about student learning?
   c. Are there means in the classes/courses that you teach for students to reflect on their own learning data? [If yes], Can you detail these processes?

6. Describe a successful student in the courses or programs in which you teach.
   a. Overall, what do you consider as the most effective teaching strategies towards developing these things?
   b. To what extent do you employ these teaching strategies?

7. A goal of the [initiative] is widespread improvement to teaching practices and learning outcomes in undergraduate STEM education across [this institution]. Our general strategy is promoting educators' learning about evidence-based instructional practices via interactions with other educators.
   a. What do you think about this goal and strategy? Do you have any evidence that widespread improvement to teaching practices and learning outcomes in undergraduate STEM education have happened in the last couple of years at [this institution]?
   b. Can you attribute any changes to the [initiative]?
   c. Have you noted any affordances and barriers towards widespread improvement to teaching practices and learning outcomes in undergraduate STEM education, that can inform efforts like [this initiative]?

8. Any other comments that could inform projects like [this initiative], focused on promoting teaching and learning improvement in undergraduate STEM education?

Thank you for your time.

Appendix B: Network survey for STEM faculty.

On a separate sheet of paper, make a list of the names of people with whom you communicate about teaching and learning over the course of a typical academic year. The list should include no more than 10 people; however, any number less than 10 is acceptable. For each person respond to the questions that follow.

Please list one person with whom you communicate about teaching and learning. State your colleague's first and last name. If this colleague does not work at [this institution], please state his or her affiliation. You will be asked follow-up questions regarding this person, and will have the opportunity to list up to 10 individuals.

What is that person's primary relationship to you?

- Colleague in your department
- Colleague in your college, outside your department
- Colleague outside your college
- Colleague affiliated with the [institution's teaching and learning center]
- [institution-affiliated] graduate student or postdoc
- Other [institution-affiliated] employee, such as a dean or non-faculty colleague
- Colleagues from outside [the institution]
- Family
- Other

If indicated other:
You indicated "other" for relationship. Please Specify:_____.

What is the highest frequency of interaction with this person over the course of a typical term?

- Less than one interaction per term
- About one interaction per term
- Multiple interactions per term
- Multiple interactions per week

What issues of teaching and learning do you discuss with this person?

- Teaching methods—how to teach
- Teaching materials and technologies—how to teach with what
- Curriculum—what to teach
- Curriculum timing—when to teach what
- Assessment—how to measure impact of teaching
- Grading issues
- Student motivation issues
- Student diversity issues
- Policy or accreditation issues
- Teaching issues related to promotion and tenure
- Making changes to curriculum or instruction
- Research/Scholarship on teaching and learning

Rate this person in terms of your perception of his or her expertise with respect issues of teaching and learning.

- 1 Novice: someone who is just starting to think about a particular issue in teaching and learning, for example, interactive engagement
- 2 Experienced: someone who has implemented a particular practice such as interactive engagement in his or her classroom
- 3 Expert: someone who has experience implementing a particular practice such as interactive engagement in his or her classroom, has reflected on this experience, adapted classroom activities based on these reflections, and has perhaps mentored others.

What is your comfort level with this person

- 1 Low
- 2 Moderate
- 3 High

Is there another person with whom you communicate about teaching and learning that you would like to list?

- 1 Yes
- 2 No

If 1 then Name02 else End Section.

Appendix C. Recruitment Script for STEM faculty engaged in practitioner inquiry.

Subject: Request for interview about [practitioner inquiry] experience

Greetings Dr. [faculty member's name],

I am a graduate student at Oregon State University in the College of Education. I am writing to seek your participation in a research study underway at [name of university] associated with the [name of grant], which seeks to improve instructional practices in science, technology, mathematics, and engineering (STEM) classes at [name of university]. I am working on a project to understand faculty experiences in the [practitioner inquiry] program.

If you agree to participate, I would like to conduct one 30- to 40-minute interview with you. The interview will be scheduled for a time and place of your choosing.

If your schedule permits participation, please reply to me [Ellen Aster, astere@oregonstate.edu] with a time and place that works for you so we can coordinate the interview.

Your participation in this study is of great value to our research project and to [name of university]. Thank you for your time and consideration.

Best,
Ellen Aster

Study Title: **[Name of study]**

Study PI: Milo Koretsky, milo.koretsky@oregonstate.edu, (541) 737-4591

Appendix D: Interview protocol for STEM faculty engaged in practitioner inquiry.

Thank you again for taking time to participate in this interview. To start off, I want to know a bit more about who you are and how you are involved in the [practitioner inquiry] program.

1. What is the title of your faculty position and how long have you been in this position at [this university]?
    a. How long have you been an educator in [your STEM field]?

2. Have you done any prior research on teaching and learning? Here I use the term 'research' to mean studying your teaching to improve practice, as you do with your [practitioner inquiry] work.

3. What motivated you to apply for the [practitioner inquiry] program?
    a. (If not already addressed) What were your goals for your participation in the [practitioner inquiry] program and/or have your goals for participation changed in any way? Please elaborate.
    b. Did you receive any support in applying for the [practitioner inquiry] program? If so, from whom or what?

4. Have you participated in any [practitioner inquiry] program meetings or events? In what ways have you participated?

5. Where are you at with your [practitioner inquiry] work? What have you done? What do you still hope to accomplish?

6. Have you made any changes to your teaching (in courses or teaching practices) since starting the [practitioner inquiry] program?
    a. What has helped you make changes to your teaching? What has motivated you to make changes to your teaching?
    b. Have you made any changes because of your [practitioner inquiry] work? If so, what?

7. Has your confidence in your ability to conduct [practitioner inquiry] work changed over time?
    a. What about the [practitioner inquiry] experience has influenced your confidence level?

8. Do you consider the [practitioner inquiry] work you do to be research and/or scholarship? Why or why not?

9. To what extent do you see yourself as a STEM education researcher when you do your [practitioner inquiry] work? Why?

10. Have you noticed any benefits from your participation in the [practitioner inquiry] program? If so, what are they?

11. Have you noticed, or to what extent do you expect, your participation in the [practitioner inquiry] program to have influenced your faculty position/promotion and tenure?

12. Have you noticed, or to what extent do you expect, your participation in the [practitioner inquiry] program to have influenced your department or program?
    a. [If not already covered] Do you anticipate your participation in the [practitioner inquiry] program to have helped you enact change beyond your classroom?

13. What has been most meaningful to you about your participation in the [practitioner inquiry] program?