A Network Model for Connecting Mathematics Faculty in Communities of Practice: Where is the Value?

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Abstract

Creating sustained, transformative change within and across organizations is challenging, particularly when those undertaking change act as individuals. COMmunities of Practice (CoPs) are organically created collaborations among like-minded participants, working toward a common set of goals (Lave & Wenger, 1991; Wenger-Trayner & Wenger-Trayner, 2014). CoPs offer an avenue for members to connect individuals across various boundaries. In this paper, we investigate the ways in which regional CoP leaders experience value participating in their community, using the Communities for Mathematics Inquiry in Teaching (COMMIT) Network as our unit of study. The COMMIT Network is a grant funded project aimed at engaging mathematics faculty at institutions of higher education in regional CoPs around teaching with inquiry. In this study we examine the experiences of CoP leaders nested within this network setting. We interviewed 19 leaders from eight United States regions to understand their perceptions of individual and collective value participating in the regional CoP and COMMIT Network structures. We framed our study on Wenger et al. (2011). Promoting and assessing value creation in communities and networks: A conceptual framework. Open University of the Netherlands.) Value Framework. Our findings show that leaders found Immediate Value as individuals participating in a collaborative, supportive CoP environment and they found Realized Value in terms of the impact their CoP could make on instructional practices, both in their region and the network. An unexpected finding examines how future opportunities for value creation may influence long-term sustainability and transformation of college mathematics instruction. We provide implications for the ways that regional CoPs, along with CoP networks, can provide value for members through such communities.

Keywords Community of Practice · Higher Education · Inquiry · Mathematics Education · Network · Value

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Introduction

Improving college mathematics student learning outcomes through the increased use of evidence-based instructional practices is an ongoing focus for all higher education institutions. Instructors using evidence-based instructional practices, including teaching with inquiry (TWI), have increased the knowledge, skills, behaviors, and motivation of their students (Abramovich et al., 2019; Freeman et al., 2014; Laursen et al., 2014; Theobald et al., 2020). However, traditional lecture-style teaching is still the predominant method of instruction in high school and college mathematics courses (Jaworski & Gellert, 2011; Laursen & Rasmussen, 2019; Nolan, 2006, 2010). Research suggests that change efforts, especially in complex educational settings with traditional views of teaching and learning, can be ineffective because they tend to rely too much on individuals to create and spread innovation (Borrego et al., 2013; Kezar et al., 2015). Faculty interested in TWI often find themselves isolated within their departments and with limited support (Banta, 2003). This can also include a lack of resources and connections needed to address deeper barriers to instructional changes that could positively influence student achievement (Henderson et al., 2018). To address such obstacles to changing instructional practices, particularly in science, technology, engineering, mathematics (STEM) areas, organizational change theorists have found promising avenues to create meaningful and sustainable change (e.g., Daly, 2010; Wenger, 1998). One such pathway has been an increased focus on using networks and communities of practice (CoPs) to initiate, promote, and sustain change (Austin, 2011; Kezar & Gehrke, 2017a). CoPs focused on TWI can provide a supportive space for like-minded faculty to exchange ideas, address shared experiences and challenges, and confront unproductive teaching beliefs and practices (Gehrke & Kezar, 2019). While small groups of faculty working together to increase their understanding and use of TWI practices is valuable, transforming mathematics education at a broader level takes a more systems-based approach to organizational change.

In response to Kezar's (2014) call for a more balanced approach to examining both formal organizational structures and informal social networks that broker change, we seek to investigate how one grassroots network of regional CoPs adopts, promotes, and sustains the widespread use of TWI practices in college mathematics. We aim to add to the global literature base that identifies not only what faculty find valuable from CoP and network engagement, but also the types of ongoing activities and structures that have the most potential to transform mathematics education. During immense uncertainty and change in reaction to the global COVID-19 pandemic, we investigate faculty CoP leaders' perceptions of personal and collective value as they seek to change the landscape of college mathematics teaching and learning. "Value" is a complex, social construct; therefore, we use the value framework developed by Wenger et al. (2011) to interrogate the intricate ways faculty leaders view value (i.e., immediate, potential) in their regional CoPs. The types of value we examine from the framework include immediate (in the moment resources, information, connections), potential (for the future), applied (tested implementation), realized (actualized implementation),

and transformative (broader dissemination to others). Further, we consider how implications of this study might inform the future stages of this Network of CoPs and other networks of STEM stakeholders interested in large-scale instructional change.

Literature Review

Effective Teaching and Learning Practices in Undergraduate Mathematics

Higher education faculty are called to be exemplary models of teaching, research, and service. With higher education institutions striving to improve their standing and recruitment in the academic marketplace, faculty members often find themselves with limited time and resources to implement evidence-based teaching practices (O'Meara & Bloomgarden, 2011). In teaching, active learning environments leveraging teaching with inquiry (TWI) practices have been shown to positively influence student learning outcomes. These outcomes include increased achievement, persistence, retention, and attitudes toward the subject matter (Bowen, 2000; Freeman et al., 2014; Graham et al., 2013; Van Dyken, 2016). Further, researchers have found that active learning environments can help close the achievement gap for historically excluded or disadvantaged students in STEM courses (Haak et al., 2011; Hrabowski & Henderson, 2017).

Many factors may contribute to the limited use of active learning and TWI practices in higher education. TWI is often a new philosophical approach to mathematicians with long-standing cultural expectations and experiences of learning and teaching mathematics. Faculty face challenges making time to shift not only their thinking, but implementation into course materials and instruction (Austin, 2011). Faculty members interested in TWI practices often find themselves lacking the resources and support they need (e.g., time, collaborators, training, feedback) to successfully implement TWI practices (Banta, 2003; Henderson et al., 2018; Jakopovic et al., 2022). For faculty seeking tenure, taking risks with teaching practices and being vulnerable could impact their overall success, leaving early-career faculty reluctant to persevere or challenge the status quo. Previous research has shown that teaching has been undervalued by colleagues, departments, and institutions in higher education, with research and grant work providing more incentives and external validity toward faculty promotion and tenure decisions (Finnegan & Gamson, 1996; O'Meara, 2007; O'Meara & Bloomgarden, 2011). Without structures in place to incentivize faculty instructional innovation, often faculty revert back or never attempt to expand beyond traditional, teacher-led instruction.

While constraints exist for faculty looking to implement TWI practices, meaningful and sustainable change is possible and has occurred at individual, department, and institutional levels (Austin, 2011; Daly, 2010; Wenger, 1998). In such cases, instructional change has been heavily influenced by relationships, networks, and communities of practice (Gehrke & Kezar, 2019; Kezar et al., 2017).

Communities of Practice as Change Levers

Communities of practice (CoPs) are defined by their domain, practice, and community (Wenger et al., 2002) and are made up of members who are focused on improving practices within the field (Lave & Wenger, 1991; Wenger-Trayner & Wenger-Trayner, 2014). CoPs are frequently smaller, grassroots initiatives that can leverage relationships among stakeholders to circumvent larger bureaucratic hurdles, especially in higher education (Fernández et al., 2022). Further, CoPs leverage the benefits of smaller, "significant networks" as they provide a private, "backstage" space for conceptual development and learning away from more risky, formal and public conversations about teaching and learning (Roxå & Mårtensson, 2009). Within these environments, as the literature supports, it is more likely for participants to establish an environment that fosters care, trust, and agency that empowers faculty to take risks and go beyond ideations about change (McGrath, 2020; Timmermans et al., 2018). Therefore, CoPs extend beyond collaboration and exhibit high levels of social bond, involvement, mutual help and support, sharing of meaning, and identity construction (Henri & Pudelko, 2003). Further, STEM CoPs in higher education have been shown to support innovation and change as a means to share knowledge, ideas, and resources (Austin, 2011; Gomez Johnson et al., 2021; Kezar et al., 2015). Organizational change theories highlight the importance of capitalizing on external pressures for disrupting organizations (e.g., using data, strategic planning goals) by creating spaces where groups and networks can broker change (Kezar, 2005; Kotter, 2012). For example, CoPs offer access to a space where social interactions and informal structures allow participants to find success implementing change due to the reduction of administrative confines found in formal units or departments (Daly, 2010; Kezar, 2014).

CoPs provide many individual and organizational benefits related to improving teaching. These benefits include facilitating instructional initiatives and innovations and creating leaders to help change the culture of STEM in higher education (Kezar et al., 2015). However, long-term sustainability is still an area of concern. CoPs are often temporal in nature- they develop organically out of a common need. Often they are not housed within a formal organization and may dissolve over time with changing leadership, lack of focus, etc. Evidence shows that the longer CoPs focused on reform exist, the greater impact they can have in scaling pedagogical changes to impact disciplinary societies, institutions, regional areas, sectors such as liberal arts colleges, and even international entities (Gehrke & Kezar, 2019).

According to Kezar and Gehrke (2017b), STEM CoPs in particular must shift at some point from a loose entity toward being more like an informal organization. Wenger et al. (2002) note that a tension exists between a CoP's sense of ownership and shared vision and its openness to new ideas. As CoPs grow, they risk losing focus. If they are closed to new ideas or evolution, they risk losing participants' interest or depleting their recruitment pool. Often CoPs dissolve because members no longer feel that their purpose is relevant or needed. There continues to be a gap in the literature addressing opportunities and barriers to CoP sustainability (Kezar & Gehrke, 2017b). A promising area of future investigation is to explore the role of

CoP leadership within a broader Network of CoPs focused on a specific domain of reform (e.g., college mathematics instruction).

Individuals within CoPs often look to a smaller number of individuals in the group to define the philosophy, values, and culture of the CoP. These key players, which we define as CoP leaders, are pivotal in CoP sustainability and distribution of leadership to include more perspectives beyond individuals traditionally in positions of authority (Kezar & Gehrke, 2017b). Many times these leaders look to others leading similar initiatives to brainstorm ideas and share resources at a more systematic level. CoP leaders find value in the ability to collaborate with other adjacent community leaders with similar shared interests (Gomez Johnson et al., 2021). Developing a network around a number of CoPs where not only the leaders, but also entire CoPs can leverage shared interests, resources, experiences, and overarching goals is a potential answer to the sustainability of individual CoPs. In this study, we examine one such Network of CoPs, focused on TWI in college mathematics, from the perspectives of regional CoP leaders. The purpose of this study is to investigate the ways in which CoP leaders have found individual and collective value in their participation and their perspectives on how the Network of CoPs model might help with sustainability.

Conceptual Framework

We utilize the value framework developed by Wenger et al. (2011) to position CoPs within "a dynamic process in which producing and applying knowledge are tightly intertwined and often indistinguishable" (p. 21). As Fig. 1 illustrates, the framework
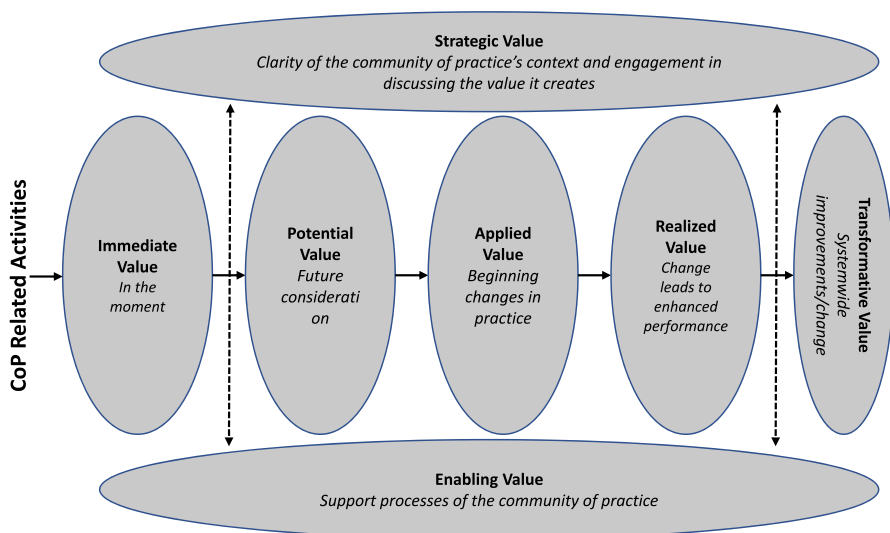

Fig. 1 Adaptation of Value Framework for CoPs from Gomez Johnson et al. (2021) and Wenger et al. (2011)

employs five cycles of value creation—immediate (in the moment resources, information, connections), potential (for the future), applied (tested implementation), realized (actualized implementation), and transformative (broader dissemination to others). In addition to the cycles, value at the CoP level is also supported by strategic value (clarity of the context and vision, ability to engage in strategic conversations) and enabling value (support processes that make Network life possible). For purposes of this study, we focus on the five cycles only.

Understanding what regional leaders and their COMMITs find valuable along with the structures they envision are necessary to maintain active, well functioning CoPs is key to sustainability. In the early stages of this project, our research team analyzed data to identify what individuals find valuable as they engage in activities within their regional CoPs. Moving into the second half of the three year project, we have expanded our investigation to also examine the types of value regional CoPs find in the Network. Therefore, the research questions for this study are: In what ways did CoP leaders find personal value participating in the COMmunity for Mathematics Inquiry in Teaching (COMMIT) Network? In what ways did regional CoPs find collective value engaging in the COMMIT Network? What opportunities do CoP leaders identify to create transformative value within the COMMIT Network moving forward?

Methods

Context of the Study

Despite the fact that many mathematics departments in higher education are familiar with the research behind incorporating active learning in undergraduate courses, this awareness does not always translate to successful implementation. A United States survey conducted by Rassmussen et al. (2019) found that, although 91% of mathematics departments reported a belief that active learning is "very important" or "somewhat important," only 15% reported effective implementation in their courses. To help faculty shift their teaching approaches from lecture-style instruction (e.g., Jaworski & Gellert, 2011), the Academy of Inquiry-based Learning previously offered national week-long inquiry-based learning workshops (http://www.inquirybasedlearning.org/). Although these workshops have provided support for hundreds of faculty, they have not yet developed a sustainable model of support that could incorporate professional development for all faculty around TWI. The COMMIT Network [https://www.comat hinquiry.org/], located in the United States, was designed to address this need by affording regional CoPs, called COMMITs, with a space for faculty to share ideas on how to create active learning environments that promote equitable teaching practice (e.g., TWI) to improve student learning outcomes.

The COMMIT Network expanded from four to twelve regional COMMITs in its first three years. While each COMMIT is established as an independent entity, the COMMIT Network offers a connection between and among the regional communities. The COMMIT Network embraces many forms of what we refer to as teaching with inquiry, including but not limited to: active learning strategies, inquiry-based learning,

project-based learning, problem-based learning, student-centered teaching, ambitious teaching, discovery learning, team-based learning, and inquiry-oriented learning. The Four Pillars of inquiry-based mathematics education (Laursen & Rasmussen, 2019, p. 138) summarize the features most important to the COMMIT Network:

- Students engage deeply with coherent and meaningful mathematical tasks,
- Students collaboratively process mathematical ideas,
- Instructors inquire into student thinking, and
- Instructors foster equity in their design and facilitation choices.

Utilizing the structure of the Four Pillars as a foundation, the COMMIT Network aims to provide strategic support to regional COMMITs to engage faculty in ongoing professional development activities related to TWI. This includes a focus on modeling equitable and accessible professional development practices at informal and formal events that can meet the needs of faculty of various identities, contexts, and from different institution types. It is necessary for STEM CoP leaders to understand how and what types of support structures the COMMIT Network offers to individual COMMIT participants, including leaders, to better inform the literature regarding the long-term sustainability of such CoPs.

Participants and Data Collection

To identify CoP leaders within the regions, we used social network analysis metrics to determine each actor's (member of the network) propensity to act both as a well-connected hub within their network as well as a bridge between otherwise unconnected network members. We identified a total of 19 participants from eight regional COMMITs through the social network analysis process. As leaders of their COMMITs, participants received an email invitation and agreed to participate in a semi-structured interview. We conducted and recorded the interviews using a video conferencing tool. Participants gave consent at the start of the video conferencing session prior to recording. Two members of the research team conducted the interviews, one asking the questions and engaging with participants and the other taking comprehensive field notes during the conversations. We then sent summaries of the interview field notes to participants as a form of member checking in order to ensure trustworthiness in the results (Creswell & Miller, 2000; Stake, 1995; Yin, 2018), and made revisions to notes as requested by participants. We removed any identifying information from the transcripts and field notes prior to analysis to ensure the anonymity of participants.

Analysis

In this study, we utilized a mix of deductive and inductive qualitative analysis focused around the value framework created by Wenger et al. (2011). Qualitative data analysis allowed us to interrogate "how people interpret…and attribute meaning to their experiences" (Merriam, 2009, p. 5). We used the interview summaries

and field notes as the primary source for analysis, with the transcripts serving as a secondary check for validity. We coded the data concurrently to calibrate and ensure intercoder reliability, as dual coding allowed us to reconcile any coding discrepancies along the way (Bradley et al., 2007; Krippendorff, 2004). We engaged in two rounds of coding (Saldaña, 2021). In the first round, we coded the data deductively using the framework for the five types of value creation to identify five a priori level one codes: Immediate, Potential, Applied, Realized, and Transformative (Wenger et al., 2011). As we coded for Transformative Value, we identified the need for a distinction between enacted Transformative Value (dissemination and systems-wide change that has taken place) and the Potential to Transform Value (future possibilities to promote TWI to the broader community).

After our first round of coding, we conducted a simple coding count to look for potential areas of interest in the data (see Table 1). We found that Immediate and Realized Value were most often identified by regional COMMIT leaders. We also noted that the number of instances coded for Potential to Transform was over three times that of implemented Transformative Value. We determined this code was worth investigating further as it could provide insights into what leaders perceived to be "next steps" in growing and/or sustaining the COMMIT Network. Therefore, we focused on these three level one codes for a second round of analysis.

We conducted a second round of descriptive coding (Miles et al., 2014; Saldaña, 2021) to identify additional emergent level two codes. We reread each of the coded segments for the three targeted level one codes to tease out more specifically what it was that regional COMMIT leaders identified as valuable. A more complete description of the coding system is outlined in Appendix A.

Findings

Our data analysis led to several findings about the types of value COMMIT leaders identified while participating in the COMMIT Network. Leaders shared examples and experiences that they found worthwhile at both an individual and regional CoP levels. In this section, we report on these findings.

Table 1 Coding Counts from Round 1 Data Analysis

Value Type	Coded Segments
Immediate	51
Potential	27
Applied	22
Realized	47
Transformative	9
Potential to Transform	33

Leaders as Individuals Finding Value in Participation

We first examined the instances where COMMIT leaders identified Immediate and Realized Value, as these were the most heavily saturated codes in our data. With regard to Immediate Value, we identified two commonalities that leaders discussed: having peers to share ideas with and developing interpersonal connections. Leaders identified multiple ways in which idea sharing took place "in the moment" (Immediate Value) within their regional COMMIT. For some, it was through attending workshops to gain insights into things like implementing TWI or adapting content for online and hybrid learning. Others expressed learning from colleagues through discussions at other events (e.g., book clubs, informal conversations). As one leader shared,

> It's validating to talk with other instructors… we are thinking very carefully about how to introduce the material... It is refreshing to have conversations with people who are thinking, 'How can I leverage student thinking?' and where things are really carefully considered.

Leaders also found Immediate Value in the development of interpersonal connections with other faculty members and COMMIT leaders. They identified value in having access to expertise, other leaders, and like-minded faculty through the COMMIT Network. One leader explained,

> Participating in a COMMIT has been a major source of community for me. Everyone has the freedom to teach the way they want. I have been able to influence some courses [at my institution] in some ways, but generally my teaching community is people outside of my institution.

Regional leaders found networking with other peers as a way to not only to share ideas, but also to simply talk about challenges and meet people from different institutions. The COMMIT Network connects faculty at different institutions who may not have otherwise had the opportunity to meet. Particularly after the onset of the COVID-19 pandemic, leaders explained that the COMMIT Network afforded them opportunities to escape the isolation and negativity many of them experienced. As one leader expressed, "This has helped in the past year to reduce isolation. In my COMMIT, everything is spread out and we don't travel to other institutions often, so people are virtually able to get together instead." Another leader shared, "I was lonely and felt I needed to connect outside of [my institution]." This sense of networking also applied to COMMIT leaders who were not yet in full-time instructor or tenure track positions. One leader, a Ph.D. candidate at the time of the interview, described the unique positionality of participating in the Network, saying, "As a graduate student I get to be in these meetings with people whose research I'm reading. To be 'on a level' with people much farther along in their career path is uncommon for a grad student." These opportunities offered by the Network provided instances of Immediate Value to leaders as members of their CoPs.

In addition to seeing Immediate Value in COMMIT participation, leaders also discussed their insights about finding Realized Value, or the sustained, expanded

use of TWI and Network engagement. Leaders described seeing themselves positioned as people with experience and expertise, which for some was perhaps a new realization. One leader described,

> I still think of my section, my participation as 'new,' but I'm realizing I have experiences to help new faculty with. I actually did have more experience, not in the sense that I know how to do it, but I've been through some of the processes and can talk about how to run a workshop, those sorts of things.

Several also remarked on how their engagement in their CoP and the COMMIT Network kept them from feeling "stale" in their teaching practice, and helped them to see how their involvement impacts their students. When asked how participating in the Network influenced their teaching practice, one leader stated, "Coming from a high school I probably would have been frightened to branch out. I would have been bored and my students would have been bored…and they wouldn't have learned as much."

Collective COMMITs Finding Value in Participation

Much like in their individual experiences, leaders most often named connecting with other COMMITs, utilizing the Network structures, and fostering collective identity through the Network as valuable to their region. COMMIT leaders also spoke to the Realized Value they saw for their communities in engaging with one another within the COMMIT Network. As new COMMITs coalesce, their leadership teams often connect with those of more established regions to look for guidance on ways to develop support structures for new leaders and communities. One COMMIT leader explained, "We have been trying to learn from others and what they are doing… it has been inspiring for us." The opportunities to connect with like-minded peer groups also surfaced as valuable to COMMITs. Leaders shared that it was meaningful to "…have access to the leadership teams and a shared voice" as they developed processes and events for their region. They expressed how having access to other faculty and CoPs allowed them to build strong interpersonal relationships with colleagues from across the Network.

Leaders also identified sustained, ongoing elements of the regional CoPs that offered value to the collective. One recurring theme was finding value in ongoing collaborations with colleagues within and across communities to leverage leadership experiences as assets to the Network. Leaders noted the Realized Value of these connections in fostering a functioning COMMIT, such as when one leader shared, "We have amazing partners and leaders (at a variety of places) dedicated, energized and well connected. There is a lot of experience in terms of both street cred for mathematicians and math educators." Leaders identified the importance of sharing the organization and structures their regions put in place with others to move COMMITs toward sustainability. One regional leader spoke to the importance of consistency in the organization of COMMIT activities,

> Our leadership team works really well together and we have different strengths. It is an equal partnership where everyone brings something new to the table.

We plan events in cohesive ways. We always have consistent flow and events. We are known for offering consistent events.

Leaders also identified support mechanisms at the Network level to help enhance individual COMMIT structures and leadership development. As one regional leader explained, the COMMIT Network supported workshops and facilitator training that provided opportunities for new leaders and regions to share ownership of the work. For some this meant stepping into new leadership roles and for others it meant stepping back and mentoring. One leader shared, "I am not a facilitator listed [on the workshop program] because I want them to have ownership of the workshop so they can see how the workshop can have an influence on how to lead." Quotes such as this illustrated the value leaders found (Realized Value) in distributed leadership as a model for moving towards sustainability.

Moreover, leaders shared the importance of the COMMIT Network in helping faculty develop a shared sense of collective identity around TWI. Several leaders shared the aspects of their leadership team and membership that added to this, saying things like, "people come with energy and motivation to our COMMIT," and "it makes it a lot more fun. It makes you feel like you are in a supportive environment where you can experiment and play and you don't have to do things the way you learned them." The CoPs and overarching COMMIT Network act as a loosely knit space where they can develop a common vision and sense of collective self. Leaders noted the importance of this in changing "the way we think about effective teaching" in both their COMMITs and individual institutions. "Having the general COMMIT Network in the background helps us generate some legitimacy," explained a leader. "It is not something we are making up because it is fashionable…that support from the back is helpful." Through resources, models, and shared experiences, the COMMITs, through their leaders, found Realized Value in being a part of something larger than themselves and growing in a new identity related to TWI.

Potential to Transform through Communities of Practice

We sought to understand what CoPs were already doing to disseminate their work and extend participation within the COMMIT Network (Transformative Value). An unanticipated finding in our analysis was the recurrence of statements from CoP leaders about the *potential to transform* their COMMIT or the Network in the future. Leaders reported regional efforts they were already doing to create Transformative Value for members as well as ideas they had to foster this value in the future (Potential to Transform). First, leaders shared strategies they had in mind to engage in transformative sharing around TWI. They identified Network structures, such as mini grant funding and opportunities to mentor new workshop facilitators that provide access to broaden expertise and distributed leadership. They also sought to examine the features of their region that supported or inhibited participation (e.g. geographic barriers, funding). Leaders identified strengths specific to their own COMMIT that they could offer to the wider Network community. For example, a leadership team member from [blinded CoP name] shared,

> I think we have a lot to offer. I think especially because we might be ahead, at least in the idea of the [regional cultural] renaissance, There is a huge focus on respecting [our] culture. Even in the aspect of math, that can be shared in the broader network nationwide and reaching out to Native American/first nations to collaborate and share ideas. [Our COMMIT] has had this ability because of the renaissance of [our] culture happening in the 70s, we are a little further along that we can share, not even inquiry based, but also focus on the place where you are and the people you are teaching.

Identifying the unique contributions that regional COMMITs can share with peers across the Network presents a currently untapped potential for CoP transformation. Leaders expressed both interest in learning from others and identifying assets that their own CoPs can offer to the broader COMMIT Network in the future.

In addition to examining *how* to increase Transformative Value in the Network, leaders also discussed *who* they wanted to engage to broaden the reach of their communities. For example, leaders shared wanting to find ways to better engage existing COMMIT members, as well as identify targeted ways to increase and expand membership. One shared idea was to recruit new individuals as well as new institutions and institution types (e.g. community colleges, high schools). Several leaders noted that there was a lack of representation from certain demographics and institution types, and hypothesized ways to support the recruitment and retention of new faculty. With diversity and inclusion as important pillars of TWI and CoPs, leaders considered how intentional efforts to include diverse perspectives could help keep them from making assumptions about what faculty in their COMMITs need.

> Coming from the four year perspective, I started with the incorrect perspective of how to transition to inquiry based learning if they are coming from a community college. Maybe they need resources, maybe need release time...there are barriers I haven't really fully understood yet.

Multiple leaders echoed this sentiment of making it a future goal to intentionally engage a wider range of institutions, including community colleges and faculty interested in TWI from different perspectives.

Finally, a number of COMMIT leaders shared a desire to connect with other regional communities within the COMMIT Network. From the established COMMIT perspective, one leader reflected, "It's nice… our community has been around for awhile. We have a history of things we have done and tried, we could give that experience and share that history with new COMMITs to help out." Leaders often noted the experiences and expertise their region had to offer that were unique to their group, but typically identified these as future opportunities rather than existing connections. One leader summarized their view of this Potential Value, saying, "There is something powerful about the regional anchoring of things but there is enough connection that regions can inform each other. There are many similarities to having a network where we can learn together what works well." These forward looking insights aligned with our consistent evidence of the value both individuals and regions found

in the strong community connections within the Network. When looking at the future goals of each regional COMMIT, it is often about engaging within the Network in addition to continuing to expand the reach of the regional CoPs.

Discussion

Creating large-scale instructional change in an area like college mathematics is no simple task. This study examined the perspectives of leaders within a Network of COMMITs hoping to not only transform their own classrooms and departments, but more broadly influence the way college mathematics is approached from an inquiry perspective. We examined not only how leaders found value in their participation in their regional COMMIT, but how they valued the interconnectedness of others in the broader Network also interested in TWI practices in college mathematics. Overall, leaders found personal value in being able to share ideas with peers and having the opportunity to develop strong interpersonal relationships with their mathematics colleagues. Further, they also saw how this collective value could provide an avenue of giving and receiving support and wisdom at a larger scale. With mathematics instructional transformation as a goal, these leaders found value in their potential to make a transformative difference on the mathematics education community using their own assets as a COMMIT and also with the collective contributions of others in the Network.

While TWI is a proven strategy to support diverse learners and reduce the achievement gap in college STEM coursework (e.g., Haak et al., 2011; Hrabowski & Henderson, 2017), faculty using these techniques continue to be the minority in their departments. Creating social change is dependent on variables such as trust, communication, and support (Henderson et al., 2018). As transformation initiatives get bigger, often the shared vision and individualized support can get lost. Within the COMMIT Network, maintaining localized CoP structures for faculty that are personalized, relevant, and responsive is critical to upholding these variables that support change. This resonates with our findings, in that, COMMIT leaders identified having structured ways to engage with individuals and groups who shared similar values about mathematics teaching and learning. They cited this as a key element of the Network that provided them Immediate, Potential, and Transformative Value as participants. One leader expressed, "It is valuable to be able to bounce ideas off of other people and not to feel like you are the only one kind of bucking the system." This sense of camaraderie was fostered through regularly occurring regional COMMIT and COMMIT Network formal meetings and events, as well as through informal networking opportunities with peers.

Beyond merely connecting like-minded faculty interested in instructional change together, CoPs need structures that support ongoing collaborations and provide outlets for members to develop relationships and common vision, as well as to share ideas and resources (Gehrke & Kezar, 2019). In our study, we found this to be true for both individual COMMIT participants as well as with the CoPs
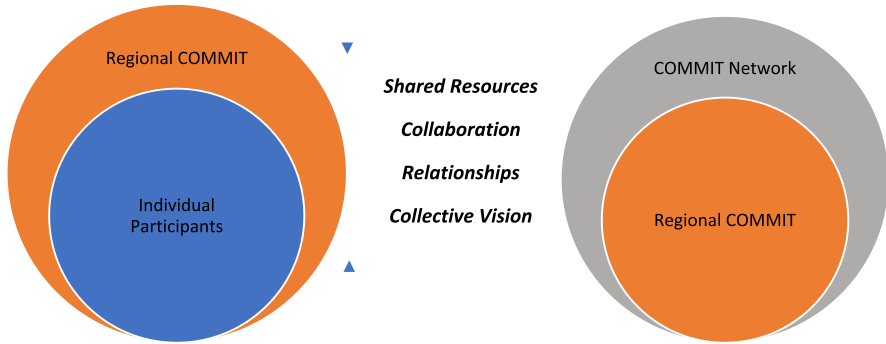
Fig. 2 Cross-cutting themes of individual, regional COMMIT, and COMMIT Network

nested within the larger COMMIT Network (see Fig. 2). Through analysis, we identified several aspects of the Network that maintained the mission and vision of these CoPs. First, the Network provides a mechanism for creating a sense of collective identity or personality within and across the regional COMMITs. Second, it affords opportunities to develop structures that keep the momentum of COMMIT-related work moving toward sustainability. Regional leaders expressed an ongoing need to both increase (number of participants) and expand (diversity of institution types and participants represented) their own CoPs, and a desire to extend their cross-network connections among COMMITs. Leaders overwhelmingly noted the power of community as a driver for instructional change at the systems level. As one leader reflected,

> For me this has been a wonderfully rich professional opportunity. It's wonderful to have a community of people close by, both physically and sort of how they're thinking about in terms of teaching. This is the go to place for support. For some people they go to the colleagues in the department I go to the regional community.

Previous research has found that structured national networks of STEM programs in higher education can make it difficult for change agents to articulate a clear vision. Further, faculty often find it hard to seek support outside of the organizational unit of their department (Kezar et al., 2015). Our findings suggest that connecting more localized CoPs within a loosely defined network afforded opportunities for members to seek out like-minded peers from across institutions and even geographic boundaries. It also presents the opportunity (e.g., the potential to transform) to develop participants' beliefs and teaching practices by connecting these CoPs at a national, and perhaps even, international level.

An unexpected finding of this study was the prevalence of leaders to have shared vision and to find value in the potential to transform their CoPs and the larger Network. With this study situated at the aftermath and ongoing struggles

of the COVID-19 global pandemic, faculty participants collectively voiced the ongoing work and progress in transforming mathematics education as needing to include more TWI practices. However, their efforts to transform were not yet realized. With the prevalence of the "potential to transform" outweighing the realized and transformative value in many areas, we wonder if the underpinnings of this finding are influenced or impacted by the contextual conditions, complexity of the change effort, or another isolated or combined factor. We see this as an opportunity for ongoing research and also a potential extension to the theoretical framing of value.

Studying a multi-layered system is important work, but also complex. One limitation of this study is the small sample size of COMMIT Network leaders. We were only able to interview leaders from eight of the twelve regional COMMITs. Therefore, it is possible that certain trends may have been overlooked due to the unique makeup of each region- both geographically and demographically. Additionally, we interviewed the COMMIT leaders at one point in time, which provides a limited snapshot of the complex nature of human collaboration. Collecting and examining longitudinal data would allow us to better identify recurrent trends at different points in each CoP's life cycle. We recommend that other, future studies around STEM CoP sustainability include those that can address these limitations by collecting robust data from multiple points across the life cycle of the CoP.

As we look ahead toward future research, the CoP leaders in our study identified potential target audiences and action steps to recruit, engage, and retain a more diverse set of participants in the COMMITs and the broader Network in an effort to both grow and sustain their work. Understanding how the COMMIT Network supports these endeavors is something our research team continues to investigate with this project. Although our study examined mathematics CoPs, we posit that this United States network of regional CoPs and our findings may have implications for transformation initiatives outside of mathematics, STEM education, and internationally. When supporting the personal and professional development of individuals, often collaboration and the use of small CoPs as a structure are recommended (e.g., Austin, 2011; Kezar & Gehrke, 2017a). This study focuses on how leaders perceive the value of leveraging localized CoPs, and a network of other like-minded CoPs to support their practice and promote transformation. Our future work is centered around the goal of hypothesizing the layers of support the COMMIT Network needs to sustain itself and the regional CoPs moving forward. This includes investigating the ongoing prevalence of "potential to transform" value indicators and how those might translate to transformative value within the CoPs or not. Ultimately, the purpose of the COMMIT Network, composed of regional CoPs, is to change the landscape of college mathematics teaching and learning to be more inquiry and student focused so that more students are successful and empowered in mathematics.

Appendix

Table 2 Codebook

Level One Code	Definition	Level Two Code	Definition
Immediate Value	Immediate interest in and awareness of mathematics education related opportunities. Level of participation in and quality of discussions	Personal Value: Idea Sharing	The leaders' perceived value in sharing ideas and strategies about teaching with inquiry
		Personal Value: Interpersonal Connections	The leader's perceived value in developing relationships/collaborations with peers
		Personal Value: Resources	The leader's perceived value in obtaining resources (tools, technology, etc.)
		Personal Value: Confidence/Competence	The leader's perceived value in the Networks ability to increase their confidence in teaching with inquiry
		Collective Value: Idea Sharing	The regional COMMITs' perceived value in sharing ideas and strategies about teaching with inquiry
		Collective Value: Interpersonal Connections	The regional COMMITs' perceived value in collaborating with peers
		Collective Value: Resources	The regional COMMITs' perceived value in obtaining resources (tools, technology, etc.)
Potential Value	Sense of connection and belonging in a community. Consideration of future use of shared resources and collaborations	N/A*	N/A*
Applied Value	Adoption of mathematics education strategies, ideas, and concepts. Increased level of engagement in peer collaboration activities	N/A*	N/A*

Table 2 (continued)

Level One Code	Definition	Level Two Code	Definition
Realized Value	Sustained or expanded use of teaching with inquiry strategies. Sustained and expanded contribution to community activities	Individual Realized Value	The leader's personal engagement in sustained practices and community activities
		Collective Identity	The features and characteristics that comprise a regional COMMIT as a community
		Connections/Community/Networking	The perceived value of the regional COMMIT in its role of fostering trust and rapport and in developing relationships among participants and COMMITs
		Structures	The systems and structures that keep the COMMIT functioning as a support to participants (e.g. regular meetings, events, methods of communication…)
Transformative Value	Promotion of teaching with inquiry/ math ideas to others in the broader community	N/A*	N/A*
Potential Transform	Recognition of future possibilities to promote teaching with inquiry/math ideas to others in the broader community	How	Methods regional leaders report they anticipate utilizing to further engage members and increase membership and access to teaching with inquiry resources
		Who	Identification of specific target audiences to extend/share with (i.e. engaging existing members and COMMITs for recruiting new individuals, institutions)

*Level two coding not included in this manuscript

Declarations

Conflict of Interest The authors of this manuscript have no known conflict of interest, financial or otherwise, related directly or indirectly to the work submitted in this manuscript.

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