

ADVANCING UNDERGRADUATE STEM REFORM THROUGH MULTI-
INSTITUTIONAL NETWORKS: THE ROLE OF FORMAL BOUNDARY SPANNERS

By

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ABSTRACT

ADVANCING UNDERGRADUATE STEM REFORM THROUGH MULTI- INSTITUTIONAL NETWORKS: THE ROLE OF FORMAL BOUNDARY SPANNERS

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Multi-institutional STEM reform networks have become a popular way to address the challenges facing undergraduate STEM education. Despite an intuitive sense that networks are effective educational reform pathways, few empirical research studies investigate their impact. Many have argued that institutional representatives, serving as boundary spanners, are key to securing the benefits of interorganizational membership. Boundary spanners are individuals who connect their organizations to the external environment and gain valuable external knowledge and resources to support local organizational performance.

The purpose of this qualitative study was to explore the inter- and intra-organizational boundary-spanning roles of institutional representatives at one multi-institutional higher education STEM reform network. The Center for the Integration of Research, Teaching, and Learning (CIRTL) is a network of 43 universities that seeks to prepare graduate students to be effective teachers so they can go on to positively affect undergraduate STEM education.

Using a case study design involving qualitative social network maps and semi-structured interviews, this qualitative study addressed three primary research questions: (1) what inter- and intra-organizational connections do formal, institutional representatives of a multi-institutional STEM reform network have (in relation to the network) and for what purposes, (2) how, if at all, do these formal institutional representatives engage in and make sense of inter- and intra-organizational boundary-spanning roles to help advance the network's reform agenda locally,

and (3) what individual and organizational attributes help or hinder their boundary-spanning activities?

Institutional representatives maintained several types of interorganizational connections related to network operations, network contributions, collaboration, and knowledge exchange. Due to these connections, they *found* numerous individual and institutional benefits and worked with their local teams to *translate* network gains for local implementation. They *diffused* network-related information to and *gained institutional support* from administrative and academic units and stakeholders. There were multiple individual and institutional attributes that influenced boundary-spanning behaviors. At the individual level, factors such as commitment, institutional role, role alignment, and managerial skills shaped how local CIRTTL leaders engaged in boundary-spanning roles. Organizational factors such as institutional alignment with the purposes of CIRTTL, programmatic infrastructure, and a decentralized organizational structure likewise played a major influencing role on boundary-spanning activities. In summary, this study demonstrated the complexity and integration of four primary boundary-spanning activities of institutional representatives in service to local STEM reform. They were able to inform campus groups and units, advance a dialogue of the importance of preparing future faculty, and influence local policies and practices.

Chapter 12: Conclusion

In this final chapter, I first provide a summary of my study, which includes a brief synopsis of the study's research questions, methods, and findings. Second, I discuss the major implications of my study focused on (1) what boundary spanners gain from multi-institutional network participation, (2) what boundary spanners need to be successful, (3) the importance of team-based boundary-spanning activities, and (4) a revised conceptual framework of boundary-spanning activities. Third, I provide a set of recommendations to key education reform stakeholders and discuss future research that could build upon my work. Finally, I discuss the limitations of my study and provide a few concluding remarks.

Study Summary

Background and Research Questions

As noted in the introduction, the lack of wide-spread adoption of evidence-based teaching practices in STEM (Austin, 2011; Henderson et al., 2011) has resulted in more systemic approaches to STEM reform that emphasize the interconnectivity between colleges and universities (AAU, 2014; Austin, 2011; Coalition for Reform of Undergraduate STEM Education, 2014; Kezar, 2014). Due to this shift, multi-institutional higher education STEM reform networks have been increasingly used as a change strategy. Despite an intuitive sense that networks are effective educational reform pathways, there is limited research that supports or contradicts this assumption (Kezar, 2014).

Many have argued that institutional representatives, serving as boundary spanners, are key to securing the knowledge-sharing benefits of interorganizational membership (Agranoff, 2008; Ahuja, Soda, & Zaheer, 2012; Brass, Galaskiewicz, Greve, & Tsai, 2004). Boundary spanners are individuals who connect their organizations to the external environment and gain

valuable external knowledge to support local organizational performance (Aldrich & Herker, 1977; Brion, Chauvet, Chollet, & Moth, 2012; Katz & Tushman, 1981). Specific boundary-spanning activities include *finding* knowledge through interorganizational connections (Aldrich & Herker, 1977; Ancona & Caldwell, 1992), *translating* network gains for local application, *diffusing* knowledge and resources into their organization (Rogers, 2003), and *gaining institutional support* (Ancona & Caldwell, 1992; Faraj & Yan, 2009; Joshi et al., 2009). Institutional representatives in multi-institutional STEM reform networks provide an important link between their network and their home college or university, yet their role as boundary spanners and in translating network participation for local implementation is not well-understood.

The purpose of my study was to explore the inter- and intra-organizational boundary-spanning roles of institutional representatives at one multi-institutional higher education STEM reform network. The Center for the Integration of Research, Teaching, and Learning (CIRTL) is a network of 43 universities that seeks to prepare graduate students to be effective teachers so they can go on to positively affect undergraduate STEM education. Specifically, my study addressed the following research questions:

1. What inter- and intra-organizational connections do formal, institutional representatives of a multi-institutional STEM reform network have (in relation to the network) and for what purposes?
2. How, if at all, do these formal institutional representatives engage in and make sense of inter- and intra-organizational boundary-spanning roles to help advance the network's reform agenda locally?

- a. What do they gain from network participation and interorganizational *finding* behaviors?
 - b. How do they *translate* network gains for application at their institution?
 - c. How do they *diffuse* network gains across their institution?
 - d. How do they *gain support* from local stakeholders to advance the STEM reform target of the network?
3. What individual and organizational attributes help or hinder their boundary-spanning activities?

Methods

I conducted four case studies of CIRTTL institutions. I based my selection criteria on the amount of time the institution had been a member of CIRTTL and the institution's depth of local CIRTTL programming. The four institutions included: (a) one long-standing institution with extensive local programming, (b) one long-standing institution with moderate-low local programming, (c) one newer institution with extensive local programming, and (d) one newer institution with moderate-low local programming. For each case institution, I identified two to three local CIRTTL leaders who acted as formal boundary spanners between their institution and the reform network ($n = 9$). I also selected individuals from CIRTTL's central administrative team and individuals at each university with whom local CIRTTL leaders had an intra-organizational connection related to CIRTTL.

Data collection consisted of a social network mapping exercise and semi-structured interviews. First, I asked local CIRTTL leaders to map their inter- and intra-organizational connections they had over the past year related to CIRTTL and to describe the type of each connection and its purpose in their STEM reform efforts. Second, I conducted 30 to 45 minute

interviews with the local CIRTTL leaders to clarify their network maps. Third, I conducted a separate 45 to 90 minute semi-structured interview to discuss their boundary-spanning behaviors. Lastly, I conducted 30-45 minute interviews with participants' defined campus connections ($n = 31$) and members of the central CIRTTL administrative team ($n = 4$) to triangulate network connections and boundary-spanning activities.

I used thematic analysis to examine participant social network maps and semi-structured interviews. I used Braun and Clarke's (2006) six steps of thematic analysis to guide my work. For hand-written social network maps, I reviewed each map, recorded their verbatim responses into a spreadsheet, identified the types of connections, and generated themes that summarized the major connection types. For interview transcripts, I familiarized myself with the data, generated initial codes, coded the dataset with NVivo, searched for themes within each code, coded for sub-themes, reviewed themes across the dataset (including the network maps), and finalized my findings.

Findings

In this section, I only provide a general summary of some of the major findings of my study. Please consult Chapters 4 through 11 for a more detailed account.

Research Question 1: Connections. I found that local CIRTTL leaders reported four major types of interorganizational connections with CIRTTL members. First, *network operation* connections were defined as local CIRTTL leaders interacting with other CIRTTL members to help run various facets of the Network. Second, *network contributions* consisted of online, cross-network programming that member campuses provided to the Network. Third, *collaboration* referred to engagement with CIRTTL members outside of regular Network operations. Lastly,

knowledge exchange related to specific interactions where local CIRTTL leaders shared information or resources with their CIRTTL colleagues.

I found that local CIRTTL leaders engaged in three main types of intra-organizational connections. First, *programmatic connections* involved local CIRTTL leaders working with various campus stakeholders to plan, implement, and evaluate local CIRTTL programming. Second, *administrative connections* consisted of local CIRTTL leaders keeping upper administrators informed of local CIRTTL activities and either maintaining or gaining their support. Third, *academic connections* involved efforts to gain support for local CIRTTL programs from stakeholders in academic units (e.g., deans, department chairs, faculty, graduate students), which included advertising local opportunities and convincing academic leaders and faculty to recognize the value of CIRTTL.

Research Question 2: Boundary-Spanning Behaviors. Local CIRTTL leaders, acting as formal institutional representatives, engaged in the boundary-spanning behaviors of *finding*, *diffusion*, *translation*, and *gaining institutional support* as described in the literature. Although I remained open to additional boundary-spanning behaviors during data collection and analysis, the boundary-spanning activities of local CIRTTL leaders were congruent with my literature synthesis. This finding demonstrates that there are similarities in boundary-spanning behaviors across different organizational settings. The purposes for engaging in boundary-spanning activities may be different (e.g., reform versus profit oriented), but the basic mechanisms are comparable.

With respect to *finding*, leaders and co-leaders were the major conduit (although not the only conduit) for acquiring the benefits of CIRTTL participation. Individual benefits consisted of gaining a supportive, likeminded community, an extended professional network, and career

advancement and professional development. Institutional benefits, centered on building local CIRTL programming, involved increased social capital through CIRTL participation, funding, CIRTL products, and programmatic resources. Motivations to engage in *finding* activities were dependent upon what leaders and co-leaders perceived as potential benefits, both personally and for their institution.

Local CIRTL leaders were also the primary mechanism for *diffusing* the benefits of Network participation into their campuses. They diffused CIRTL into their institutions by sharing network gains with their local CIRTL team, keeping campus leaders informed of CIRTL activities, and advertising CIRTL programs. Each communicative channel affected the local CIRTL team's ability to translate CIRTL locally and gain support from administrative and academic campus units. Other individuals on campus also participated in diffusion activities, such as advisory board members and student advocates, who helped spread the word about CIRTL and marketed local and national CIRTL offerings.

Translation was the epicenter for all boundary-spanning behaviors. Leaders and co-leaders (and their local teams) had to make sense of what was available through CIRTL participation, with whom to share certain kinds of CIRTL-related information, and how to integrate CIRTL content into existing local programming. They and their teams also had to determine the best strategies to inform and convince campus leaders and other stakeholders of the importance and value of being in the CIRTL Network and efforts to prepare future faculty as effective teachers.

Lastly, local CIRTL leaders (and their local teams) routinely worked to *gain support* from academic and administrative units. They used their formal institutional roles, social capital, the advisory board, personal and professional connections, and extensive marketing strategies to

seek support for and participation in local CIRTTL programs. They also used their formal campus positions to show upper administrators the value of CIRTTL membership and to update campus leaders on the progress of local CIRTTL efforts. Overall, I found that local CIRTTL leaders had to utilize a mixed set of *gaining support* strategies that involved many other campus colleagues to broaden their reach into diverse and decentralized campus units.

Research Question 3: Factors that Help or Hinder Boundary Spanning. At the individual level, there were four major individual attributes that influenced boundary-spanning behaviors. First, I found that commitment to the reform ideals of CIRTTL shaped how and why local CIRTTL leaders engaged in the four boundary-spanning behaviors. Second, I found that institutional roles contextualized boundary-spanning behaviors by providing varying amounts of decision-making and access to key campus constituents. Third, the degree to which CIRTTL aligned with other work roles and responsibilities significantly shaped boundary-spanning activities. Lastly, managerial skills in the form of delegating local CIRTTL responsibilities and reading the institutional landscape were vital skills in developing and running local CIRTTL programs.

My study also revealed three key institutional factors that influenced boundary-spanning behaviors. First, I found that it was important for institutional goals and priorities to align with the mission of the CIRTTL Network. Second, programmatic infrastructure, in the form of pre-existing programs and a local team with members from key campus units, was the foundation for building and sustaining local CIRTTL programs. Lastly, I found that decentralization, due to campus unit autonomy, greatly expanded the organizational boundaries that local CIRTTL leaders had to span in order to advance local CIRTTL efforts.

Discussion and Implications

In this section, my goal is to present the four most salient implications of my study, both for research and practice. The four implications include: what individuals gain from boundary-spanning activities, what skills and dispositions are needed to be a boundary spanning, the importance of team-based boundary-spanning activities, and a revised conceptual framework that modifies the interplay between the four boundary-spanning activities, Crossan et al.'s (1999) 4I framework, and four STEM reform categories (Henderson et al., 2011).

Why would you want to be a boundary spanner?

As noted above, local CIRTTL leaders gained many individual and institutional benefits by participating in the CIRTTL Network. My intent here is not to reiterate the list of various benefits, but to instead discuss why an individual would want to become an institutional representative in a higher education network. My study demonstrated that local CIRTTL leaders were extremely busy individuals who had many pressing commitments and responsibilities. Why would someone like this take the time to engage in a network such as CIRTTL? To frame this discussion, I talk about the mixed motivations of institutional representatives, a sense of community, and interorganizational knowledge exchange.

Mixed Motivation. Local CIRTTL leaders were complex individuals who had individual and organizational goals and motivations. March (1991) and Lavie et al. (2010) described organizations as either displaying explorative and exploitative behaviors. While the authors originally applied these dispositions to the organizational level, they are equally applicable to institutional representatives (i.e., local CIRTTL leaders). First, if an institutional representative displayed explorative qualities, they would have a disposition for outward seeking behaviors that extend beyond the confines of their organization. Second, if an institutional representative

displayed exploitative qualities, they would be content with what they already had within their organization. Local CIRTTL leaders simultaneously engaged in explorative and exploitative behaviors. For instance, consider a local CIRTTL leader who views CIRTTL as a source for professional growth and development but rarely extracts knowledge from the Network to build their local community because they consider their programs to already be strong. In contrast, consider a local CIRTTL leader who only has institutional motivations and wants to gain network knowledge and resources for their institution. Both polar examples demonstrate that a local CIRTTL leader can engage in explorative and exploitative behaviors at the same time, depending on the mix of individual and institutional goals.

My study also showed that local CIRTTL leaders were simultaneously motivated by individual and institutional goals. For example, a local CIRTTL leader could care deeply about preparing future faculty as effective teachers, their formal institutional role responsibilities could involve creating and implementing teaching professional development, and their institutions could fully support the advancement of teaching. Another local CIRTTL leader could share the same degree of devotion to preparing future faculty, but lack a work role directly related to teaching professional development and be at an institution with minimal desire to improve graduate student education. Each of these factors combine to form and influence a blend of motivation specific to the local CIRTTL leader and their unique organizational context. In addition, the mix of motivation is dynamic and can change due to factors such as a change in role or position and shifting individual or institutional values and mission.

The implication is that institutional representatives enter interorganizational connections as complex individuals who are not merely representatives for their organization. They also have individual desires and interests that shape their network participation. Multi-institutional

networks need to realize this and purposively design the community to engage, meet, and build upon individual and institutional interests, realizing that there is not a single mold for an institutional representative. In the next section, I highlight two important incentivizing agents that can appeal to both individual and institutional motivators.

Sense of Community and Knowledge Sharing Benefits. As I mentioned in Chapter 2, multi-institutional networks can be conceptualized as communities of practice, since members share a common purpose, work and interact regularly, and work together to advance their specific practice (Wenger et al., 2002), which in the case of CIRTTL is teaching professional development for future faculty. My study showed that CIRTTL was indeed a vibrant community of practice that espoused collegial interactions and, congruent with the literature (e.g., Ahuja, Soda, & Zaheer, 2012; Brass et al., 2004; Hemmasi & Csanda, 2009; Kirkman et al., 2011; McDermott & Archibald, 2010), had an active knowledge sharing culture.

The benefits of network participation for individual local CIRTTL leaders and their institutions came from integrating into the community through the four types of interorganizational connections described in previous chapters. Yet, local CIRTTL leaders in my study had varying degrees of network participation and often concentrated their efforts on certain types of interorganizational connections. For example, a few leaders narrowly focused on connections that they believed would have direct benefits for their institution and disregarded most network-level activities (e.g., serving on committees). This approach assumes that network benefits are packaged commodities, where a local CIRTTL leader could “shop around” until they found a specific kernel of knowledge or resource that fit individual or institutional needs. While this demonstrates one aspect of finding behaviors, it ignores the greater benefits that could result from deeper participation in the community of practice.

Expanded participation across the four types of interorganizational connections allowed local CIRTTL leaders to develop strong professional relationships and a network of potential knowledge- and/or resource-sharing connections. Viewed from this perspective, community of practice participation offers its members actual and potential, direct and indirect, knowledge-sharing benefits. Institutional representatives who only scan the surface of the community for information to immediately affect their home campus potentially miss out on deeper levels of knowledge exchange and the collective advancement of practice. While there is an increased time commitment associated with expanded network participation, it is possible to align network activities with individual and institutional motivators. This requires that institutional representatives see and understand the potential value of increased participation and that benefits may not be immediate. It also requires that network participation be viewed as an opportunity to engage in an active, dynamic community pushing for collective action.

Another implication of viewing the network as a community of practice is that knowledge- and/or resource-sharing benefits are non-linear and instead represent the connective potential of their interorganizational ties. Put another way, the extent of network connections influences their social capital or “the goodwill available to individuals or groups [that comes from]...the structure and content of the actor's social relations [that]...flow from the information, influence, and solidarity it makes available to the actor” (Adler & Kwon, 2002, p. 23). Local CIRTTL leaders who develop many different interorganizational connections in the Network can draw upon those connections as individual and institutional circumstances dictate over time. In short, as local CIRTTL leaders move from the periphery to core of the community of practice, they potentially increase the potential benefits of network participation if viewed from a longitudinal perspective.

In closing, an individual thinking about taking on the role of an institutional representative in a multi-institutional STEM reform network should examine their individual motivations and what they expect to gain for their institutions. They should ask questions such as “Am I committed to the reform goal of the network,” “Will network participation benefit my career and professional aspirations,” “Will the network inform or improve my on-campus responsibilities,” and “Will involvement provide knowledge and resources of worth and value to my institution.” In addition, potential institutional representatives should weigh their individual and institutional motivators against short-term and long-term gains of network participation. They should also understand that reform networks operate as communities of practice and that their membership is not just a means of knowledge and resource access but an opportunity to join a collective change effort. Personal, professional, and institutional benefits are all contingent upon the quality and extent of an institutional representative’s interorganizational connections. It is possible to secure short-term, immediate benefits, but “information, influence, and solidarity” build over time through community of practice involvement.

What does it take to be a boundary spanner?

Beyond articulating the factors that help or hinder boundary-spanning behaviors, my study also revealed several important characteristics of boundary spanners. My goal is not to articulate the “ideal” boundary spanner but to discuss several key characteristics that increase the likelihood of success, knowing that such characteristics may be spread among multiple institutional representatives or local team members.

Committed and Passionate. The first quality is that boundary spanners must genuinely care about the reform mission of a multi-institutional STEM reform network. This was the most consistent trait of local CIRTTL leaders. It served as a major individual motivator and shaped the

functioning of CIRTTL as a community of practice. Local CIRTTL leaders were extremely busy people who had many work role responsibilities outside of their CIRTTL duties. Despite time limitations, they still chose to attend network meetings and develop and run their local CIRTTL programs, at times without any compensation. They all felt strongly about the importance of preparing future faculty as effective college instructors and used that passion to fuel their network participation.

Other institutional representatives in interorganizational networks (i.e., not education reform-centric) undoubtedly share the quality of commitment and passion, but their zeal would likely concentrate on their home institution. Institutional representatives in an education reform network have a broader purpose, demonstrating commitment to their college or university, the campus units with which they affiliate, and the cause or reform mission of the network. Harking back to mixed motivations, institutional representatives in multi-institutional reform networks have multiple loyalties. Yet, I argue that their commitment to the reform ideal of the network is the most prominent influencing factor for their boundary-spanning activities. If we were to strip away reform commitment, institutional representatives would only participate in a reform network or engage in intra-organizational boundary-spanning behaviors if their respective work roles or organization incentivized or required their participation. Thus, the heart of boundary spanning for reform purposes is the commitment and passion for the reform itself.

Change Leader. Boundary spanners must also be change leaders on their respective campuses. They can be change leaders who utilize a top-down, planned approach (Bess & Dee, 2008b; Eckel, Hill, Green, & Mallon, 1999) and/or advance change through more grassroots-oriented methods (Kezar, 2011b). To help advance change from a top-down level, boundary spanners must possess at least some degree of decision-making authority, be well-connected, be

able to communicate the need for change to campus constituents, and understand their campus context and how it may influence change efforts. Similarly, from a grassroots level, boundary spanners must also be well-connected since they are not necessarily able to draw upon campus authority to diffuse information or garner support for change. However, my study demonstrated that local CIRTTL leaders often worked at both ends of the change spectrum due to their extensive informal ties on campus and their formal institutional positions. In addition, change efforts embedded in boundary-spanning activities were performed by many of the members of the local CIRTTL team, suggesting that change leadership was very much a distributed activity. Regardless of who performed change leadership duties, the common theme was that boundary spanners were change leaders on campus and that their boundary-spanning activities were a direct extension of change efforts.

Learning Leader. Related to organizational change, I found that local CIRTTL leaders were also closely connected to organizational learning because of their boundary spanner activities. As I pointed out in my conceptual framework, each of the four major boundary-spanning activities line up with the components of Crossan et al.'s (1999) 4I framework. Boundary spanners need to be able to intuit potential learning gains from network participation, weighing individual and institutional motivators to guide their finding behaviors. They must also be able to interpret knowledge gained from the network, both individually and with a local team, and determine the best way to apply that knowledge locally. In addition, boundary spanners can use their varied campus connections to integrate learning gains across campus by diffusing that knowledge and engaging in effective dialogue. Lastly, they can help to institutionalize learning gains through their formal institutional roles or through ongoing campus interactions. In short,

boundary spanners can participate in all four levels of organizational learning, though they may have less direct ownership of the integration and institutionalization levels.

Connected. Being an organizational change and/or learning leader is highly dependent upon intra-organizational connections (Brands, 2013; Dyer and Nobeoka; 2000; Gherardi et al., 1998; Hansen, 1999; Mohrman et al., 2003; Phelps et al., 2012; Tenkasi & Chesmore, 2003; Tsai, 2001). In addition, there are benefits of both strong and weak ties (Ahuja, 2000; Burt, 1992; Granovetter, 1983; Krackhardt, 1992; Tiwana, 2008). The implication for boundary spanners is that their reach and effectiveness is contingent upon their on-campus connections, which are a direct result of their formal institutional roles, faculty affiliations, and informal relationships. A boundary spanner with minimal campus connections will find it especially challenging to diffuse network gains and garner support from administrative and academic units. However, campus connections are not a factor of just a small amount of multi-institutional representatives. Instead, the local team attached to the particular reform agenda of the network represents a comprehensive connective potential. Thus, boundary spanners must not only take stock of their individual strong and weak ties on campus but also map the connections of those similarly engaged in the same local reform effort. A single boundary spanner will reach a connective saturation point and must rely on others to maximize reach for organizational learning and change efforts.

Time Management. Lastly, as evidenced in prior literature (Boardman & Bozeman, 2007; Friedman & Podolny, 1992; Johlke & Duhan, 2001; Organ, 1971; Stamper & Johlke, 2003), boundary spanners simultaneously interact in multiple organizational contexts and lack sufficient time to solely focus on their network involvement or responsibilities. They have to balance parallel and possibly competing work demands, not to mention familial duties. The

implication is that boundary spanners need to find ways to align their other work responsibilities or at least have their activities serve dualistic purposes. They can also coordinate with other boundary spanners to distribute boundary-spanning activities that match time availability. In summary, boundary spanners must be able to seriously examine their current responsibilities, what they can realistically do, and then carve out time for inter- and intra-organizational connections.

Can boundary spanners do it alone?

In line with the last section, my findings repeatedly showed that two or three institutional representatives could not be responsible for or even carry out all boundary-spanning behaviors. Instead, the boundary-spanning behaviors of *finding, diffusion, translation, and gaining institutional support* were distributed amongst local CIRTTL leaders and their local CIRTTL team. Local CIRTTL leaders were definitely the primary boundary spanners given their direct interorganizational connect to CIRTTL, but at the local level in particular, they were one of many attempting to embed CIRTTL into local reform efforts or advance local change initiatives.

Diversified and Expanded Reach. There are many benefits to a distributed boundary-spanning model. For instance, local reform efforts can draw upon the diverse experiences and connections of the local team to gain audience with administrative and academic units. No singular boundary spanner, regardless of their role and institutional authority, can develop effective connections with everyone on campus. A distributed approach provides multiple inlets into campus units and utilizes the existing social capital of team members. In addition, because of differences between top-down and grassroots change, certain local team members would conceivably gain more traction than others because of their formal institutional appointment or

existing professional relationships. In short, a team-based boundary-spanning approach allows a campus to build a tapestry of connections versus relying on a few thick cords.

In order for a team-based boundary-spanning approach to work, individual boundary spanners have to coordinate their efforts. The CIRTTL institutions in my study often used an advisory committee to accomplish this goal, since they could meet together regularly and make decisions regarding local programs, advertising, and gaining support from key players or units. However, it was obvious that these advisory boards were not always thinking about boundary-spanning activities. Instead, they were focused on accomplishing certain tasks that had implicit boundary-spanning implications. These groups may improve their ability to coordinate connections and activities by mapping their intra-organizational connections in light of their organizational change and learning goals (McGrath & Krackhardt, 2003; Quardokus & Henderson, 2015). This process could identify connective gaps in key units or even key players who would be good additions to the local team. The main point is that boundary spanners must find a way to coordinate their boundary-spanning behaviors to maximize their reach across campus and energize their short- and long-term reform goals.

There are also implications for interorganizational connections. For the most part, there were two or three connections to the CIRTTL Network from the four participating institutions (i.e., the local CIRTTL leaders). A few study participants discussed the problematic nature of this structure, since it could create a bottleneck of information. Instead, they suggested that institutions participating in multi-institutional STEM reform networks should have multiple local representatives engaged in the network. Going back to the tapestry or quilt metaphor, by building more than two or three inter-organization connection points, institutions would be able to garner the expanded reach and perspectives of multiple campus representatives. Each institutional

representative has a mix of individual and institutional motivators that shape their finding behaviors. By diversifying network participation, there would be a greater chance for novel or useful information to enter the institution. It was not clear what the magic number would be (e.g., 5, 10, etc.), but my findings suggested that expanding network involvement could generate more chances for individuals to engage in the multi-faceted interorganizational connection types, thereby increasing connective potential.

A Revised Conceptual Framework

My conceptual framework in Chapter 2 was an effective way to frame my study and create data collection instruments. My framework consisted of four primary boundary spanners extracted from the literature (*finding, diffusion, translation, and gaining institutional support*), Crossan et al.'s (1999) 4I organizational learning framework (intuit, interpret, integrate, and institutionalize), and Henderson et al.'s (2011) four categories of institutional STEM reform (disseminate best practices, develop reflective practitioners, create shared vision, and enact policies). The four boundary-spanning behaviors aligned with elements of the 4I framework (e.g., finding/intuiting) and led to various types of STEM education reform. However, in the process of data analysis, it was apparent that a few modifications to the framework were needed to accurately account for the CIRTL case and inter- and intra-organizational boundary spanning.

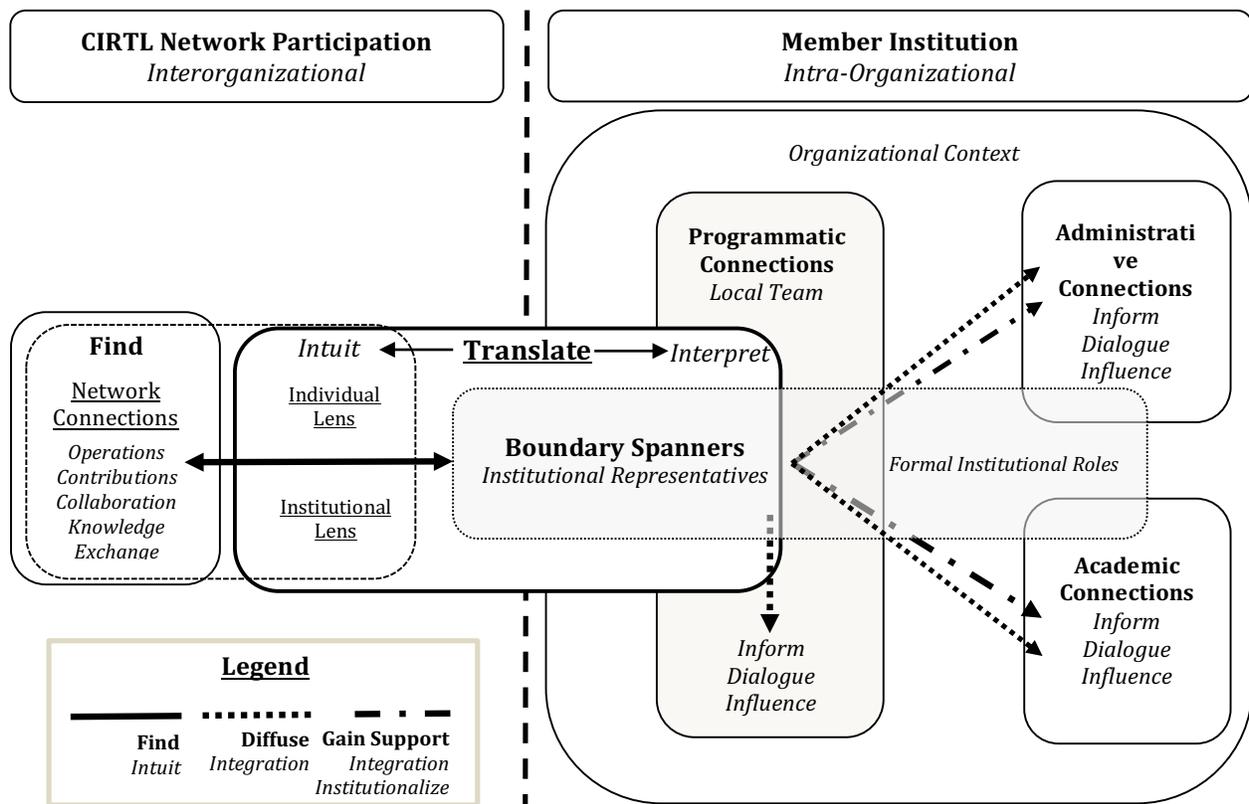
Translation. My study showed that *translation* was central to the boundary-spanning activities of local CIRTL leaders. It influenced what they found from Network participation, how they diffused CIRTL information across campus, and even how they attempted to gain support from campus stakeholders and units. Initially, I linked the behavior of *translation* to the *interpretation* component in the 4I framework (Crossan et al., 1999). However, my findings suggested that *translation* was really a product of both *intuiting* and *interpreting*.

Boundary spanners (institutional representatives) occupy a unique space between the network and their home institution. In order to participate in finding behaviors, they must intuit potential knowledge from network participation through their specific individual and institutional lenses. For instance, personal (e.g., career advancement) and institutional goals (e.g., improve their local CIRTl program) could influence what a local CIRTl leader sees in the network and what they seek from their network connections. Even before they actually find something of worth or interest in the network, they must carry out a preliminary translative activity. Another way to describe this process is that local CIRTl leaders likely establish a sort of cognitive filter, based upon needs, interests, and goals. This filter shapes their decisions to engage in various types of network connections and what they seek from the network and network members. In short, as local CIRTl leaders enter interorganizational space, they initially translate and intuit potential learning gains that they can find and bring back to their home campuses.

Once local CIRTl leaders identify or intuit something to be of worth to them individually or institutionally, they bring that new knowledge to the other side of translation, namely, *interpretation*. Before they cross the interorganizational/intra-organizational divide, local CIRTl leaders take their newly acquired network gains through the same individual and institutional lens to make key decisions on how such knowledge could be applied at the local level. They also share their network learning with key campus staff and work with a local team to further translate Network gains for their local programs. In the diagram, a local CIRTl leader's programmatic connections (those with whom he or she shares network knowledge gains and engages in translation activities) intersect with the translation box to demonstrate that translation and interpretation activities occur simultaneously at individual and group levels.

In addition, formal institutional roles extend from the translation box across the rest of the framework. I found that institutional roles were a major shaping agent for intra-organizational boundary-spanning behaviors, both for local CIRTTL leaders and their local teams. I also found that organizational context (depicted in the large encompassing square) highly influenced local boundary-spanning activities. Overall, translation activities were not only a product of individual and group interpretation intersections, but were embedded within individual and institutional context.

Figure 6: A Revised Boundary-Spanning Framework



Finding. As mentioned above, the behavior of *translation* was aligned with both the intuition and interpretation components of the 4I framework. *Finding* was also found to be an intuiting activity. I found that local CIRTTL leaders engaged in four major types of interorganizational connections: network operations, network contributions, collaboration, and

knowledge exchange. Each connection type represented a potential node where local CIRTTL leaders could apply their cognitive filters to extract useful knowledge or resources. As local CIRTTL leaders engaged in these relationships, they brought their translative lenses to discern what is of value and what warrants further consideration or action. Thus, intuiting involved the boundary-spanning behaviors of *finding* and *translation*.

Programmatic Connections. My initial framework lacked specificity of where local CIRTTL programs fit into the local boundary-spanning mix. In my study, I found that local CIRTTL leaders maintained three types of connections: programmatic, administrative, and academic. For greater continuity to my findings, I incorporated each into the revised framework.

As noted above, local CIRTTL team members participated in translation/interpretation activities. The local CIRTTL leaders *informed* the local team of national CIRTTL progress, novel information, and resources, which closely aligns with the boundary-spanning behavior of diffusion and Henderson et al.'s (2011) reform category of the dissemination of best practices. The local CIRTTL leaders (in some cases other institutional representatives) served as the primary link to the CIRTTL Network and diffused CIRTTL content into local CIRTTL programs.

In addition, local CIRTTL leaders engaged their local programmatic teams in *dialogue* about CIRTTL, the preparation of future faculty, and ways to augment and improve their local offerings. This closely aligns with Henderson et al.'s reform category of developing reflective practitioners, where local CIRTTL leaders used CIRTTL as a means to advance the conversation of graduate student professional development amongst those that plan, implement, and evaluate these programs.

Lastly, local CIRTTL leaders' connection to their programmatic teams not only represented a chance for fruitful dialogue but provided a chance to *influence* local programs. For

instance, local CIRTTL leaders and their respective teams translated CIRTTL's learning outcomes and achievement levels or made other changes to their programs as result of their network participation. Thus, local CIRTTL leaders' network participation and individual and group-based translation activities resulted in opportunities to *inform*, *dialogue*, and *influence* local efforts to prepare future faculty.

Administrative and Academic Connections. In the diagram, I represented diffusion and gaining institutional support activities by two different types of arrows. Unlike the initial model, I purposely placed the origin of these arrows at the intersection point between programmatic connections, the boundary spanner, and translation boxes. Decisions to engage in diffusion and gaining support were often a direct extension of translation activities, where local CIRTTL leaders and their teams made key decisions as to when, where, and how to engage in these activities. In addition, local CIRTTL leaders were not the only ones to interact with administrative and academic units. Furthermore, the *diffusion* and *gaining institutional support* lines travel through the formal institutional roles box, demonstrating that the ability to engage in these behaviors is often a result of institutional roles and existing social capital.

For the diffusion arrows, I retained their connection to the integration component of the 4I framework. Diffusion was a major means for local CIRTTL leaders and their team members to share information or knowledge about CIRTTL with other campus units in hopes that organizational learning realized at the programmatic level would disseminate out into other campus units. For gaining institutional support, I changed it to align with the 4I framework components of integration and institutionalization, since gaining support could consist of embedding knowledge within campus units and working to routinize learning gains into everyday practice.

I also included the same set of outcomes as the programmatic connections box. First, local CIRTTL leaders (or members of their local team) *informed* administrative or academic stakeholders/units of CIRTTL information or opportunities, which aligned with the dissemination of best practices of Henderson et al.'s (2011) model. However, intra-organizational boundary spanners were not always relating a specific best practice. Instead, they would inform campus leaders of local progress, explain what CIRTTL was and how it could help, and tell faculty and graduate students about programmatic opportunities.

Beyond simply sharing CIRTTL-related content, local CIRTTL leaders (and team members) had the opportunity to engage campus stakeholders in dialogue about the importance of preparing future faculty, the need and utility for professional development programs, and how individuals could get involved. This process roughly translates to developing reflective practitioners (Henderson et al., 2011). Local CIRTTL leaders (and their teams) were able to use or could potentially use CIRTTL as a means to advance conversations surrounding STEM education reform with administrators, academic leaders (department chairs, deans), faculty, and graduate students.

Lastly, I truncated the creating a shared vision and enacting policies components (Henderson et al., 2011) in the initial framework because diffusion and gaining support behaviors in this study were more aptly described as mechanisms of influence than absolute directive actions. Yet, by engaging in diffusion and gaining support activities, local CIRTTL leaders could influence a shared vision of the importance of preparing future faculty as effective teachers by engaging colleagues and connections in fruitful dialogue. They could also slowly influence policies and practices surrounding professional development opportunities for graduate students. Most local CIRTTL leaders were not in a position to singlehandedly change policy on

campus (e.g., they could not just flip a switch to change tenure and promotion criteria), but they could influence key campus leaders. Thus, local CIRTTL leaders could *inform*, *dialogue*, and *influence* administrative and academic units through their boundary-spanning roles.

Broader Theory. While my revised framework is specific to CIRTTL institutions, it has theoretical value for other higher education reform networks, especially those that focus on professional development programming. Institutional representatives of other networks likely must engage in translation activities to both intuit what they may find through multiple types of interorganizational connections and to translate any knowledge/resource gains for their campus. In addition, it is unlikely that they would be the only ones involved locally with the particular reform focus of the network. They might have a local team to aid in translation activities that would inform local efforts, create beneficial dialogue amongst practitioners, and influence and improve local programs. To create widespread impact, they and their teams would have to develop connections with administrative and academic units, as direct extensions of their institutional roles, to diffuse network gains and to convince campus groups of the importance of the reform agenda. Through these connections they would be able to inform, dialogue, and influence. In short, my revised framework could easily transfer to other multi-institutional higher education reform networks because it describes the interplay between boundary-spanning behaviors, organizational learning, and reform targets.

Recommendations

The findings and implications of my study can inform several groups of constituents involved in STEM education reform and higher education networks. First, I recommend that institutional representatives in higher education networks use the results of my study to examine their own boundary-spanning behaviors and to reflect upon their network engagement, their local

institutional roles, their on-campus connections, their interaction with a local education reform team, and how they perform *finding, translation, diffusion, and gaining institutional support* functions.

Second, I likewise encourage leaders of multi-institutional networks (such as CIRTl) to examine how their members engage in boundary-spanning activities and to purposively select a team of institutional representatives that possess positive boundary-spanning attributes. Related to that, I recommend that multi-institutional networks provide professional development opportunities for their members that are designed to help them explore their inter- and intra-organizational connections related to the network, assess their local team dynamic and institutional context, and identify what connections they need to create and how they could develop them.

Third, I recommend that campus leaders use my findings as a means to justify multi-institutional network involvement and to reassess their resource allocation to properly support boundary spanners. By better understanding the dynamics of local boundary-spanning behaviors, campus leaders could help overcome obstacles and become additional connective nodes in advancing local reform efforts.

Fourth, I encourage funding agencies and donors to explore the complexity of educational reform using a networked approach and identify funded projects that increase the finding benefits of network participation, improve or support the translation of network gains for local implementation, aid the diffusion of network learning or products into participating campuses, and provide tools and resources for boundary spanners to gain the support from administrative and academic units on campus. My hope is that funders will be able to reference my study to target interventions that will increase the impact of higher education networks. In

summary, I recommend that multiple constituency groups use my study as a means to more fully understand one major avenue of network impact and to identify ways to improve the effectiveness of boundary spanners.

Limitations

The first limitation of this study was that it was limited to the CIRTL Network and the universities involved in the study. While my methods provided ample depth to explore inter- and intra-organizational boundary spanning, the study's findings were context specific and may not apply to other networks or higher education institutions. This does not mean transferability is not possible, just that the specific findings of a case study are bound to the case it describes or analyzes (Yin, 2014). Thus, my study was not meant to be a comprehensive account of everything that has to do with boundary spanning and its connection to local STEM reform. Instead, it was an initial exploration, which could inform future research on the role of boundary spanning and its influence on local STEM undergraduate education reform.

Second, time was a major limitation. Boundary spanning is dynamic, since, in a given year, a local CIRTL leader may be more or less engaged in certain boundary-spanning behaviors. I collected data at one point in time, which did not take into account the historical and longitudinal nature of boundary spanning in relation to STEM reform efforts. I addressed some of this by selecting institutions that have been involved with CIRTL for varying amounts of time, selecting institutions that have varying levels of CIRTL programming, and by having respondents reflect upon their entire time within the CIRTL Network. However, this did not remove all time-bound concerns. For example, interview protocol questions did not probe enough about why the four campuses decided to join the CIRTL Network and how those decisions shaped initial and ongoing connections with the national network or the development

of local CIRTTL programming. In addition, I did not collect institutional documents (e.g., meeting agendas) that could have captured some of the temporal elements of local CIRTTL dynamics over time. Thus, the findings of this study are further constrained to a specific point in time versus a holistic view of boundary-spanning behaviors over time. Despite this limitation, future studies will be able to build upon my descriptive work and frame additional studies to factor in this missing element.

The third limitation is related to reliability issues. For example, since every named campus connection of local CIRTTL leaders at my four case institutions did not participate in my study, there may be important information missing that could confirm or contradict the responses from other participants. Participants may have attempted to “save face” by focusing more on the positive aspects of their CIRTTL involvement or local CIRTTL dynamics. Interviewees may not have had much chance, prior to the interview, to think about their boundary-spanning roles. Each of these concerns could shape the reliability of my data and subsequent analysis.

Future Research

My study deeply explored the role of institutional representatives as boundary spanners in a specific higher education network. Given my study’s focus on a single network and the exploratory nature of the study, there are many additional lines of research that could be explored in the future. For instance, future work could take my conceptual framework and findings and conduct similar studies with other higher education networks (STEM and non-STEM specific) to further examine boundary-spanning behaviors and to see if the same mechanisms applied in each network case. Future work could also use my qualitative, exploratory findings to generate survey instruments to measure network and institutional characteristics that help or hinder the boundary-spanning process and the impact of boundary-

spanning activities on local education reform. These types of studies would greatly expand the transferability of my study and help identify general and network-specific aspects of boundary-spanning activities.

Future work could more fully examine the impact that STEM network participation has on participating campuses, both through key boundary-spanning individuals and other network impact mechanisms. My study primarily focused on an important change mechanism, but I was unable to investigate actual, measured impact of network participation on member campuses. Future studies could concentrate on changes that occur because of network membership and boundary-spanning activities of institutional representatives and their local organizational teams.

Related to measured impact and change, future studies could also more fully explore local institutional dynamics including elements such as (1) the social construction of a local reform community and subsequent knowledge, products, and programs; (2) local organizational context; and (3) the balance between national network involvement and local autonomy. The exploration of local institutional dynamics (as related to network involvement) would address the temporal limitations of my study by including multiple rounds of data collection (including perceptions of the past by participants), expanding data collection strategies (e.g., interviews, social network data, documents, observations and site visits), expanding the number of participants, and better triangulating data to demonstrate similarities and differences among institutional representatives that engage in the national network, their local reform teams, and other campus stakeholders. Another direction could be to more fully examine group-based intra-organizational boundary spanning and see how campus leaders and constituents draw upon their varied positions and connections to advance education reform. My study demonstrated the

importance of the team in local boundary spanning, but future work could focus greater attention on team-based processes.

In addition, another line of research could track, using quantitative and qualitative social network methods, boundary-spanning activities over time to see how boundary-spanning behaviors change as a result of shifting priorities, positions, institutional culture, varying levels of network participation, and so forth. Future research questions could also focus on individuals that maintain membership in multiple higher education networks and other interorganizational connections related to STEM reform. My study focused on the CIRTL Network but many local CIRTL leaders had connections to similar initiatives that could have shaped their boundary-spanning activities and local reform activities.

Lastly, another study could explore the similarities and differences between the social capital derived from multi-institutional network participation and the social capital that comes from institutional work roles and existing professional connections. My study demonstrated the importance of both types of social capital for boundary-spanning activities, but it primarily focused on the social capital of the individual boundary spanners. It may also be possible for social capital to be defined and applied at the institutional level. Future studies could explore this dynamic in relation to multi-institutional network membership.

In summary, there are numerous research tracks that could be explored to investigate the mechanisms by which multi-institutional networks and associated institutional representatives influence local education reform.

Conclusion

Institutional representatives in multi-institutional higher education STEM reform networks perform a key boundary-spanning role by linking their campus to an

interorganizational community of practice. I studied four member institutions of the Center for the Integration of Research, Teaching, and Learning to examine what inter- and intra-organizational connections they had with respect to CIRTTL, how they made sense of their boundary-spanning roles, and what helped or hindered their boundary-spanning activities. Local CIRTTL leaders maintained several types of interorganizational connections related to network operations, network contributions, collaboration, and knowledge exchange. Due to these connections, they *found* numerous individual and institutional benefits and worked with their local teams to *translate* network gains for local implementation. They *diffused* network-related information to and *gained institutional support* from administrative and academic units and stakeholders. There were multiple individual and institutional attributes that influenced boundary-spanning behaviors. At the individual level, factors such as commitment, institutional role, role alignment, and managerial skills shaped how local CIRTTL leaders engaged in boundary-spanning roles. Institutional factors such as alignment with the purposes of CIRTTL, programmatic infrastructure, and decentralized likewise played a major influencing role on boundary-spanning activities. In summary, my study demonstrated the complexity and integration of the four primary boundary-spanning activities of local CIRTTL leaders in service to local STEM reform. They were able to inform campus groups and units, advance a dialogue of the importance of preparing future faculty, and influence local policies and practices.