A SOCIAL NETWORK ANALYSIS OF AN ONLINE TEACHER COMMUNITY OF PRACTICE: A MIXED METHODS STUDY

by

DIEGO ANDRES BOADA BELTRAN

(Under the Direction of Lloyd Rieber)

ABSTRACT

The Center for Latino Achievement and Success in Education (CLASE) launched an online platform in summer 2016 for teachers to build a community of practice (CoP) around the Instructional Conversation (IC) pedagogy. Within 18 months, 382 teachers joined the CoP to seek ongoing support, share resources, collaborate with one another, and build community. This mixed methods study uses cultural-historical activity theory (CHAT) (Cole, 1996; Engeström, 1987, 2001; Leont'ev, 1978; Vygotsky, 1978) and sociotechnical interaction networks (STIN) (Kling, McKim, & King, 2003; Meyer, 2006) to understand the formation, development, and evolution of an online teacher CoP. This study followed an explanatory sequential design (Creswell, 2014). In the first phase, a social network analysis (SNA) was conducted to identify network attributes, node centrality measures, and evidence for homophily (Kolaczyk & Csárdi, 2014; Scott, 2013; Wasserman & Faust, 1994). Then, in-depth interviews with two core contributors, two brokers, and two peripheral observers were conducted and coded using thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006). The SNA revealed the structure of the network, patterns of engagement, and helped identify members of interest for interviews. Mixed evidence for homophily was found after triangulating quantitative and qualitative data.

Participants reported positive attitudes towards the online CoP and increased opportunities for reflection, collaboration, and mentorship. Access to high-quality instructional resources was one of the main reasons for teachers to join the CoP. Teachers expressed a preference to reach out in person to members of the CoP at their workplace. All teachers interviewed reported creating value through the online CoP despite their limited time to participate. This study reinforces the critical importance of real-life interactions to strengthen trust and sense of community in online communities. Some of the nuances at the intersection between teacher *communities* and *networks* are examined (Wenger, Trayner, & de Laat, 2011). Implications for theory, research, and practice are discussed, as well as suggestions for future research.

INDEX WORDS: Online community of practice, cultural-historical activity theory, sociotechnical interaction network, social network analysis, communities and networks, teacher learning, teacher professional development, mixed methods

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DEDICATION

I dedicate this dissertation to all the friends, family, and colleagues who have guided me through this journey. I especially want to thank my mom, Beatriz Beltran, and Eric Antepenko, who just married me this summer, for their unconditional love and support.

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I have always believed in the power of education to transform lives, communities, and generate social change and justice. When I lived in Colombia, I never imagined I would be able to pursue advanced graduate degrees in the United States. Back then, so many people always encouraged me to study hard and try my best. I still remember when I first arrived at the Hartsfield–Jackson Atlanta International Airport on July 28, 2012 to pursue a master's degree in Learning, Design, and Technology at the University of Georgia. I couldn't believe my dream was about to come true thanks to a Fulbright scholarship. Thanks Fulbright Colombia and Fundación Saldarriaga Concha for believing in me! Since then, I have met wonderful professors, colleagues, and lifelong friends who have supported me throughout this journey and shared with me their wisdom and passion for life and learning. I leave the University of Georgia with great memories and a stronger urge to "change the world" than when I arrived.

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CHAPTER 1

INTRODUCTION

Teacher professional development consists of experiences that allow in-service teachers to enhance their knowledge, attitudes, and skills to improve their students' learning (Crawford, 2014). Ongoing support and opportunities for teacher learning are of paramount importance to adopt new curricula or address educational problems (Francis & Jacobsen, 2013; Hawley, 1999). Teacher professional development programs vary in duration, content, and mode of delivery. Content may range from subject-specific knowledge to pedagogical approaches, assessment methods, technology integration, or any other professional skills. Such programs can be either formal or informal and adopt face-to-face, online, or blended delivery modes. Over the last two decades, computer-mediated teacher professional development has received a lot of attention given its potential to accommodate teachers' schedules, reduce implementation costs, overcome local or geographical barriers, and increase levels of support and reflection (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2009).

Research on online teacher professional development typically focuses on program effectiveness, differences between delivery modes (online vs. face-to-face), impact of professional learning communities, and teachers' perceptions and interactions in online environments (Dede et al., 2009). Although design principles for professional programs have been identified (e.g. Hill, Beisiegel, & Jacob, 2013), outcomes are still not as satisfactory and online professional programs report high attrition rates (O'Dwyer et al., 2010). Many computer-mediated initiatives are not sustainable, transformative, or teacher-owned (Borko, 2004; Dede et

al., 2009; Polly & Hannafin, 2010). Much of the research available on online teacher learning is anecdotal, relies on teachers' self-reported surveys, does not evaluate long-term effects, and does not build on informal learning opportunities (Dede et al., 2009; Grover, Walters, & Turner, 2016; Polly & Hannafin, 2010).

A particular area of interest is how teachers can build professional learning communities in online environments (Barab, Barnett, & Squire, 2002; Mackey & Evans, 2011; Prestridge, 2010; Tsai, Laffey, & Hanuscin, 2010; Wang & Lu, 2012). Online communities have been proven to foster collaboration, reflection, and professional learning. However, concerns have been raised about misusing the term *community* to refer to any kind of online group interaction (Barab & Duffy, 2000; Kling & Courtright, 2003). Barab, MaKinster, and Scheckler (2004) defined a *community of practice* (CoP) as "a persistent, sustained social network of individuals who share and develop an overlapping knowledge base, set of beliefs, values, history and experiences focused on a common practice and/or mutual enterprise" (p. 55).

In an effort to support the education of English language learners in Georgia, the Center for Latino Achievement and Success in Education (CLASE) partnered with more than 20 rural, suburban, and urban districts across the state to provide teacher professional development on the Instructional Conversation (IC) pedagogy. The IC is an evidence-based model that positively impacts the academic achievement of English learners and other students by fostering small-group dialogue (Gokee, 2017; Portes, González Canché, Boada, & Whatley, 2018; Tharp & Gallimore, 1991). CLASE works with each district to customize teacher professional development programs to meet the needs of administrators, teachers, and students in each district. The options for professional learning include 30 hours of intensive training over the summer, course refreshers in the fall and spring semesters, bi-monthly academic coaching, bi-

monthly learning labs in which teachers and coaches analyze videotaped lessons, classroom observations/visits, and access to our online teacher platform.

With the aim of developing a sustainable and transformative professional learning experience for teachers, CLASE launched an online platform in summer 2016 for teachers to build a CoP around the IC pedagogy (http://instructionalconversation.ning.com/). Within 18 months, 382 members have joined the CoP to seek ongoing support, share resources, collaborate with one another, and build community. Only teachers who were trained in the IC pedagogy were eligible to join the online community. The online CoP is hypothesized to be a useful addition to CLASE's face-to-face professional development model and substantially increase the scope and outreach of our programs.

Towards a Theoretical Framework to Understand an Online Teacher CoP

Building an online community is a major accomplishment because a community needs to emerge from the needs and interactions of its participants and cannot be designed from an instructional perspective (Barab, MaKinster, Moore, Cunningham, & The IFL Design Team, 2001; Kling & Courtright, 2003). The term *community* has a very broad meaning when used colloquially, but very restrictive meanings in scholarly circles. For example, cooperation is not a defining characteristic of a community from a sociological perspective (Brint, 2001). Instead, communities are defined on the basis of factors such as geographical or non-geographical ties, activities or beliefs that the members share, or the frequency of interaction (Brint, 2001). In the fields of business and education, *communities* are understood as a highly desirable or aspirational form of social relationships characterized by warmth, cooperation, mutual support, and a symbolic value (Kling & Courtright, 2003). The problem with the term *virtual communities* is that it generates high expectations regarding how individuals should behave, but there is no

clarity on how to structure and motivate such interactions in online environments (Kling & Courtright, 2003). As instructional designers, we can only enable and facilitate the formation of online communities.

A CoP is an informal social network of individuals who share a set of beliefs, values, history, experiences, and knowledge base in the pursuit of a common practice or enterprise (Barab, MaKinster, et al., 2004; Wenger, 1998). Other defining characteristics of a CoP include mutual interdependence, mechanism for reproduction, opportunities for interaction and participation, meaningful relationships, and respect for diverse perspectives and minority views (Barab et al., 2002; Barab, MaKinster, et al., 2004). A CoP is not a temporary gathering of people for a specific purpose, but a sustainable social and professional network that has mechanisms to grow and reproduce. In the words of Barab and his colleagues (2004), "much like a living organism, they (CoP) are self-organizing, and cannot be designed prima facie. They grow, evolve, and change dynamically, transcending any particular member and outliving any particular task" (p. 55). Therefore, design and research efforts should be oriented towards understanding the characteristics that cultivate and maintain community functioning.

This study uses cultural-historical activity theory (CHAT), sociotechnical interaction networks (STIN), and Communities of Practice (CoP) to understand the formation, development, and evolution of an online teacher community (see Figure 1). Other instructional design researchers have used CHAT in conjunction with other theoretical perspectives to better understand complex sociocultural contexts (Barab, Schatz, & Scheckler, 2004; Hung & Chen, 2001). Both CHAT and STIN are complimentary theoretical perspectives that can work synergistically and provide deeper understanding of the social phenomena and the mediating role of technology (Barab, Schatz, et al., 2004). From this standpoint, the online community of

teachers is an activity system that makes part of a larger STIN in which technologies influence and are influenced by the social world. Technology is also a mediating tool that accelerates transformation and redistribution of representations (Clarà & Barberà, 2013). Such representations (or knowledge) are psychological tools that mediate between the subject and the object. Representations are located outside the individual and distributed within communities and systems of activity. Learning occurs when individuals are able to use the representation with others within a Zone of Proximal Development (ZPD) (Vygotsky, 1978), which results in internalization once the individual is able to use the representation on his or her own.

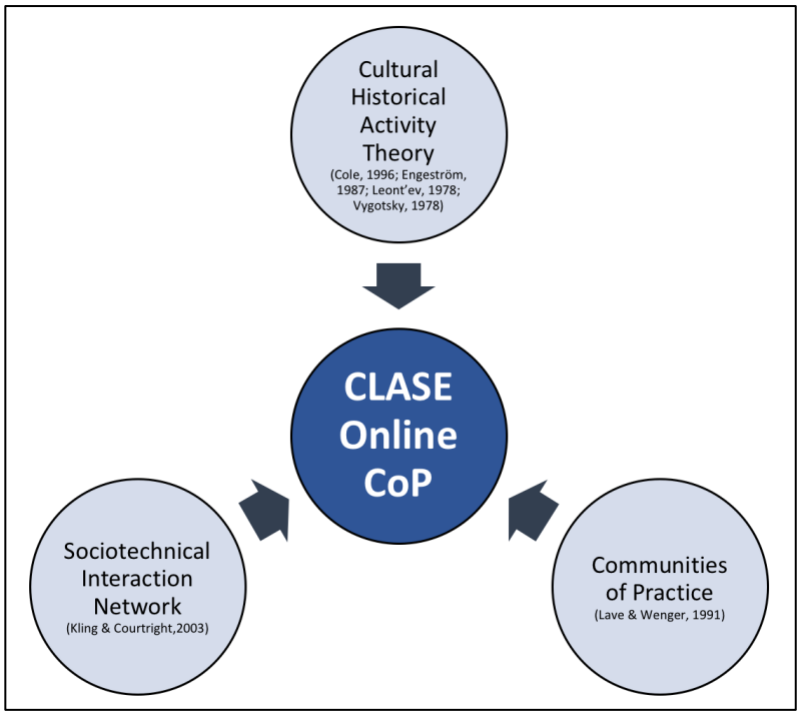

Figure 1. Conceptual Framework for the CLASE CoP

Vygotsky (1978) defined the ZPD as the distance between the child's actual development level (what he or she can do independently) and the level of potential development (what the child can accomplish with the guidance of an adult or a more capable peer). In other words, the ZPD consists of psychological functions that are in the process of maturation. An implication for

education is that learning only occurs within the ZPD and instruction should target the development of skills within the learner's ZPD. From a developmental perspective, reinforcing the learner's current skillset or teaching beyond the learner's capabilities does not result in development gains.

Cultural-historical activity theory. Adopting a cultural-historical lens facilitates the identification of relationships and contradictions within and between systems derived from the online community. CHAT also guides the instructional design process by bringing attention to each component of the activity system during the design and implementation phases. In addition, the analysis of the hierarchy of the activity (i.e. motives, actions, and operations) may provide further insight into how to facilitate the development of the community.

Figure 2 adapts Engeström's model (1987) to illustrate how the online teacher community is an activity system. The overall outcome is to improve teaching practices for English languages learners and other students through the Instructional Conversation pedagogy. The teachers who engage in the online community are the subjects of the activity and the IC model constitutes the object. The online platform that mediates teachers' interactions acts as the main artifact or tool. The community is formed by all teachers along with researchers, instructional coaches, and designers. Some rules for a safe environment include respectful comments and positive criticism. Finally, the division of labor guarantees that everybody contributes to build a sustainable community of practice.

Although Engeström's model is useful to understand the design and community functioning processes, compartmentalizing components in the triangle does not reflect a community of practice. If we were to represent a community of practice through Engeström's triangle (1987), community would not only be a mediator of the activity, but it would also be the

subject, the tool, the object, and the outcome simultaneously. Therefore, a community of practice is not ontologically consistent with Engeström's model (Barab, Schatz, et al., 2004). Following the example of Barab and his colleagues (2004), this study conceptualizes the online community as both an activity system and a sociotechnical interaction network.

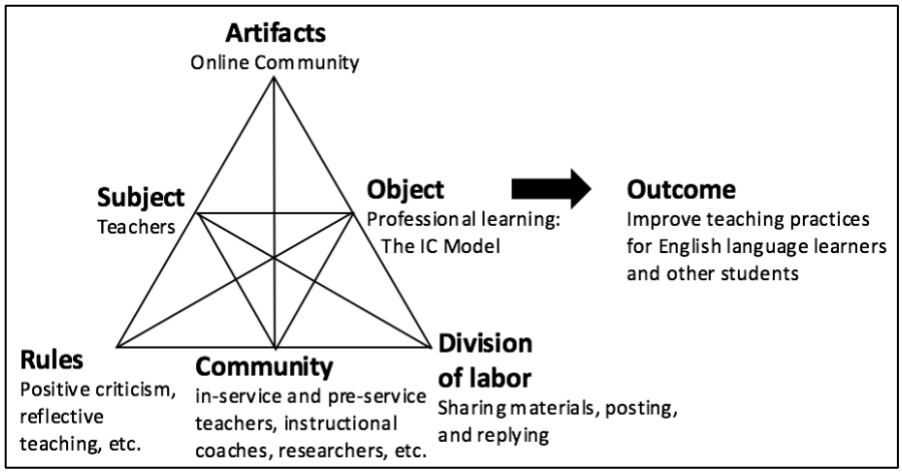

Figure 2. The Online Teacher Community as an Activity System (Adapted from Engeström, 1987, p. 78)

Sociotechnical interaction network. This perspective reveals the transactional nature of the activity systems. A STIN is a network consisting of heterogeneous elements and encompassing social, economic and political interactions (Kling et al., 2003). Such network is composed of "people (including organizations), equipment, data, diverse resources (money, skill, status), documents and messages, legal arrangements and enforcement mechanisms, and resource flows" (Kling et al., 2003, p. 48). STIN models examine social behavior in technology-mediated environments such as online forums, collaboratories, discussion boards, and professional development sites. All components in an activity system are constantly transforming through a dialectic and transactional relationship (Garrison, 2001). As Dewey and Bentley (1960)

discussed, “inter-action” involves two or more elements forming a casual interconnection, whereas “trans-action” does not allow to separate elements into different entities or realities.

Figure 3 illustrates the online teacher community as a sociotechnical network. In this network, human and non-human actors transact in a dialogic and symmetrical relationship. Teachers do not only rely on the online community for their professional development needs, but each one belongs to a unique network of tools, information, and *vivencias*. Among the teachers group, there are actors that are necessary to maintain the STIN given their unique positionality and resources that they bring to the network. A deeper analysis of the network may reveal excluded actors, undesired interactions, additional technological tools, teachers’ motives, incentives to engage in the network, etc.

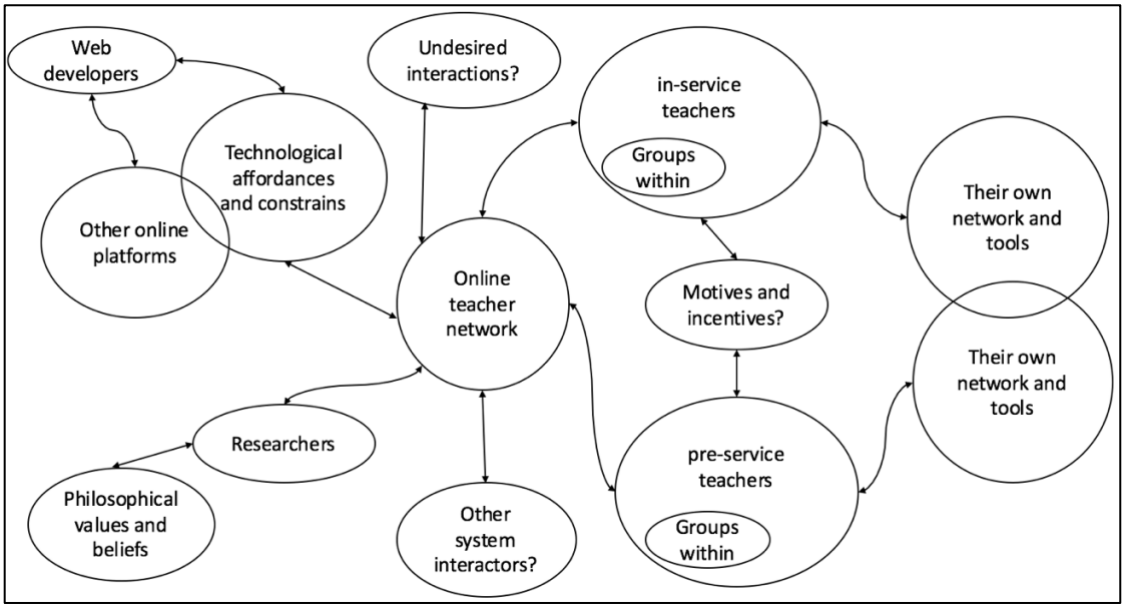

Figure 3. The Online Teacher Community as a Sociotechnical Interaction Network

Design Considerations for the CLASE Online Teacher CoP

We envision the CLASE online teacher CoP as an activity system that makes part of a larger sociotechnical interaction network (Engeström, 1987; Kling et al., 2003). Each participant

belongs to multiple communities and networks of people and resources. In the CoP, various formal and informal networks coexist and involve human, organizational, and technological resources. The overall design goal is to create systems and structures that support online sociability (Barab et al., 2001; Preece, 2000). We also adopt a Vygotskian perspective in which individuals learn by navigating through their social networks and using psychological tools as mediators within their own ZPD with the assistance of a more knowledgeable other (Vygotsky, 1978).

The CLASE CoP allows for mentorship and collaboration among teachers and fosters the formation of individual identities and community membership. To facilitate human-human interaction in online environments, it is necessary to build trust so members can engage in honest and reflective conversations (Jarvenpaa & Leidner, 1998; Kling & Courtright, 2003). Face-to-face exchanges are useful to create social ties before participating in online communities. Sometimes, bounded groups within the general community might naturally emerge as subgroups start to work on shared projects (Barab & Duffy, 2000). Finally, the community needs to have mechanisms for growth and reproduction, so it is crucial to welcome new members as well as strengthen the involvement of core members and *brokers* (Barab, Schatz, et al., 2004; Wenger, 2000). Participants who act as a bridge or liaison between communities are *brokers* and are essential to maintain strong ties and disseminate new ideas. Table 1 summarizes the design considerations for the CLASE CoP and provides research evidence for such decisions.

Research Questions and Contributions to Knowledge Base

The purpose of this mixed methods study is to describe the formation, development, and evolution of an online teacher CoP as a sociotechnical network to support teacher's implementation of the Instructional Conversation pedagogy. Findings inform

Table 1

Design Considerations for the CLASE Online Teacher CoP

Characteristics	Description	Research evidence
The CoP is an activity system within a larger sociotechnical interaction network	Based on Engeström's model for an activity system, the CoP shares an outcome and involves the interplay between subject, artifacts object, rules, community, and division of labor. This system, however, interacts with other systems as well as with teacher's own networks.	(Barab, Schatz, et al., 2004; Cole & Engeström, 1997; Engeström, 1987; Kling et al., 2003; Leont'ev, 1978)
The notion of community is not designed but facilitated	Researchers and subject matter experts are to identify and minimize conflicts and tensions within the CoP and allow the system to evolve organically. We do not *design* virtual communities but design *for* them.	(Barab et al., 2002; Barab & Duffy, 2000; Barab et al., 2001; Lave & Wenger, 1991; Wenger, 2000)
Focus on designing usability but supporting sociability	The online platform should support social interactions with an emphasis on trust and collaboration.	(Barab et al., 2001; Preece, 2000)
Foster individual identity and community membership	Online groups are not natural communities so it is necessary for members to get to know each other and become part of the community.	(Graves, 1992; Kling & Courtright, 2003)
Allow for mentorship and collaboration between expert and novice teachers	Teachers who were recently trained on the IC model interact with more experienced peers and reflect on their teaching practice in a similar fashion as cognitive apprenticeships.	(Brown, Collins, & Duguid, 1989; Cole, 1996; Vygotsky, 1978)
Build trust face-to-face whenever possible	Online interactions limit how individuals read emotional reactions and build trust. Face-to-face exchanges facilitate the creation of social ties. Teachers tend not to reveal their professional weaknesses or discuss each other's practice in a critical and reflective fashion.	(Haythornthwaite, Kazmer, Robins, & Shoemaker, 2000; Jarvenpaa & Leidner, 1998; Kling & Courtright, 2003)
Support for bounded groups	Groups within the online community emerge naturally as members start to work on shared projects. It is easier to provide an online communication platform to preexisting groups than to expect to build an exclusively online CoP.	(Barab & Duffy, 2000; Kling & Courtright, 2003)
Promote high engagement of core members and "brokers" to sustain the reproduction mechanism of the CoP	Learning occurs in a CoP when members move from being peripheral participants to core participants. Some teachers act as *brokers* between communities, strengthening weak ties and allowing the diffusion of new ideas between groups.	(Barab, MaKinster, & Scheckler, 2003; Barab, MaKinster, et al., 2004; Granovetter, 1981; Wenger, 2000)

discussions about the interplay between network and community for sustainable teacher professional development, as well as guidelines for instructional designers to enable the formation of such communities. The research questions are as follows:

1. How is the online CoP structured as a sociotechnical network? (Quantitative/structural)
    a) What network attributes (i.e. density, diameter, dyads, transitivity, reciprocity, cliques, components, and cut vertices) can be identified in the online CoP?
    b) What does node centrality (i.e. degree, closeness, betweenness, eigenvector) reveal about the CoP formation?
    c) What does node assortativity suggest about how members interact with each other?
2. How do teachers perceive the social network dynamics and the value of their participation in the online CoP? (Qualitative)
3. How do teachers' perceptions about the online CoP help explain and expand the structural network analysis? (Mixed)

This study advances our understanding of online teacher CoPs given its unique theoretical approach and research methods. The online community is approached from two main theoretical perspectives: Cultural-historical activity theory (CHAT) and sociotechnical interaction networks (STIN). CHAT is a robust framework to design, model, and evaluate instructional contexts and it has been used in conjunction with other theories to better understand complex human-human, human-object, and human-technology relationships (Barab, Schatz, et al., 2004; Belland & Drake, 2013; Hung & Chen, 2001; Karakus, 2014; Ryder & Yamagata-Lynch, 2014). First, CHAT facilitates the identification of contradictions within and between activity systems. Such contradictions are not interpreted as dysfunctions, but rather as functions of a system in constant development and potential areas for intervention and improvement (Cole

& Engeström, 1997). Second, the analysis of the hierarchy of the activity (i.e. motives, actions, and operations) may reveal the necessary conditions to best support the activity as well as important considerations for design and development (Barab, Schatz, et al., 2004; Leont'ev, 1978). And third, a STIN strategy serves to understand the highly transactional and dynamic nature of the activity system in a dialogic and symmetrical relationship between human and non-human actors (Kling et al., 2003).

From a methodological standpoint, this study collects both quantitative and qualitative data to better understand the formation and evolution of an online teacher CoP. In the first phase, a structural analysis of the CoP and its larger sociotechnical network reveals core contributors, peripheral observers, brokers, and relevant network attributes. In the second phase, key actors are identified for in-depth interviews for the purposes of complementarity and triangulation (Greene, 2007). Qualitative findings help to explain and expand the structural network analysis. This methodological design is innovative as it approaches online teacher CoPs from a social network perspective. Little is known about the interplay between community and network, which are both complementary yet separate aspects of the "social fabric of learning" (Wenger et al., 2011, p. 13).

CHAPTER 2

REVIEW OF LITERATURE

This review of the literature is divided into three main sections. First, *cultural-historical activity theory* (CHAT) is discussed as a guiding framework to understand the mediating role of technology in teacher learning and comprehend how individuals transform and are transformed by culture, artifacts, and mediation over time (Cole, 1996). Second, *social network analysis* (Wasserman & Faust, 1994) and *sociotechnical interaction networks* (Kling et al., 2003) are reviewed as complimentary approaches that provide further insights into how teachers engage in an online community of practice. Finally, empirical research on online teacher communities and online teacher professional development is reviewed to situate the current study within the larger body of literature.

Cultural-Historical Activity Theory (CHAT)

A solid theoretical framework is necessary to understand how teachers engage in communities of practice through technology-mediated environments. CHAT is rooted in the work of Soviet Russian psychologists Vygotsky, Luria, and Leont'ev during the late 1920s and early 1930s (Cole & Engeström, 1997). In the instructional technology literature, CHAT is sometimes referred to as socio-cultural theory, cultural-historical theory, or activity theory (AT) in spite of theoretical differences between these terms (Kaptelinin & Nardi, 2006; Karakus, 2014; Yamagata-Lynch, 2013). Cole (2010) noted that an important distinction between traditions is how the basic unit of analysis is defined. Vygotsky's followers focus on mediated

action in context (Wertsch & Tulviste, 1992), whereas Leont'ev's followers define activity as the unit of analysis (Kaptelinin, 1996b).

According to Cole (1996), CHAT serves as a framework to overcome Wundt's schism between psychology while incorporating culture in mind. Wundt (1832-1920), one of the founding scholars of modern psychology, believed in a "first psychology" based on the physical sciences and concerned with laboratory measurements, and a "second psychology" based on the human sciences and focused on the role of culture. Cole (1996) argued that psychologists cannot rely on moment-to-moment developmental changes at the individual level (ontogenesis), but they need to study evolutionary and historical development changes at the group level (phylogenesis). Cole (1996) defined culture as "the entire pool of artifacts accumulated by the social group in the course of its historical experience" (p. 110), which implies that artifacts are the medium for human development and culture accounts for a group's entire history as evidenced in the present.

Although Russian cultural-historical scholars named mediational devices as *tools*, Cole (1996) favors the term *artifacts* to avoid misunderstandings about the scope and variety of mediational devices. He claimed that artifacts are ideal (conceptual), material, and modified for goal-directed human action. Cole proposed three levels of artifacts: The first level consists of primary artifacts used for production of material good or social life such as tables, knives, or words; Second level artifacts are representations of primary artifacts and modes of actions such as recipes, traditional beliefs, and norms; And third level artifacts are those used to represent the real world such as works of art, perception, or cognitive schemas.

Regardless of the theoretical orientation, Cole (2010) identified five principles that CHAT approaches share: a) mediation of experience through material or symbolic artifacts, b) situated activity/context as the essential unit of analysis, c) the cultural organization of human

life as evidenced by the use of cultural mediators, d) the primacy of the social since social interactions precede learning, and e) genetic analysis as the study of history to understand current phenomena. Also, CHAT research tends to study qualitative changes over time (longitudinally) through the use of interviews, structured and informal observations, participant observation, and quasi-experiments (Cole, 2010).

Unit of analysis. In instructional design, cultural-historical approaches have usually defined *activity* as the basic unit of analysis to support research efforts and the design of constructivist learning environments (Karakus, 2014; Yamagata-Lynch, 2013). In particular, Engeström's framework has been helpful to operationalize theoretical constructs and apply them to diverse instructional design problems (Barab, Schatz, et al., 2004; Yamagata-Lynch, 2010). However, there is no consensus as to which is the most appropriate unit of analysis in cultural-historical theory (Garrison, 2001; Portes & Salas, 2011; Toomela, 2000, 2008). It has been argued that the study of activity is necessary but not sufficient to understand relationships between individual minds and culture. In Toomela's words (2000), "external activity and psychological operations supporting that activity are not in one-to-one correspondence" (p. 356). That is, the individual mind and activity are both parts of a complex system but they cannot be studied in isolation. What seems to be two similar external activities may correspond to significantly different mental operations. An analysis of the activity alone disregards *why* or *how* an individual decides to engage in a specific activity. Toomela (2000) proposed going back to Vygotsky's theory who focused on the sign meaning as unit of analysis. The use of signs and tools are external to the individual but they still reveal internal aspects of the psyche.

González Rey (2011), who has extensively studied Soviet Union psychologists, argued that Vygotsky defined *perezhivanie* as the unit of analysis at the latest stage of his career. This

concept is commonly translated into English as “emotional experience”, but González Rey contended that *perezhivanie* involves the integration of the affective and cognitive dimensions into the human psyche as a generative and dynamic system. This view is consistent with other Soviet scholars, such as Rubinstein, who highlighted the role of lived experiences in human development. Arias (2011) discussed Vygotsky’s *perezhivanie* using the term *vivencia* to signify “a basic functional unit of the psychical, of conscience, and of personality” (p. 57). *Vivencia* denotes how an individual lives an experience and what emerges from the socio-cultural and historical context.

Generations of Cultural-Historical Activity Theory

Engeström’s (1987, 2001) proposed three generations of CHAT: Vygotsky’s cultural mediation, Leont’ev’s activity system, and his own model. Vygotsky’s notion of mediation was revolutionary due to the use of cultural artifacts to explain human actions. The individual could no longer be understood without the cultural component and society needed to be studied through individuals who use and produce artifacts. According to Engeström (2001), a limitation to this first CHAT generation was that the basic unit of analysis was still focused on the individual. Then, Leont’ev introduced human activity as the basic unit for scientific inquiry and distinguished between internal and external activity as well as motives, actions, and operations. Finally, Engeström (1987, 2001) suggested a third CHAT generation to address multiple perspectives and networks of interacting activity systems.

First generation: Vygotsky’s cultural mediation. Many consider Vygotsky’s work to be the foundation for CHAT (Cole, 1996; Engeström, 1987). Vygotsky (1978) suggested that any human activity is mediated by signs and tools, challenging behaviorist psychologists who studied stimulus-response reactions in animals and humans. *Signs* are internally oriented and “a means of

internal activity aimed at mastering oneself" (p. 55), whereas *tools* are externally oriented and serve as "the conductor of human influence on the object of activity" (p. 55). For example, language can be both a *tool* for external communication and a *sign system* for planning and self-regulation. In this regard, signs are instruments for psychological activity and tools assist with cognitive processes that lead to changes in our environment. Vygotsky (1978) used a triangle to represent mediated human activity (see Figure 4).

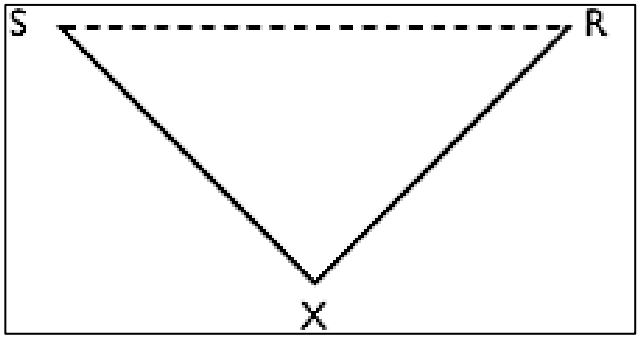

Figure 4. Vygotsky's Mediated Act (1978)

In Figure 4, "S" and "R" stand for "stimulus" and "response", which are commonly reformulated to subject and object (Cole & Engeström, 1997). The "X" represents the mediating signs and tools. Cole (1996) criticized Vygotsky's triangle because it fails to represent the complexity of the process and suggests that the mediated and non-mediated paths from subject to object are mutually exclusive and only one route is possible at a time. Also, the triangle ignores the fact that actions and artifacts do not exist in isolation. Cole (1996) contended that both the mediated and non-mediated interactions between subject and object operate synergistically. Further, artifacts and artifact-mediated human action are interwoven with each other and with the social world, forming "vast networks of interconnections" (Cole, 1996, p. 120).

Second generation: Leont'ev's activity system. Leont'ev (1978) changed the focus of attention from the mediating tools and sign to the analysis of activity as a method of scientific

inquiry. Leont'ev defined activity as a "unit of life, mediated by psychic reflection, the real function of which is that it orients the subject in the objective world" (p. 51). He viewed human life as a system of activities with their own internal transformations and development in a socio-cultural context. Individual activity is determined by our place in society, our experiences, and circumstances. In Leont'ev's words, "society produces the activity of the individuals forming it" (p. 51). He also studied the impact of tools, language, and the division of labor in the human mind. As for the mediating role of tools and language, Leont'ev subscribed to Vygotsky's ideology. However, Leont'ev further discussed how the distribution of tools and specialization of activities led to the prevalence of complex socio-historical structures in the development of the mind. The distribution of labor is of particular importance as it helps to explain how an individual's actions may be motivated by an object but directed to another (Kaptelinin & Nardi, 2006).

Leont'ev (1978) justified the relationship between internal and external activity by using Vygotsky's notion of internalization, that is, how psychological processes first originate from our interactions with others and only later become internal functions. According to Leont'ev, "the activity of the subject, external and internal, is mediated and regulated by a psychic reflection of reality" (p. 75). Such psychological reflection of reality is mediated by human consciousness, subjective activity, and personality. Marx extensively studied consciousness as a quality of the psyche and a social product. Marxist psychology remained ignored for more than 50 years until Soviet Union psychologists, such as Vygotsky and Rubinshtein, started to comprehend the meaning of Marxism in the early 1920s. Marx defined human practice as the basis for human cognition and introduced activity in a materialistic way as the sensory and practical interaction between people and their surrounding world.

Concerning the general structure of activity, Leont'ev (1978) distinguished among *motives, actions,* and *operations*. Activities differ from each other in terms of the object that determines their direction. This object represents the *true motive* of the activity, which typically corresponds to a material or ideal need and the subject may or may not be aware of this motive. *Actions* are goal-oriented and are subordinated to a purpose. Goals are conscious and can be different from the general motive. *Operations* refer to the conditions or methods required to achieve an action. Individuals are not typically aware of operations.

Third generation: Engeström's activity theory. The work of Soviet Union theorists focused in the context of play and learning among children until the cultural-historical tradition started to spread to the west in the 1970s (Engeström, 2001). As a result, new contexts to study activity theory became available such as work settings and human-computer interaction (Nardi, 1996a). There was increased interest in the study of internal contradictions as the driving force for change and development in activity systems (Engeström, 2001). As activity theory became more prominent internationally, issues about diversity and dialogue between traditions emerged.

Engeström's (1987) activity system model is extensively cited in the literature (see Figure 5). All mediating components in the triangle have a direct connection to the subject and object. The purpose of the subject is to transform the object into a concrete or abstract outcome of the activity. The relation between subject and community is mediated by the group's complete collection of mediating artifacts and rules to define socially acceptable interactions. Division of labor refers to the negotiated distribution of tasks, powers, and responsibilities among participants. This conceptualization of an activity system helps us to understand how human cognition is distributed among cultural artifacts and people, but fails to address how cognition is

distributed through time from generation to generation within a human group (Cole & Engeström, 1997).

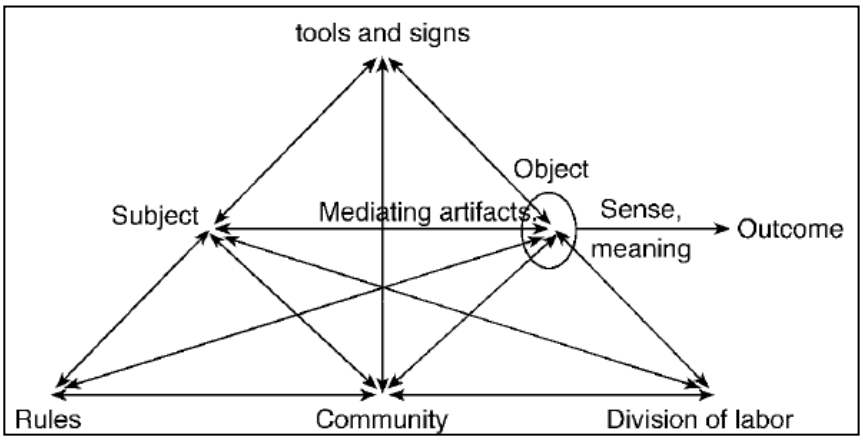

Figure 5. The Structure of a Human Activity System (Engeström, 1987, p. 78)

In a revision of his theoretical model, Engeström (2001, 2009) expanded his model and suggested that the unit of analysis should include minimally two interacting activity systems (see Figure 6). The objects constructed by each system goes on to form a shared or jointly constructed object. For example, Gutiérrez, Baquedano-López, and Tejeda (1999) provided evidence of systems crossing boundaries in their ethnographic study of a dual immersion elementary school classroom. Gutiérrez et al. (1999) proposed a "third space" to describe hybrid literacy and discursive practices between the teacher and the students that result in a new context for development or ZPD.

According to Engeström (2001), the current state of activity theory can be summarized with the following five principles:

- The activity system is the unit of analysis as a collective, artifact-mediated and object-oriented system, which interacts with other activity systems.

- Activity systems are characterized by multi-voicedness, which is caused by the diversity in background, history, and interests in the system and has a dynamic structure with problems and contradictions.
- Activity systems are formed and shaped over lengthy periods of time (historicity).
- Contradictions are not regarded as problems but rather as important sources of change and development.
- Expansive transformation cycles in activity systems are possible and they are defined as a "collective journey through the zone of proximal development of the activity" (p. 137).

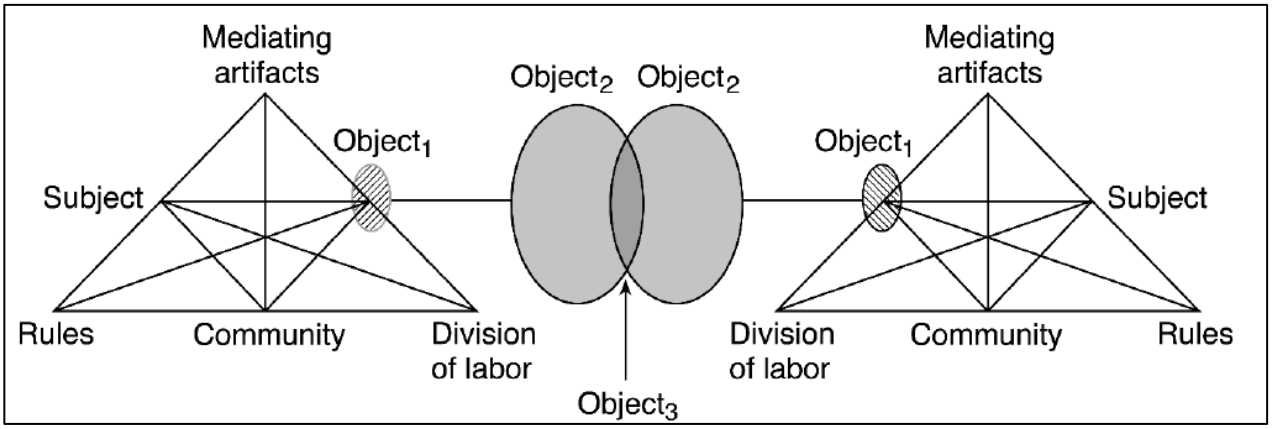

Figure 6. Two Interacting Activity Systems (Engeström, 2001, p. 131)

CHAT as a Framework in Instructional Design

Interest in cultural-historical activity theory (CHAT) began in the field of human-computer interaction in the 1990s as an alternative to the dominant cognitive approach (Bødker, 1989; Kaptelinin, 1996a; Kuutti, 1996; Nardi, 1996b). In instructional design and technology, CHAT gained popularity in the 2000's as a theoretical, methodological, and design framework leading to the numerous publications in research journals (e.g. Barab, Schatz, et al., 2004; Belland & Drake, 2013; Collis & Margaryan, 2004; Jonassen, 1999; Lim & Hang, 2003;

Stevenson, 2008), book chapters (Jonassen, 2000; Yamagata-Lynch, 2014), books (Yamagata-Lynch, 2010), and two entries in the *handbook of research on educational communities and technology* (Barab, Evans, & Baek, 2004; Karakus, 2014). In the instructional design literature, CHAT and activity theory (AT) are often used interchangeably.

Researchers in instructional design have used AT to understand how human cognition is distributed in the learning environment, study the subject and community that form the activity system, and explore the history and development of the activity. The first scholars to suggest AT as a design framework were Jonassen and Rohrer-Murphy (1999). They argued that due to the predominant constructivist views in the 1990s, behavioral and cognitive task analysis and methods were no longer appropriate and so, instructional design needed to assume new philosophical values about learning. In this new paradigm, learning only occurs in the context of meaningful activity and thus, engagement in an activity is the precursor to learning. In contrast, classical methods assumed that knowledge can be embedded in the instruction and transferred to the learner. From an AT perspective, instructional designers need to assume that knowledge is not transferred or acquired, but rather socially constructed based on mediation tools, intentionality, culture, and history (Jonassen & Rohrer-Murphy, 1999).

AT has also been used as a framework to study virtual learning environments and their integration in higher education. For example, Mwanza and Engeström (2005) used AT to manage content in e-learning environments to produce contextually meaningful and relevant descriptors of content as opposed to simply using metadata and tags to locate and access information. Benson, Lawler, and Whitworth (2008) used AT in a comparative study of Moodle at two institutions in the U.K. and the U.S. to explore how activity systems are mediated through tools, rules, and roles. Stevenson (2008) used AT to explore pedagogical implications of

conceptualizing digital technology as tool, tutor, environment, or resource in a sample of 60 computer-mediated activities in schools in England. He concluded that depending on how the role of technology is defined, activity systems redefine the focus of the task, intended outcomes, types of technology used, who controls the technology, and how activities are developed.

Other applications of AT in instructional technology include the conceptualization of an online community of teachers (Barab, Schatz, et al., 2004), the study of school and university partnerships (Tsui & Law, 2007; Yamagata-Lynch & Smaldino, 2007), the exploration of innovation in educational settings (Lim, Tay, & Hedberg, 2011; Russell & Schneiderheinze, 2005), the study of tensions in teacher professional development and students' transpacific collaboration (Ryder & Yamagata-Lynch, 2014; Yamagata-Lynch & Haudenschild, 2009), the conceptualization of how K-12 students use computer-based scaffolding based on motives and affordances (Belland & Drake, 2013), and the study of technology integration as a mediator to engage students in critical thinking (Lim & Hang, 2003). All of these studies have found AT to be a robust theoretical framework to design, model, and evaluate contexts involving complex human-human, human-object, and human-technology relationships.

Social Network Analysis (SNA)

The origin of SNA can be traced back to 1930s when scientists started to represent the shape and characteristics of social structures (Scott & Carrington, 2011). For example, Moreno (1934) invented the *sociogram* as a tool to visually represent social networks with points and lines. This idea is taken for granted today but it was revolutionary when it was first introduced (Scott, 2013). Since then, network analysis has drawn from disciplines such as sociology, anthropology, mathematics, statistics, and computer science (Scott, 2013; Wasserman & Faust,

1994). For instance, a branch of mathematics called graph theory, has provided axioms and theorems to understand the behavior and properties of networks (Scott & Carrington, 2011).

Today, SNA studies relationships among social entities and has flourished as an analytical strategy in the natural, social, and behavioral sciences (Wasserman & Faust, 1994). Networks are represented by a graph with nodes (actors) and lines (relationships) or an adjacency matrix representing the presence or absence of a relationship between pairs of actors with "1" or "0" (Carrington, 2014). Networks can occur formally or informally and within or between organizations. Actors may include individuals, families, households, political actors, countries, or organizations. Examples of relationships that can be explored through SNA are power, influence, information exchange, and emotional proximity (Hollstein, 2014). Some important assumptions of SNA include (Wasserman & Faust, 1994):

- Actors and their actions are interdependent and influenced by each other.
- Relational ties between actors serve to transfer material or nonmaterial resources.
- An individual's actions are constrained by the network structure.
- Network structure (e.g. social, economic, political, etc.) is conceptualized as a lasting pattern of relations among actors.

Structural network analysis is not theory or method, but a *social science paradigm* (Marin & Wellman, 2011; Scott & Carrington, 2011). As a paradigm, SNA guides how we conceptualize social life, and the types of data, analysis and research questions to be addressed. Marin and Wellman (2011) provided an example of how innovation in Silicon Valley can be understood from an individualist or attribute-based perspective versus a network approach. In the first case, a researcher may argue that the high levels of innovation in the region are a direct result of people's characteristics, training, and skillset. Instead, a researcher adopting a network

perspective would argue that innovation occurs due to the mobility of individuals which creates many connections among educational institutions and companies. In other words, as people move from one organization to another, their ideas, expertise, and tacit knowledge travel with them, which leads to accelerated rates of innovation. SNA does not explain social phenomena based on individual attributes (e.g. gender, race, education), but as a result of the social structure. People with similar attributes tend to have similar network structures, and thus, similar perceptions, opportunities, and constrains (Marin & Wellman, 2011).

Networks are generally used to study four types of mechanisms: *Transmission, adaptation*, *binding*, and *exclusion* (Marin & Wellman, 2011). Transmission is concerned with how network ties serve as pipelines for the flow and diffusion of information, social support, disease, material aid, among other processes. Adaptation occurs when two actors make similar choices as a result of sharing comparable network positions, which exposes them to similar constrains and opportunities. Binding explains the influence of a strong network on common actions or outcomes, acting as one unit. And finally, exclusion seeks to understand why the presence of one tie impedes the existence of others, which affects the relationship of the excluded node with the whole network.

Concerning the typology of networks, social networks can be *egocentric* vs. *sociocentric* and *one-mode* vs. *two-mode networks* (Carrington, 2014; Hollstein, 2014; Marin & Wellman, 2011). Egocentric networks focus on an individual's personal network, whereas sociocentric (or whole networks) study relationships between people in a group. These distinction is fundamental to identify the instruments and types of data required to study a network. The analysis of a whole network requires defining the system and listing all relevant actors prior to examining the presence or absence of relationships among nodes. Ego networks, on the other hand, do not

require identifying possible actors beforehand and data can be collected by surveying a particular actor or extracted from a whole network by choosing a focal node. Network data can also be collected through observation, archives, historical materials, or online communications.

One-mode networks refer to a system composed of a single type of node (e.g. people in a friendship network), whereas a two-mode network has two different types of nodes (e.g. members and organizations, or events and attendees) (Marin & Wellman, 2011). The network mode limits how nodes interact and therefore, dictates the analytical procedures. In a one-mode network, any two nodes have the potential to be connected as opposed to two-mode networks in which certain relationships cannot exist between the same type of node. For example, a person can belong to any organization, but a person cannot belong to another individual. Two-mode networks are also known as affiliation networks. A one-mode network can be derived from two-mode data by extracting relations that imply co-membership or co-attendance.

Relational ties can represent four types of dyadic phenomena: *similarity, social relations, interactions,* or *flows* (Borgatti & Lopez-Kidwell, 2011). Similarity describes physical proximity, co-membership, or sharing of behaviors, attitudes, or believes among actors. Social relations refer to either role-based ties (e.g. boss of, teacher of, friend of), or cognitive/affective ties (e.g. knowing, liking, disliking). Interactions refer to discrete and separate events that have a specific start and end point in time, such as talking, fighting, or eating with someone. The last category, flows, involves resources, information or diseases that move from one node to another.

Once the network type and relevant relationships have been identified, the researcher needs to decide how measure those relations (Marin & Wellman, 2011). Ties can be measured as *directed* or *undirected*, and as *binary* or *valued*. Relations that are directed go from one node to another (e.g. advice seeking), while undirected relations exist with no particular direction (e.g.

co-memberships). Directed ties can be reciprocated depending on whether the relation exist in only one direction or both. Some kinds of directed ties impede reciprocity as is the case of command among military members. Both directed and undirected ties can be measured as a binary (e.g. "1" or "0") for existence or absence of a relationship between dyads, or measured as a scale (e.g. "1" to "5") representing strength, quality, or frequency. For instance, friendship ties can be binary if they only indicate if two people are friends or not, or the ties can be valued if they assign higher or lower scores based on how close people feel to one another. Such decisions are determined theoretically by the nature of the relationship, or pragmatically by the researcher.

Network Theory. As a social science paradigm, SNA has led to the development of multiples theories, a set of commonly used methods, and a body of empirical research (Scott & Carrington, 2011). In general, network theories can be categorized in two types: Formalist and structuralist (Marin & Wellman, 2011). Formalist theories are concerned with the mathematical form, patterns, and effects of network formation or dissolution. These theories do not necessarily require empirical data and can be studied using mathematical modeling and computer simulations. *Small-world theory,* for example, posits that any two individuals in a network are likely to be connected through a short path of intermediary nodes (Borgatti & Lopez-Kidwell, 2011). Experiments in which people are asked to contact strangers by using friends and their acquaintances have shown that any two individuals in the planet are separated by an average of five to seven connections (Dodds, Muhamad, & Watts, 2003; Travers & Milgram, 1967). This principle is commonly known as "six degrees of separation". Other formalist theories include network exchange theory, network flow theory, and the strength of weak ties theory (Borgatti & Lopez-Kidwell, 2011).

On the other hand, structuralist theories, are concerned with how patterns of relations can be used to understand a phenomenon in a given discipline (Marin & Wellman, 2011). For example, researchers may use a network perspective to study particular outcomes (e.g. obtaining a promotion, getting sick, decision making, etc.) or to understand a phenomenon or a theory that was previously formulated in terms of individual or group-based attributes. In a study about poverty and underclass, Wilson (1987) concluded that African Americans tended to live in high-poverty areas with few connections to people in the job market, which hindered social mobility. This study took a group-based approach treating neighborhoods like isolated communities and neglecting the possibility of out-group connections to the job market. Smith (2005) demonstrated that African Americans in poor urban areas did have out-group ties to jobs but lacked connections to people willing to offer assistance in finding jobs. Structuralist theories study topics in diverse areas such as health, crime, work, community, economics, politics, etc. (Marin & Wellman, 2011; Scott & Carrington, 2011).

A learning theory that resonates with network principles is *connectivism* (Siemens, 2005). From this perspective, learning is a continuous process of network exploration and pattern finding that can happen formally or informally in a variety of settings: a classroom, a community of practice, a personal network, or the workplace (Siemens, 2005). Learning occurs when we are able to navigate and expand our network by making meaningful connections (AlDahdouh, Osório, & Caires, 2015; Siemens, 2005). We can no longer personally experience everything new we aim to learn and thus, learning communities must create networks to share their ideas with others, which causes "cross-pollination" of the learning environment (Siemens, 2005, para. 21). In the next section, strengths and weakness of connectivism as a learning theory are briefly discussed.

***Connectivism*.** Traditional learning theories only focus on the process of learning and disregard the value of what is being learned or how learning can occur within organizations (Downes, 2006; Siemens, 2008). Typically, learning theories subscribe to one of three epistemological paradigms: objectivism, pragmatism, or interpretivism (Driscoll, 2005). In objectivism, reality is external to the mind, and knowledge and perception are acquired through experience. In pragmatism, knowledge is a negotiation between reflection and experience, inquiry and action. In interpretivism, knowledge is an internal construction and is informed through socialization and cultural cues. Instead, connectivism argues for "distributed knowledge" as a fourth epistemological paradigm, because learning is a continual and socially enacted process that may be constructed *inside* or *outside* the individual (Downes, 2006; Siemens, 2005, 2008).

Connectivism expands the notion of network by identifying internal and external nodes (AlDahdouh et al., 2015). At the neural level, the network consists of neurons connected by axons and dendrites. At the conceptual level, the network consists of ideas and thoughts connected by relationships such as similarity or correlation. At the external level, the nodes are people, books, websites, programs and databases connected by the Internet, intranet or direct contact. The relationships between the nodes may not be seen as a singular link or connection. Instead, they are more like *patterns* of relationships that come together as a single whole (AlDahdouh et al., 2015). The network is dynamic and its patterns may change over time.

In short, connectivism can be summarized by the following principles (Siemens, 2005):

- Learning and knowledge rest in diversity of opinions.
- Learning is a process of connecting specialized nodes or information sources.
- Learning may reside in non-human appliances.

- Capacity to know more is more critical than what is currently known.
- Nurturing and maintaining connections is needed to facilitate continual learning.
- Ability to see connections between fields, ideas, and concepts is a core skill.
- Currency (accurate, up-to-date knowledge) is the intent of all connectivist-learning activities.

Criticism on connectivism. Critics of connectivism argue that there is not enough empirical research to support this new learning theory and challenges connectivist contributions to existing learning theories (Bell, 2011; Kop & Hill, 2008). For example, Vygotsky's social constructivism (1978), Papert's constructionism (1991), Clark's embodied active cognition (1997), or Wenger's communities of practice (1998) may serve to explain the relationship between internal and external knowledge environments and how learning is affected by the interaction with "more knowledgeable" others. Furthermore, critics have also argued that connectivism oversimplifies human interaction and dialogue (Clarà & Barberà, 2013). For instance, the interaction between a teacher and two different students would be represented by the same binary and static connections when such relationships can possess very different attributes. Interaction is a process that evolves and plays an important role as mediation for learning.

Another critique is that connectivist environments can paradoxically lack connection and structure. Students without strong self-regulation skills may not be successful at achieving their learning goals due to the unevenly distributed and emergent learning structure (Anderson & Dron, 2011). Unlike connectivism, cognitive-behaviorist environments do provide explicit routes to learning and constructivist theories rely on scaffolding and mediation for learning. Clarà and Barberà (2013) claimed that connectivism does not address the Socratic learning paradox, that is,

learners are unable to recognize a pattern unless they already know how a specific configuration of connections make a pattern and why.

According to Bell (2011), connectivism is "insufficient as a theory to inform learning and its technology-enabled support in an internetworked world" (p. 112), yet many practitioners find this approach to be useful in explaining the role technology for education. Bell (2011) proposes that a combination of learning theories should be used to advance our understanding of technology-enabled learning, depending on the research scope and purpose, funding available, and the researcher's philosophical stance. Examples of theories that can inform the dynamic context for learning are actor-network theory and activity theory to explore the role of mediating artifacts overt time; or Vygotsky's theory of the zone of proximal development to understand how individuals learn incrementally and socially with the help of more capable peers in an informal digitally mediated setting (Bell, 2011).

Sociotechnical Interaction Networks (STIN)

A STIN model (Kling & Courtright, 2003; Kling et al., 2003) adopts a network perspective to understand phenomena involving human and non-human actors, their agency, and interaction. A STIN network is not exclusively composed of people or organizations, but it may also include equipment, data, resources, documents, or any other critical elements that affect how we interact socially, economically, technologically, and politically with the world (Kling et al., 2003). Assigning agency to non-human actors is an area of tension between different philosophical traditions within network theory (Emirbayer & Goodwin, 1994). Others defend the agency of non-human elements to interact with human actors in symmetrical networks, as is the case of actor-network theory (Latour, 1996).

STIN acknowledges that technology influence and is influenced by the social world, thus this perspective is well suited to studying human social behavior in technology-mediated environments (Kling & Courtright, 2003). STIN is consistent with traditional and modern views on learning such as constructivism and connectivism. In constructivism, learners construct their own knowledge and make meaning of the world by engaging in authentic tasks and interacting with others (Ertmer & Newby, 2013). In connectivism, knowledge is an infinite network with nodes and connections that we can virtually access anytime, anywhere (Siemens, 2005).

Kling et al. (2003) presented STIN models as an alternative framework to understand how people engage in electronic communications, as opposed to more traditional views such as information processing. If a person's behaviors are solely motivated or constrained by the technology, then the cultural context of the actor and the ecology of communications become irrelevant factors. Kling et al. (2003) argued for a more comprehensive perspective that would account for the broader social context in which people and technology are embedded. Therefore, a STIN model needs to take into account the relationships between people and people, between people and technology, and between technology and its infrastructure. Some fundamental assumptions that underlie STIN networks include:

- The social world and technology are not separate entities, instead they co-constitute each other.
- Theories of social behavior should drive technical design decisions.
- People belong to multiple, overlapping, and non-technologically mediated social relationships, which may cause conflicting commitments.
- Sustainability and routine operations are fundamental and need to be part of the design thinking.

Meyer (2006) noticed that there is no clarity in the literature as to whether STIN should be defined as a methodology, entity, framework, or heuristic tool. He argued that STIN did not quite reach the level of theory or method, and thus suggested to refer to STIN as an "analytical strategy." As such, no particular methods are associated to STIN research, maintaining an open-mind perspective to social informatics, an interdisciplinary field that studies information technologies and their interaction with the institutional and cultural contexts (Kling, 2007). As a strategy, STIN provides a way to see the world and identify potential research problems and analytic tools. The overall goal is to reach a deeper understanding of the interplay between the social and the technical in socio-technical systems.

In an effort to exemplify how STIN models can be applied to practical situations, Kling et al. (2003) suggested a series of steps to understand the use, evolution, and sustainability of an e-forum. Frist, we need to identify relevant population of system interactors or stakeholders and their needs regarding the e-forum. Then, we identify core interactor groups or sub-groups and their interests (or conflicts) in the e-forum. We proceed to identify incentives, that is, the types of strategies that would foster engagement and promote sustainability. Next, we identify excluded actors and undesired interactions or why some members would choose not to take part. At this point, we can identify other existing communication forums that may reinforce or compete against the desired forum. The focus is then shifted towards the flow of resources or information to better understand any possible interactions within the network. Next step is to identify system architectural choice points, in other words, specific technological features or social arrangements over which the designer has control to enable better communication. Once we have characterized the different socio-technical components of the network, we can use such knowledge to inform future architectural choice points.

SNA and STIN Research in Instructional Design and Technology

As an analytical approach, SNA has only gained visibility in the last few years with most studies being published in the *British Journal of Educational Technology* and *Computers & Education*. Most research has been published after 2010 with topics ranging from patterns of interaction and collaboration of students in online environments (Haya, Daems, Malzahn, Castellanos, & Hoppe, 2015; Heo, Lim, & Kim, 2010; Mansur & Yusof, 2013; Rienties et al., 2012; Stepanyan, Mather, & Dalrymple, 2014), to teachers' participation in educational MOOCs and virtual learning communities (Kellogg & Edelmann, 2015; Lin, Hu, Hu, & Liu, 2016); to SNA techniques to detect plagiarism (Zrnec & Lavbic, 2017) or identify trends and issues in the field through citation network analysis (Cho, Park, Jo, & Suh, 2013). These studies typically use SNA as part of multi-method or mixed-methods research design involving other statistical or qualitative analyses.

Concerning teacher learning and teacher professional development, SNA has been used to study teachers' support networks and social networks in the workplace (Baker-Doyle, 2015; de Laat & Schreurs, 2013), as well as teacher engagement in MOOCs and online environments (Kellogg, Booth, & Oliver, 2014; Kellogg & Edelmann, 2015; Lin et al., 2016). For example, de Laat and Schreurs (2013) used SNA to visualize informal professional social networks among 52 school teachers in the Netherlands. The researchers used a multimethod approach to examine teachers' discussions and their school contexts through content and contextual analysis. The goal was to identify who was talking to whom, what they were talking about, and why. Based on this information, de Laat and Schreurs (2013) created a "Network Awareness Tool", in which users were able to create a profile page, list projects and collaborators, and visualize current networks. The purpose of this tool was to help schools and organizations uncover and support existing

informal communities of practice. However, the interplay between network and community remains vastly unexplored.

In a different study, Baker-Doyle and Yoon (2011) used SNA to examine how 16 in-service science teachers built professional support networks during a summer workshop. The researchers predicted that teachers' networks would maximize their access to "practitioner-based social capital", that is, the knowledge and resources that all teachers within the network possessed. Teachers completed three weekly surveys identifying any people they had sought advice from and characterizing their relationship. The researchers found that more-expert teachers would tend to be isolated in the network, and in general, teachers did not naturally build or cultivate their support networks. This study raises awareness to the fact that teachers' networks need to be facilitated from an instructional design perspective.

SNA has also been used to study teacher learning in online environments (Kellogg et al., 2014; Kellogg & Edelmann, 2015; Lin et al., 2016). Kellogg et al. (2014) conducted a mixed-methods case study to understand peer interaction and support networks in two MOOCs for K-12 educators in the USA and abroad. The first MOOC, titled "Planning for the Digital Learning Transition in K-12 Schools", was designed to assist school and district leaders to implement digital learning initiatives. An SNA dataset (edge list and nodes) has been made publicly available for two iterations of this MOOC (Kellogg & Edelmann, 2015). The second MOOC, titled "Mathematics Learning Trajectories: Equipartitioning", was designed to help educators to interpret an implement Common Core State Standards. The researcher collected data from participants' registration forms and discussion forums to conduct network and qualitative analyses. Factors such gender, workplace, geographical location, or prior exchanges were statistically significant as predictors for peer interaction. Kellogg et al. (2014) concluded that

technological affordances such as MOOCs can foster the process of knowledge construction among educators.

Although Kellogg and colleagues' study (2014) advance our understanding of how teacher networks may behave in online environments, a question regarding the intersection between online and real-life networks remains of interest. Lin et al. (2016) found that teachers' networks in real life were a lot more connected than virtual networks, yet both types of collaboration were necessary and complemented each other. In a multimethod study, Lin et al. (2016) explored how 172 in-service teachers in China collaborated in both virtual and face-to-face professional contexts. Data were collected through online participation, questionnaires, and focus group interviews. Using SNA and content analysis, the researchers created three sociograms based on data from virtual interactions, real-life exchanges, and a blended network merging data from the first two network types. The goal was to reveal the overall relationship in terms of teaching and research. The real network did not have any isolated nodes and showed strong ties in comparison to the virtual network, whose structure was loose. The blended network presented a more typical structure with strong ties among core members and some peripheral observers. Strong correlation between the three network matrices revealed that virtual and real-life interactions were essential for collaboration.

STIN approaches have also been used to understand phenomena involving human and non-human actors (Creanor & Walker, 2012; Skrypnyk, Joksimović, Kovanović, Gašević, & Dawson, 2015; Walker & Creanor, 2009). For instance, Skrypnyk et al. (2015) used STIN and SNA to understand the flow of information in a MOOC. The main goal was to examine the role of course facilitators, learners and technology in a distributed or connectivist MOOC. The course was designed based on the premise that online learning occurs through a network of

interconnected students, and that the role of the teacher is to facilitate communication and enable such connections. The actual content of the MOOC was on connectivism and connective knowledge and the facilitators were the main proponents of this learning theory: George Siemens and Stephen Downes. The researchers analyzed course interactions on Twitter using a sociotechnical network composed of human participants and hashtags. The latter represented the affordances of the social networking platform to foster information seeking and community formation. Hashtags play an important role in terms of how learners find, aggregate, connect information, and interact with each other. The researchers argued that considering both human and non-human agents as part of the network reduced the amount of bias regarding the influence of technology on learning. By assuming a reciprocal effect, the social and technological dimensions are at the same level with no prior judgements about the importance or effects of either one.

Skrypnyk et al. (2015) collected data from 800 active participants that created 2,483 tweets over the course of twelve weeks. Demographic data were retrieved from Twitter and other publicly available profiles on social networking websites. The sociotechnical network was analyzed over time through common measures such as centrality, authority weight, hub weights, weighted degrees, and community detection algorithms. Despite the course facilitator having a high level of influence over the flow of information, Skrypnyk et al. (2015) found that the teaching function was distributed among influential human and technological actors. Hashtags were originally used to designate shared information but later, the use of recurrent tags by certain sub-groups indicated the formation of communities within the MOOC. Such communities were based on common interests and facilitated via technical nodes (i.e. hashtags) and one or two social nodes (i.e. participants). Over the course, some influential hashtags and course participants

came to develop network positions similar to those of the MOOC facilitators, providing evidence for distributed teaching. Hashtags were the most popular nodes which highlights their role in the community building process.

Research on Online Teacher Communities and Professional Development

Online teacher communities have been studied using a number of terms including communities of practice (Barab et al., 2002; Mackey & Evans, 2011; Prestridge, 2010; Tsai et al., 2010; Wang & Lu, 2012), professional learning communities (Francis & Jacobsen, 2013), or simply online learning communities (Elster, 2010; Masters, De Kramer, O'Dwyer, Dash, & Russell, 2010). There is not a clear distinction among these terms and sometimes they are used interchangeably. Most of this research builds upon the work of Lave and Wenger (1991) and Brown et al. (1989) on communities of practice and situated learning. Overall, there is some evidence that online teacher communities are effective to promote collaboration and support professional learning through the use of synchronous and asynchronous tools (Smith, Hayes, & Shea, 2017). However, there are concerns about the extent to which teachers are able to build a true community and engage in meaningful interactions in virtual environments (Barab et al., 2002; Barab et al., 2001; Macià & García, 2016).

The body of literature on online teacher professional development is centered around randomized controlled trial comparisons of delivery mode, program effectiveness, communities of practice, collaboration, and reflection (Dede et al., 2009; Smith et al., 2017). In a comprehensive review of nearly 400 articles on online, face-to-face, and hybrid teacher professional development programs, Dede et al. (2009) found that most empirical work was anecdotal, lacked full details of the participants, settings, research questions, methods of data collection and analysis, and a long-term impact evaluation. Updating the work of Dede and

colleagues', this section reviews empirical research on online teacher professional development programs published from 2010 to 2016.

Search procedures. To conduct a valid review of the literature, it is critical to provide clear definitions of the inclusion and exclusion criteria for all studies reviewed (Cooper, 1998). A computerized search of the literature on online teacher professional development programs was conducted by using ERIC and PsycINFO databases. Search descriptors included combinations such as: Teacher development, professional development, online learning, in-service teacher education, computer-mediated environments, continuing teacher education, teacher improvement, faculty development, and career development.

The review of the literature was limited to empirical studies reporting primary data from an online or hybrid teacher professional development program. The analysis did not exclude any theoretical approaches, academic disciplines, grades, or types of technology. The following was the criteria to search, evaluate, and select the studies for this review:

1. The study was published from 2010 to 2016 in a peer-reviewed journal.
2. The study is methodologically sound and rigorous (clear research questions, methods, analyses, and coherence with findings).
3. The study reports primary data and includes an intervention in which K-12 teachers participated in some type of online or blended professional development approach.
4. Participants are K-12 teachers (Higher education faculty or pre-service teachers were excluded).
5. The study was published in English.

Results and discussion. A total of 30 studies that met the inclusion criteria were identified and reviewed (see appendix A). In terms of research methods, the studies reviewed

used multiple research traditions, including quantitative studies (e.g. Masters et al., 2010; Moore, Haviland, Moore, & Tran, 2016; Reeves & Pedulla, 2011), qualitative studies (e.g. Francis & Jacobsen, 2013), and mixed-methods approaches (e.g. McFadden, Ellis, Anwar, & Roehrig, 2014; Pape et al., 2015). Although only studies that involved the participation of in-service K-12 teachers were considered for this review, some programs were not exclusively designed for in-service teachers, and also involved pre-service teachers, coaches, and university professors (e.g. Tsai et al., 2010). The number of participants ranged from N=3 to N=3,998 teachers and from N=152 to N=1,689 students.

The studies reviewed were classified according to whether their purpose was to compare modality, investigate professional learning communities, evaluate program models and their impact/effectiveness, or analyze teachers' perceptions and engagement. Results are shown in Figure 7, however, this classification is broad and some studies may belong to more than one single group.

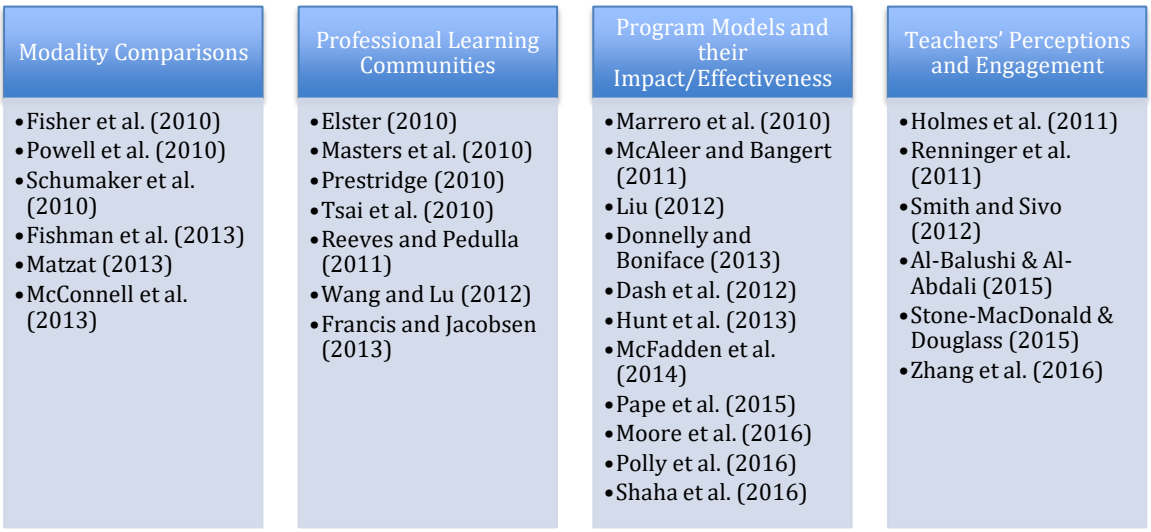

Figure 7. Research on Online Teacher Professional Development

***Modality comparisons*.** Comparisons of instructional media delivery options have prevailed in the instructional technology field for decades (Clark, 1983). A lot of research has

been published comparing classrooms using radio, TV, iPads, and other types of technology versus control classrooms which do not use such technologies (Cuban, 1986; Dundar & Akcayir, 2012). Although some studies still compare delivery modes, there is a consensus that media comparisons are likely to yield no statistically significant results (Clark, 1994; Reeves, 2011). Instead, researchers need to adopt a learner-centered approach and focus on the *affordances* that media provide, that is, the unique opportunities that technology can leverage (Jonassen, Campbell, & Davidson, 1994; Reiser, 1994). Also, knowing *what works* is not enough and more emphasis needs to be placed on the *why*, *for whom*, and *under what circumstances*.

Not surprisingly, studies that have compared delivery of teacher professional development (e.g. online vs. face-to-face) have found no differences in terms of teacher or student learning (e.g. Fisher, Schumaker, Culbertson, & Deshler, 2010; Fishman et al., 2013; Powell, Diamond, Burchinal, & Koehler, 2010; Schumaker, Fisher, & Walsh, 2010). In two separate but complimentary studies, Fisher et al. (2010) compared a computerized professional development program without human facilitation and a face-to-face program based on Kirpatricks's four evaluation levels: teacher and students' learning, reaction, behavior, and results. The professional program focused on a concept mapping technique to support student learning, called mastery routine. In a randomized controlled trial, 50 teachers participated in study one, and 160 teachers in study two. The researchers found that teachers in both the treatment and control conditions gained similar knowledge but those in the face-to-face program expressed somewhat higher satisfaction rates. No significant differences in terms of students' learning and satisfaction were reported.

Using a similar two-study randomized controlled trial design, Schumaker et al. (2010) studied the effects of a virtual versus a face-to-face professional development program on

teachers' classroom practices and the performance of students with and without learning disabilities. The first study collected data from 60 teachers certified teachers from 4th through 12th grades who were enrolled in a graduate-level course on reading methods. The second study collected data from 21 teachers and 292 students. The computerized program was as effective as the face-to-face professional development in terms of reaction, teacher learning, student learning and student satisfaction. The computerized program was more effective than face-to-face delivery relative to teacher behavior in the classroom.

Two other randomized controlled trials found no differences for professional development delivery mode (Fishman et al., 2013; Powell et al., 2010). In another randomized control trial, Powell et al. (2010) evaluated the effects of a literacy-focused professional development program, particularly the differences between online and on-site delivery of expert coaching. After this one-semester long intervention involving 88 teachers and 759 children, no significant differences were found between online and on-site coaching. However, the intervention had positive effects on early literacy and language development. Similarly, Fishman et al. (2013) examined differences in teacher knowledge and beliefs, teacher classroom practice, and student learning outcomes in an online and face-to-face professional development programs. This program focused on a year-long environmental science curriculum for 49 high school teachers. No significant differences were found between professional development modality and teachers exhibited gains in both experimental conditions.

Concerning teacher communities of practice, studies comparing delivery modality have also been conducted (Matzat, 2013; McConnell, Parker, Eberhardt, Koehler, & Lundeberg, 2013). Matzat (2013) examined whether blended learning communities are more beneficial for teacher professional development than fully online communities for secondary teachers in The

Netherlands. Matzat (2013) analyzed a total of 26 informal online learning communities involving 1,492 teachers. The comparison was made based on three specific aspects: teachers' perceived improvement of content knowledge, pedagogical knowledge, and availability of information about vacancies to support teacher mobility. Multiple linear and logistic regression analyses revealed that a mix between online and face-to-face interaction showed additional benefits to fully online learning communities. However, a combination of online and real-life exchanges between *some* members may be enough to strengthen the community as a whole. Therefore, Matzat (2013) argued that online teacher communities are a viable alternative to scale up professional development initiatives without requiring synchronous meetings for all members.

Using phenomenology and a comparative case study, McConnell et al. (2013) examined the benefits and challenges of virtual professional learning communities (PLCs) in comparison to face-to-face PLC meetings. This particular professional development program was designed to help 54 K-12 science teachers implement inquiry-based learning. The program was delivered face-to-face but required teachers to meet (either online or face-to-face) with a professional learning community for over a year. The teachers were assigned to a total of 11 learning communities. Teachers who engaged in the virtual PLCs experienced the same benefits as members of the face-to-face PLCs. However, McConnell et al. (2013) highlighted that technology provides unique affordances, such as video-conferencing, which promotes collaboration from remote distances and helps PLCs be more sustainable over time.

***Professional learning communities*.** Most of the research on communities of practice focuses on teachers' perceptions, engagement, and professional growth. For example, Wang and Lu (2012) studied 283 secondary school teachers in China and found that teachers exhibited positive attitudes towards an online community and reported transformational changes.

Similarly, Tsai et al. (2010) reported significant changes in the perceptions of 92 science teachers in an online community in terms of sense of community, social ability, ease of use, usefulness, effectiveness, and satisfaction. Elster (2010) evaluated the effectiveness of 10 learning communities involving 144 German science teachers and highlighted how information literacy skills impact sustainability of learning communities.

Two other studies that bring attention to the importance of online discussion and selection of questions/tasks in online learning communities were conducted by Prestridge (2010), and Francis and Jacobsen (2013). Prestridge (2010) explored the role of online discussions and constructive dialogue to support teacher professional development. She examined how 16 teachers engaged in online discussions to reflect on their pedagogical practice. Qualitatively and quantitatively analyses provided evidence of community, as well as different forms of feedback and levels of discussion in the online forum. The researcher concluded that online conversations were critical to help teachers transform their pedagogical beliefs and practice. In a different study, Francis and Jacobsen (2013) described the intent and formation of a professional learning community for math teachers using a hermeneutical-phenomenological method. A total of 13 Canadian teachers engaged in online discussions on how to design learning experiences to promote creativity and imagination in their students. The online synchronous environment allowed teachers to learn about collaborative mathematical problem solving and improve their teaching practices. The researchers concluded that the selection of appropriate discussion questions and tasks was essential for meaningful interactions.

Finally, two large-scale quantitative studies sponsored by the U.S. Department of Education were conducted on the e-Learning for Educators (eFE) initiative (Masters et al., 2010; Reeves & Pedulla, 2011). This project sought to establish an effective mode of online

professional development to meet the needs of almost 30,000 teachers from nine states. Masters et al. (2010) evaluated the effects of a learning community on teachers' knowledge and instructional practices and reported that the online program had a significant effect on English language arts teachers' pedagogical and content knowledge in the treatment group versus the control group. However, the eFE initiative experienced high levels of attrition. In general, only 74% of enrolled teachers completed the online professional courses during the first three-and-a-half years of the eFE project. Interested in attrition and teacher satisfaction, Reeves and Pedulla (2011) analyzed almost 4,000 self-reported evaluations of teachers using hierarchical ordinary least squares linear multiple regression. Contrary to popular belief, there was not a significant relationship between satisfaction and teachers' computer proficiency, ease of access to technology, or number of training hours. Instead, Reeves and Pedulla (2011) concluded that the variables most related to teacher satisfaction were "the beneficence of discussion topics, quality of learner interactions, the ease of content transferability, the adequacy of compensation, course organization and the clarity of participation expectations" (p.10).

Program models and their impact/effectiveness. This was the largest category with 11 studies reviewed that sought to assess the impact or effectiveness of online or hybrid professional development initiatives. Most of these studies measured impact only in terms of teacher learning and growth, with the exception of two studies (Dash, de Kramer, O'Dwyer, Masters, & Russell, 2012; Shaha, Glassett, Copas, & Huddleston, 2016) that also included measures of student achievement. This is a major limitation to understanding how teacher professional development affects teacher practice and student outcomes. In a randomized controlled trial, Dash et al. (2012) found no significant differences in terms of academic achievement between students whose teachers participated in an online professional development program and students in the control

group. The researchers explained that student measures were administered in a short period after the online teacher training concluded, which may not have given treatment teachers the opportunity to implement their new skill set.

In their study, Dash et al. (2012) evaluated the effects of the e-Learning for Educators (EfE) initiative, which was sponsored by the US Department of Education, and involved 79 5th grade math teachers and 1,438 students. Teachers in the experimental group exhibited significant gains in pedagogical content knowledge and pedagogical practices but no effect was found on student achievement. This is an important finding that calls for further research to better understand the interplay between professional development, teacher learning, and student outcomes. Positive effects of teacher professional development have also been reported in the literature. Shaha et al. (2016) conducted a meta-analysis using data from nine previous studies to explore the impact of a hybrid professional development model on student performance. The teacher program was provided to 52 schools in five states. Students improved their reading and math scores by 19% and 24% respectively. Title 1 schools also showed significant gains when contrasted with non-Title 1 schools. The researchers concluded that a program combining seminars with online and on-demand professional learning had higher impacts on student learning than each approach separately.

Another interesting finding is that 7 of the 11 studies reviewed under this category used mixed research methods to evaluate online professional development programs (Hunt, Powell, Little, & Mike, 2013; Liu, 2012; Marrero, Woodruff, Schuster, & Riccio, 2010; McAleer & Bangert, 2011; McFadden et al., 2014; Pape et al., 2015; Polly, Martin, Wang, Lambert, & Pugalee, 2016). In an attempt to gain deeper understanding of teacher learning, these studies used both quantitative and qualitative methods not only to determine whether a particular

program worked, but to explain why. Others had previously raised the need for mixed methods research to study online teacher programs (Dede et al., 2009).

In a hybrid professional development program on formative assessment, Polly et al. (2016) explored teachers' instructional decisions for math teaching. This was a year-long program consisting of 40h of face-to-face workshops and 40h of classroom-embedded activities that were facilitated asynchronously in an online environment. The program followed guidelines for learner-center professional development (LCPD) (Polly & Hannafin, 2010). From this perspective, teacher professional development is most effective when teachers engage in activities that promote: a) discussion on student learning deficiencies, b) improvement on teachers' content and pedagogical knowledge, c) ownership of their professional learning, d) collaboration with peers, e) sustainable professional development over time, f) implementation of new knowledge or skills in the classroom and e) reflection on teachers' experiences and students' data.

In their mixed methods study, Polly et al. (2016) collected data from 138 teachers from kindergarten through second grade. Teachers reported gaining expertise on how to use an assessment tool to collect student data and develop targeted instructional plans. However, there was a lot of variance between teachers and school districts, suggesting that the teachers' context and environment affect the outcomes of the professional development program. Another mixed methods study was conducted by Marrero et al. (2010), who evaluated the relevance of online interactive short-courses as a source of teacher professional development. The goal of the program was to promote the use of NASA educational content in classrooms. Marrero et al. (2010) collected data from 59 K-12 teachers using questionnaires, reflective essays, personal communications, and field notes. The researchers concluded that teachers valued the flexible

design of the professional development program and showed interest in engaging in communities of practice with other educators across the nation.

Two studies centered around the Electronic Mentoring for Student Success (eMSS) program using a randomized controlled design. The eMSS program was initially developed to support science and math teachers and retain educators new to the profession. Later, the program was expanded to mentor novice special education teachers. McAleer and Bangert (2011) explored the professional growth of mentor mathematics teachers after participating in this e-mentoring program, specifically the relationship between patterns of engagement and program design. The researchers analyzed surveys and online portfolios from 43 mathematics mentor teachers using mixed methods. Results indicated that the eMSS program promoted individual and social knowledge construction in mathematics mentor teachers. Teachers' level of engagement was correlated with their perceived growth in knowledge, skills, and changes in practice. Also, mentor teachers reported learning best when reflecting on peer posts, underscoring the importance of communication, collaboration, and reflection as core principles for the design of online professional development programs.

Focusing on the impact of the eMSS program on novice special education teachers, Hunt et al. (2013) evaluated the effects of teacher participation in terms of their perceived preparedness and knowledge of professional standards. They also analyzed teachers' perceptions of their professional growth over a year. In a mixed methods study, a sample of 22 teachers was used for the quantitative analysis and 10 teachers for the qualitative portion. The researchers found that there were statistically significant differences in teachers' levels of perceived preparedness and knowledge of standards and laws after their participation in the e-mentoring program. However, there were no effects on perceived teacher knowledge.

Also focusing on general and special education teachers, Pape et al. (2015) developed a year-long development program, called *Prime Online*, to help educators to teach Math to all students, particularly those with disabilities, and promote teacher inquiry habits. The researchers examined teacher learning and growth using two measures (Content Knowledge for Teaching – Mathematics, and Learning Mathematics for Teaching), followed by teacher focus groups. Twenty-three teachers from third to fifth grades participated in this study, which was part of a larger 3-year research project funded by the U.S. Department of Education's Institute of Education Sciences. Pape et al. (2015) were interested in identifying specific components of the online program that lead to teacher learning and success. Such components were opportunities to engage with: mathematical modeling, practitioner-focused journals and websites, developer-constructed materials, classroom implementation, reflection, and discussion. The researchers concluded that *Prime Online* provided teachers with rigorous and high-quality learning opportunities to improve their content and pedagogical knowledge. They also recommended further research on design features and implementation of online programs for teacher professional development.

Another quantitative oriented study was conducted by Moore et al. (2016), who assessed the impact of a hybrid professional development program using a one-group pretest, posttest design. The program was designed to prepare science and math teachers to implement Geographic Information Systems (GIS) technology in their classrooms. The researchers highlighted that their purpose was not to evaluate program effectiveness but to assess its impact on teachers' learning. In their logic model, the researchers hypothesized that for teachers to be able to use and implement GIS technology, the program needed to address five main areas: Relevance, community, competence, comfort, and empowerment. That is, teachers needed to

find GIS relevant for state and national standards, then they needed to feel part of a community of practitioners, competent and comfortable with GIS technology, and empowered to use and troubleshoot GIS.

The Moore et al. study (2016) was funded by the National Science Foundation and included three teacher cohorts over a three-year period. Each cohort received 40 hours of synchronous online instruction and 80 hours of in-person instruction and support over an eight-month period. In total, 59 of 139 teachers completed the project with an attrition rate of 58%. The researchers argued that attrition was expected and accounted for from early stages of teacher recruitment. Correlation, ordinary least squares, and ordered logit regression analyses revealed that teachers reported higher frequency of GIS use in the classroom, as well as enhanced feelings of preparation, competence, community, and comfort with GIS. Teachers' attitudes about empowerment and relevance did not change. This study found hybrid professional development models to be *efficient,* flexible, and able to serve large geographic spaces.

The only qualitative study in this category was conducted by Donnelly and Boniface (2013), who analyzed science teachers' perceptions on the use of a wiki for professional development to share their knowledge and practice. The wiki was used to support teachers' adoption of the New Zealand curriculum for science. In a case study involving six participants, Donnelly and Boniface (2013) found that the potential for the wiki to serve as a tool for professional development was affected by teachers' technological competence. Teachers also reported that the wiki helped reduce isolation within and across schools, promoted cooperation, and provided timely feedback.

One last finding about the studies reviewed in this category is that all but one paper focused on professional development for math and science teachers. The only study that did not

follow this trend was conducted by Liu (2012), who investigated English as a foreign language teachers in Taiwan. The teachers (21 pre-service teachers, seven secondary teachers, and four university teachers) engaged in Web-based videocase discussions for over a year and the purpose of the study was to examine the impact of such online discussions as a professional development tool. Data collected through teaching videos, online discussions, interviews, reflection journals, and an open-ended questionnaire provided evidence for online videocase discussions as a valuable source for professional development. Pre-service and in-service teachers tended to adopt different views during the online discussions, but after a year of collaborating, novice teachers learned to be more critical and assertive from the interaction with more seasoned educators.

Another study on how a video annotation tool impacted reflective practices of novice secondary science teachers was conducted by McFadden et al. (2014). In a convergent parallel mixed-methods design, the researchers examined the frequency of reflective stances and the nature of video annotations and levels of reflection. The video annotation tool facilitated teachers' reflection on their classroom practices. However, teachers had a tendency to focus on just description and explanation, rather than on higher-level reflection such as evaluation and interpretation.

Teachers' perceptions and engagement. An area of particular interest is teacher perceptions of their participation in online environments and how they interact with one another. Although technology provides specific affordances and can scaffold teacher learning, teachers' online social presence tends to be lower than expected (Al-Balushi & Al-Abdali, 2015). Teachers justify their low rates of participation because of their lack of time, school commitments, and the heavy workload of online professional development courses (Al-Balushi & Al-Abdali, 2015;

McFadden et al., 2014). Some research suggests that educators prefer face-to-face feedback from instructors or supervisors over fully online interactions (Stone-MacDonald & Douglass, 2015).

Research in this area frequently cites the Community of Inquiry framework (Garrison, Anderson, & Archer, 1999) to study teachers' online presence. This framework was originally devised for higher education, but it has been adopted to online learning environments and validated in a number of studies (Arbaugh et al., 2008; Garrison & Arbaugh, 2007). The model identifies cognitive presence, social presence, and teaching presence as being interrelated and mutually dependent for a successful educational experience (see Figure 8). Cognitive presence is defined as the extent to which participants construct meaning based on their interactions. Social presence is the ability of participants to emulate their personality and socio-emotional characteristics in an educational setting. And teaching presence relates to the design of the educational experience and the facilitation offered during the learning process.

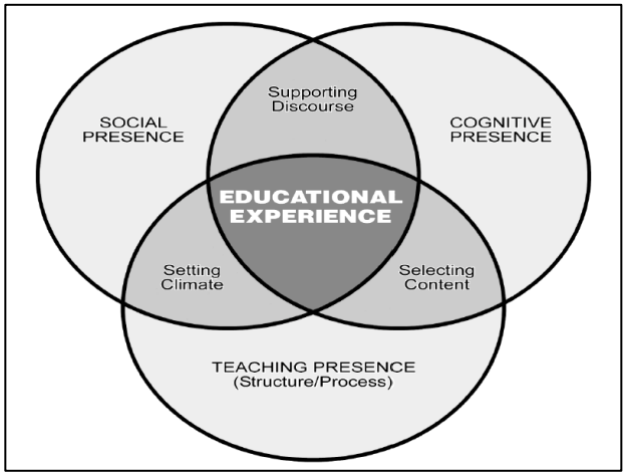

Figure 8. The Community of Inquiry Framework (Garrison et al., 1999, p. 88)

For example, Al-Balushi and Al-Abdali (2015) used the Community of Inquiry framework to design and evaluate the effectiveness of a Moodle course whose goal was to help science teachers in Oman to teach for creativity. A total of 19 teachers from grades 5-10 participated in this study. Using a pre–post one-group quasi-experimental design, the researchers

found statistically significant improvements in terms of teacher knowledge. Teachers engaged cognitively in the online course but their social presence was limited. Teachers did not create social bonds due to their lack of time, workload, or the intense nature of the Moodle course.

Some of the factors that are critical to establishing online rapport and maximizing teacher engagement include strong teaching and social presence, promoting a safe learning environment, and creating trust among members for honest and reflective online conversations (Holmes, Signer, & MacLeod, 2011; Kling & Courtright, 2003; Smith & Sivo, 2012). Holmes et al. (2011) described teachers' perspectives on an online professional development program, the value of online presence, and the factors that affect professional development quality and satisfaction. A group of 95 in-service teachers participated in various online courses that offered two graduate credits at a university. Using a within-stage mixed-method, the researchers found that social and teacher presence in the online program were the most important factors related to teacher's learning and satisfaction. Other factors included cognitive presence, social networking, and prior experience with online courses.

Similar results were found by Smith and Sivo (2012), who examined how the Technology Acceptance Model (TAM) could predict teachers' desire to engage in online professional development based on their perception of social presence and sociability. This online course on reading strategies and practices in the classroom was completed by 517 certified K-12 teachers. Using structural equation modeling, Smith and Sivo (2012) concluded that perceived ease of use, usefulness, and social presence were significant predictors of teacher's intention to engage in online professional development.

The structure of the online professional development has also been found to be critical to engage teachers. Renninger, Cai, Lewis, Adams, and Ernst (2011) analyzed teachers' motivation

and learning in a non-moderated online workshop. The program provided math teachers with opportunities for exploration on reflection about technology-enhanced rich challenge problems for algebraic reasoning. In a mixed methods study involving 164 teachers, the researchers found that teachers' participation on the online workshop did not necessarily depend on their levels of motivation and self-efficacy but on the contents and structure of the workshop. Based on this, designers of online teacher programs should provide enough flexibility to accommodate teachers' disciplinary content, strengths, and needs.

However, some educators may prefer face-to-face interactions over online exchanges. Stone-MacDonald and Douglass (2015) examined the perceptions of early child educators and teacher trainers to determine the technological knowledge and processes required for teachers to engage in an online training program. The online program was mandated by the state to fulfill training requirements of the Quality Rating and Improvement System (QRIS). The researchers surveyed 231out of 801 educators, and 28 out of 62 teacher trainers who completed the program. Although some early education teachers exhibited the necessary technological skills to complete a fully online training, most educators preferred having the guidance and support of a supervisor who could answer any questions related to the content or use of technology.

With regard to teacher engagement in online environments, Zhang, Lin, Zhan, and Ren (2016) identified four levels of engagement: Passive, active, constructive, and interactive. Passive engagement involves activities such as reading or listening. Examples of active engagement include repeating a lecture or a video. Constructive engagement requires learners to go beyond learned materials and produce new explanations or artifacts. Interactive engagement implies collaborative discussions and negotiation of meaning. Using this framework, Zhang et al. (2016) examined the impact of teaching presence on the levels of engagement of Chinese middle

school teachers in an online professional development program. The program consisted of three modules on general pedagogy, domain-specific pedagogy, and case studies. Data were collected from 218 middle school English teacher participants in Shanghai. A principal component analysis and regression analyses on survey and log data revealed that online teacher presence only had statistical significant effects on the constructive and interactive engagement levels.

Other relevant research. Two studies that did not meet the inclusion criteria for the review of the literature but which are particularly relevant to the proposed study were conducted by Mackey and Evans (2011) and Barab, Schatz, et al. (2004). Through a case study of 15 teachers pursuing an online graduate diploma, Mackey and Evans (2011) analyzed how teachers created their own networks and communities of practice through online and offline interactions in New Zealand. The researchers noted that teachers did not build strong ties in their online interactions. Instead, teachers would cross boundaries between their online formal communities and their professional practice in the workplace. Some teachers would act as *brokers* between communities, strengthening weak ties and allowing the diffusion of new ideas between groups (Granovetter, 1981; Wenger, 2000). Mackey and Evans (2011) concluded that a connectivist approach may help to explain how teachers navigate between local and virtual contexts within the broader sociocultural milieu.

Barab, Schatz, et al. (2004) used activity theory to conceptualize an online community for teachers interested in inquiry-based learning and learner-centered classrooms. The *Inquiry Learning Forum* (ILF) was initially created for math and science teachers but it was later open to all teachers, school administrators, university faculty, and pre-service teachers. The forum was funded by the National Science Foundation and remained operational for almost a decade supporting thousands of teachers. The ILF was designed as a virtual space in which teachers

could visit each other's classrooms to discuss and reflect on their pedagogical practice and share artifacts. Teachers were able to work in groups on specific projects and share lesson plans or video lessons to advance the notion of community. Researchers from the ILF design team as well as external researcher collected qualitative data such as observations, field notes, and semi-structured interviews. The overarching research goal was to understand the design principles for facilitating, sustaining, and scaling a CoP in which the value of sharing one's practice and engaging in the discussions outweighs the costs of participation.

Because of the nature of the ILF, the research team (2004) approached the design process and community functioning using activity theory (AT) and sociotechnical interaction network (STIN). AT helped the researchers to understand discrepancies between their design conceptions and the needs and constraints of the community. AT served as a lens to characterize the process of designing the online forum and the activity in which teachers engaged. On the other hand, A STIN perspective highlighted the social relationships of technological structures, assuming that technologies influence and are influenced by the social world (Kling et al., 2003). From this perspective, the online forum was part of a larger STIN along with teachers and other actors, in which mediation was transactional and symmetrical. The researchers concluded that both AT and STIN frameworks were complimentary and when used synergistically, they provided deeper understanding of the social and technical phenomena.

Concerning design decisions, the ILF was built with three commitments in mind: 1) a visit-the-classroom metaphor where teachers share video lessons and anchor their discussion on their actual practice; 2) a network of knowledge where teachers are not passive attendees of workshops but active contributors to a common knowledge base; and 3) a focus on building community where individuals negotiate their cultural-historical heritage, cosmology, and

practice to pursue a collective goal or enterprise. Barab et al. (2001) reported that the visit-the-classroom metaphor was not as successful as expected because some of the videos being shared were not pedagogically sound and subject-matter inaccurate. Based on feedback from the teacher advisory board, the researchers decided to implement a video review board and a rubric. Also, isolated video lessons were unable to convey a general sense of the classroom culture and students' needs. Hence, it was necessary to interview the teachers afterwards, and share other artifacts such as lesson plans and students' samples of work.

According to Barab et al. (2001), the main design challenge for the ILF was not to support usability but sociability. Although the forum was shown to be effective at facilitating human-computer interaction, teachers did not feel encouraged to participate and build social relationships. *Sociability* refers to the social and technical structures that allow group members to interact and pursue a shared goal (Preece, 2000). To support human-human interaction, Barab et al. (2001) created new website elements to foster participation and collaboration such as guidelines for first timers, personalized suggestions and notifications for members, video trailers featuring recently added materials, a new page highlighting hot discussion topics, and enhanced support for small group projects. Social structures to support online sociability included integrating the ILF into college courses, assigning new roles to members as moderators and reviewers, and offering face-to-face workshops to foster trust and social ties. Kling and Courtright (2003) questioned the extent to which the ILF provided evidence of community and instead, they characterized the e-forum as a "valuable peer-to-peer resource center for in-service and pre-service teachers" (p. 230).

Summary

This literature review explored *cultural-historical activity theory* (CHAT) (Cole, 1996) as a guiding framework to understand how technology can mediate teacher learning; *social network analysis* (Wasserman & Faust, 1994) and *sociotechnical interaction networks* (Kling et al., 2003) to study teacher's interactions in an online community of practice; followed by a review of empirical research on online teacher professional development and CoPs. These main components inform this study to describe the formation, development, and evolution of an online teacher CoP as a sociotechnical network to support teacher's implementation of the Instructional Conversation pedagogy.

CHAT builds upon the work of Soviet Russian phycologists (Leont'ev, 1978; Vygotsky, 1978) and other contemporary scholars (Cole, 1996; Engeström, 2001; González Rey, 2011) to understand the mediation of material, symbolic, or cultural artifacts in human experience. Arguably, the unit of analysis is the situated human activity/context (Kaptelinin, 1996a; Leont'ev, 1978), but others suggest that the sign (Toomela, 2000; Vygotsky, 1978) or *vivencias* (lived experiences) (Arias, 2011; González Rey, 2011) are more appropriate units of analysis as they embrace internal, external, and emotional aspects of the human psyche.

In instructional design and technology, Engeström's (1987, 2001) model of activity theory has been widely used to operationalize the constructs and apply them to problems involving human-human, human-object, and human-technology relationships (Kaptelinin & Nardi, 2006; Karakus, 2014; Yamagata-Lynch, 2013). Engeström (1987, 2001) suggested that the subject and the object are mediated through tools, signs, rules, community, and division of labor. He used a triangle to represent this relationship (see Figure 5). In a revision of his model, Engeström (2001, 2009) argued that the unit of analysis should include at least two interacting

activity systems since mediation exists within a larger and interconnected social world, forming shared or jointly constructed objects. However, this conceptualization of activity theory fails to represent historicity, that is, how cognition is distributed through time from generation to generation (Cole & Engeström, 1997).

In an effort to better understand the complexity of human interactions, *social network analysis* (SNA) emerged as a social science paradigm to study relationship among social entities (Marin & Wellman, 2011; Scott & Carrington, 2011; Wasserman & Faust, 1994). SNA facilitates the exploration of transmission, adaptation, binding, and exclusion mechanisms in networks across natural, social, and behavioral sciences (Hollstein, 2014; Marin & Wellman, 2011; Scott, 2013; Wasserman & Faust, 1994). SNA is built on the premise that actors and their actions are interdependent and influenced by each other, therefore SNA adopts a network approach to explaining social phenomena as opposed to an individualist or attribute-based perspective (Marin & Wellman, 2011). Multiple network theories have been posited to explain either mathematical forms, patterns, and effects of network formation, or to understand patterns of relations within a given discipline. A learning theory that draws from network principles is *connectivism* (Downes, 2006; Siemens, 2005), where learning is viewed as a continuous process of network exploration, pattern finding, and "cross-pollination" of ideas that may occur inside or outside the individual.

With a focus on both human and non-human actors, *sociotechnical interaction network* (STIN) models acknowledge the role of non-human agents that may affect how we interact socially, economically, technologically, and politically with the world (Kling et al., 2003). STIN assumes that technology and the social world co-constitute each other and are not separate entities. Therefore, equipment, data, resources, documents, or other elements can play an

important role within a network. Also, individuals are part of multiple overlapping social and technological networks, which may cause incentives, conflicts, and tensions. Both SNA and STIN approaches have gained a lot of visibility in the fields of teacher education and instructional design and technology over the last few years (e.g. Baker-Doyle, 2015; Cho et al., 2013; Haya et al., 2015; Heo et al., 2010; Lin et al., 2016; Walker & Creanor, 2009).

In the last section of this chapter, a review of empirical research on online teacher CoPs and online teacher professional development from 2010 to 2016 is presented. This synthesis of research updated the work of Dede et al. (2009), who reviewed nearly 400 articles on online, face-to-face, and hybrid teacher professional development programs and found that most research was anecdotal, lacked scientific rigor, and did not provide a long-term impact evaluation. After defining the search procedures and criteria for inclusion, 30 studies were identified on online or hybrid professional development for K-12 educators. The studies were classified according to their purpose: compare modality, investigate professional learning communities, evaluate program models and their impact/effectiveness, or analyze teachers' perceptions and engagement (see Figure 7).

Although there is a consensus that media delivery comparisons are likely to yield no significant differences (Clark, 1994; Reeves, 2011), some research still compares face-to-face and online teacher programs using randomized controlled trials (e.g. Fisher et al., 2010; Fishman et al., 2013; Powell et al., 2010; Schumaker et al., 2010). Not surprisingly, such studies reported no differences in terms of teacher or student learning given the delivery format. However, this body of literature serves to provide evidence that online or hybrid programs may be suitable models to scale up teacher professional development and provide ongoing support. Further

research needs to focus on the unique *affordances* that technology provides (Jonassen et al., 1994; Reiser, 1994) and how to design program with such opportunities in mind.

Concerning teacher CoPs, a few studies also compared delivery modality and found that blended communities provided slightly more benefits than fully online groups (Matzat, 2013; McConnell et al., 2013). Although real-life interactions among teachers strengthen online communities, Matzat (2013) concluded that not *all* members need to know each other in real life for the community to be successful. However, most research on communities of practice is centered around teachers' perceptions, engagement, and professional growth. Teachers have reported positive attitudes towards online CoPs resulting in transformational changes to their practice (Barab, Schatz, et al., 2004; Elster, 2010; Mackey & Evans, 2011; Tsai et al., 2010; Wang & Lu, 2012). From an instructional design perspective, the selection of tasks and discussion questions is critical to foster reflective and meaningful teacher interactions in online environments (Francis & Jacobsen, 2013; Prestridge, 2010). Despite high levels of teacher attrition, two large-scale quantitative studies reported positive effects on teachers' pedagogical and content knowledge after participating in an online learning community (Masters et al., 2010; Reeves & Pedulla, 2011). Teachers' satisfaction was driven by the usefulness and transferability of online discussions, quality of interactions, course organization, and clear expectations (Reeves & Pedulla, 2011).

Most studies reviewed focused on assessing the impact or effectiveness of teacher professional development programs in terms of teacher professional growth (e.g. Hunt et al., 2013; Marrero et al., 2010; Pape et al., 2015; Polly et al., 2016). Only two studies (Dash et al., 2012; Shaha et al., 2016) included student achievement measures, which is a major limitation to evaluating how teacher learning impacts student outcomes. In general, this body of literature

suggests that online teacher professional development programs yield positive results if key design principles are present, such as teacher ownership of their own learning, program sustainability, and opportunities for reflection, discussion, collaboration, and classroom implementation.

The last category of empirical research was centered around teacher's perceptions and engagement in online settings. Researchers in this area often use the Community of Inquiry framework (Garrison et al., 1999) to conceptualize and operationalize social presence, cognitive presence, and teaching presence. Teachers' online presence is typically lower than expected given their busy schedules and multiple school commitments (Al-Balushi & Al-Abdali, 2015; McFadden et al., 2014). Some educators find more value in face-to-face interactions as opposed to fully online exchanges (Stone-MacDonald & Douglass, 2015). Some factors that are of paramount importance to foster teacher online social presence include promoting a safe learning environment, creating trust among members, perceived ease of use, quality and structure of the program, as well as teachers' prior experience with online learning (Holmes et al., 2011; Kling & Courtright, 2003; Renninger et al., 2011; Smith & Sivo, 2012).

This chapter informs and guides the CLASE online teacher CoP as an activity system that makes part of a larger STIN network (Engeström, 1987; Kling et al., 2003). Using different theoretical perspectives allow for a better understanding of teacher learning and the mediating role of technology. Technology influences and is influenced by the social world and thus, human and non-human actors transact in a dialogic and symmetrical relationship. Finally, a cultural-historical lens facilitates the identification of relationships and contradictions within and between systems derived from the online community.

CHAPTER 3

METHODS

The Center for Latino Achievement and Success in Education (CLASE) is a research and development center with a mission to reduce the achievement gap for Latino children, especially in Georgia. The Center provides professional development and resources for teachers working with Latinos as well as outreach programs for Latino students placed at risk. In summer 2016, CLASE launched an online platform for teachers to build a community of practice (CoP) around the Instructional Conversation pedagogy (Gokee, 2017; Portes et al., 2018; Tharp & Gallimore, 1991). Within 18 months, 382 teachers joined the platform to seek support and share ideas. Membership was open to any educator who has participated in CLASE's face-to-face training programs. The online CoP was intended to extend teacher learning and collaboration beyond the in-person sessions and provide ongoing support for a sustainable and transformative program.

Research Questions

The purpose of this mixed methods study was to describe the formation, development, and evolution of an online teacher CoP as a sociotechnical network to support teacher's implementation of the IC pedagogy. Findings may inform discussions about the interplay between network and community as complementary but separate aspects of the "social fabric of learning" (Wenger et al., 2011, p. 13). Findings can also inform guidelines for instructional designers on how to enable the formation of CoPs, given the many challenges and constraints. The research questions, data sources, and analyses are presented in Table 2.

Table 2

Research Questions, Data Sources, and Analyses

Research Question	Data Sources	Analyses
1) How is the online CoP structured as a sociotechnical network? a) What network attributes (i.e. density, diameter, dyads, transitivity, reciprocity, cliques, components, and cut vertices) can be identified in the online CoP? b) What does node centrality (i.e. degree, closeness, betweenness, eigenvector) reveal about the CoP formation? c) What does node assortativity suggest about how members interact with each other?	Online interactions on the online platform (i.e. forums, postings, comments, etc.)	Social Network Analysis (Kolaczyk & Csárdi, 2014; Scott, 2013; Wasserman & Faust, 1994)
2) How do teachers perceive the social network dynamics and the value of their participation in the online CoP?	Semi-structured interviews with actors of interest (i.e. core contributors, peripheral observers, brokers, etc.)	Thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006)
3) How do teachers' perceptions about the online CoP help explain and expand the structural network analysis?	Using an explanatory sequential design (Creswell, 2014), qualitative data are analyzed further to explain and elaborate on the quantitative results with the purposes of complementarity and triangulation (Greene, 2007). New data are not collected to answer this research question.	Meta-inferences based on both quantitative and qualitative findings (Teddlie & Tashakkori, 2003)

Significance of the Study

This study explores online teacher CoPs and is of critical importance for theory, research, and practice. From a theoretical standpoint, little is known regarding the intersection between

community and *network* in the context of teacher professional development (Macià & García, 2016). This study approaches teacher communities from the perspectives of cultural-historical activity theory (CHAT) and sociotechnical interaction networks (STIN). CHAT is a robust framework that illustrates how individuals transform and are transformed by culture, artifacts, and mediation over time (Cole, 1996). STIN highlights how different systems transact and involve both human and non-human agents (Kling et al., 2003). By investigating teacher communities through a CHAT and STIN lens, this study may provide insights into how networks and communities overlap and work together as complementary aspects of the "social fabric of learning" (Wenger et al., 2011, p. 13).

In research, this study may help inform large-scale interventions on teacher programs that evaluate their impact on both teacher and student outcomes. Many have suggested to approach the design and evaluation of teacher professional development programs in multiple stages or phases (Borko, 2004; Desimone, 2009; Hill et al., 2013). For example, Hill et al. (2013) suggested five research stages including one-site studies, randomized controlled trials, efficacy trials, scale-up trials, and meta-analyses. This type of programmatic research would allow to make comparisons across sites, contexts, and modes of delivery for a more comprehensive assessment of teacher professional development programs (Borko, 2004; Hill et al., 2013). However, Hill et al. (2013) warned that higher emphasis needs to be placed at the initial stages of program development to understand why a teacher program may or may not work across contexts. Large-scale experimental studies are costly and can only inform theory and practice when positive outcomes are found. But when results are not as expected, these studies provide little information on what specific program design features may lead to better outcomes.

In practice, this study may inform how to enable the formation of online teacher CoPs. As others have discussed, a community cannot be imposed and needs to emerge from the needs of its participants (Barab, MaKinster, et al., 2004). For this reason, a teacher CoP cannot be designed but facilitated. In program design, CHAT may reveal tensions and contradictions within the activity system, which offers valuable opportunities for improvement and refinement. Understanding community/network functioning may provide instructional designers (or others attempting to improve teacher quality) with clear guidelines and best practices to leverage the formation, development, and evolution of online teacher CoPs.

Additionally, this study may support teacher trainers and school administrators in providing sustainable programs and ongoing teacher-support, which are necessary factors to successfully adopt any new curricula or pedagogical models (Francis & Jacobsen, 2013; Hawley, 1999). Online teacher CoPs have been found to facilitate sustainability by increasing levels of teacher support, reflection, and collaboration through the use of technology (Barab, Schatz, et al., 2004; Elster, 2010; Mackey & Evans, 2011; Matzat, 2013; McConnell et al., 2013; Tsai et al., 2010; Wang & Lu, 2012). Online teacher CoPs can also help overcome geographical barriers and provide synchronous and asynchronous opportunities for teacher participation. Such technological affordances can be of particular importance for large-scale teacher professional development programs that occur in multiple sites.

In terms of how this study fits within the larger objectives of CLASE as a research and development center, this study supports the expansion of our teacher professional development programs across the nation and helps pave the way for future large-scale research interventions. From 2011 to 2015, CLASE conducted a randomized controlled trial assessing the effectiveness of the Instructional Conversation pedagogy on third and fifth graders (Portes & González

Canché, 2016; Portes et al., 2018). The trial was funded by the institute of Education Services (IES) and involved a total of 61 schools, 16 districts, 126 teachers, and 2351 students dispersed across three cohorts. Each cohort was studied for a period of two years – one training/practice year, and one experimental year. Preliminary findings suggest that this pedagogical intervention resulted in improved academic achievement outcomes, particularly for students whose first language was not English. Although the study focused on the impact of the IC pedagogy on student learning, an intensive teacher professional development program had to be designed and executed for fidelity of implementation. Teachers in the treatment group participated in a one-week summer institute, two refresher sessions per year, and on-going support from a dedicated instructional coach. Exploring online teacher CoPs may help strengthen our teacher programs, reduce costs, facilitate sustainability, and maximize our outreach for current and future projects.

Rationale for Mixed Methods Research

Definition of Mixed Methods Research. In this study, mixed methods research (MMR) is understood as a combination of qualitative and quantitative research approaches (e.g. viewpoints, data collection, analysis, inference techniques) for the purposes of "breadth and depth of understanding and corroboration" (Johnson, Onwuegbuzie, & Turner, 2007, p. 123). Bazeley (2015) distinguished between mixed methods and multimethod research. Multimethod research is when different approaches or methods are used in parallel or sequence but are not integrated until inferences are being made. Mixed methods research involves the integration of approaches occurring during the program of study and not just at its concluding point (Bazeley, 2015). Many leading researchers agreed that using different methods to examine different questions in the same overall study does not constitute mixed methods research (Johnson et al., 2007).

MMR acknowledges that there is more than one way of knowing and representing social phenomena (Greene, 2007). This "third paradigm" usually yields more informative, complete, balanced, and useful research results than the quantitative and qualitative paradigms separately (Johnson et al., 2007). Hollstein (2014) claimed that MMR in network studies must satisfy three conditions: 1) the study is based on both numerical and textual network data and the researcher may use data transformation techniques such as *qualitizing* or *quantitizing*; 2) the researcher uses either mathematical or interpretative strategies to analyze networks and relations, and 3) there is an integration of data or analysis strategies at least at one stage of the research process (data collection, data analysis, or interpretation of results).

Qualitizing and *quantitizing* are commonly used strategies to transform one type of data into the other for integration and analysis in MMR (Tashakkori & Teddlie, 2010). An example of the former is when researchers verbally profile participants and construct narrative descriptions based on quantitative data. An example of the latter is when researchers create numerical codes such as frequency counts or rating scales for verbal data to conduct statistical analyses. Teddlie and Tashakkori (2009) argued that social network analysis (SNA) data is inherently mixed because it integrates quantitative sociomatrices (indices of relationships in matrix form) and qualitative sociograms (network diagrams). That is, SNA uses a qualitizing technique to convert the numeric raw data (e.g. "1" when two people interact and "0" when they do not) into a qualitative visualization of the data through diagrams.

Suitability of Mixed Methods Research. According to Hollstein (2014), the concept of "social networks" started to be explored in the 1950s by cultural anthropologists who were studying local communities. Since then, structural network analysis was "mathematized" and flourished in fields such as sociology, political science, economics, computer science, medical

science and history. Social network analysis (SNA) is concerned with the social structure of the embedded actors, and it is neither quantitative or qualitative in nature (Carrington, 2014). Instead, SNA is structural although many people still consider SNA to be a primarily quantitative approach to social science (Carrington, 2014). Critics of this "structural determinism" argue that network research should be more concerned about the process through which actors make sense of the network, human agency, and cultural implications (Emirbayer & Goodwin, 1994; Hollstein, 2014). Because network structures cannot be studied from an exclusively quantitative or qualitative standpoint, only MMR can provide insights into network perceptions, interpretations, practices, outcomes, formation, and evolution (Domínguez & Hollstein, 2014; Engel, Coll, & Bustos, 2013; Hollstein, 2014).

Purpose of Mixed Methods Research. This mixed research study served the purposes of complementarity and triangulation (Greene, 2007). In SNA, purely quantitative analyses limit the explanatory power and only MMR can provide rich and thick network descriptions (Hollstein, 2014; Wald, 2014). In this study, the qualitative findings helped to elaborate, illustrate, and clarify the quantitative results. This approach allowed to increase the interpretability, meaningfulness, and validity of the SNA findings. Also, the use of both quantitative and qualitative methods compensated for each other's weaknesses.

Mixed Methods Research Design

This study is situated within a pragmatic philosophical stance. Pragmatism is outcome-oriented and interested in determining the meaning of things or focusing on the product of the research (Johnson & Onwuegbuzie, 2004). Pragmatism seeks to create practical solutions to social problems by focusing on communication and shared meaning-making. Pragmatism rejects dualisms such as subjectivism vs. objectivism, and views knowledge as both constructed and

based on the reality we experience. A pragmatic research method is eclectic and uses quantitative and qualitative techniques, assumptions, and designs to best respond to a particular set of research questions (Onwuegbuzie & Johnson, 2006).

Specifically, this study followed an explanatory sequential design (Creswell, 2014). In the first phase, a quantitative structural analysis of the CoP was conducted to identify network and node attributes. Network characteristics include density, diameter, dyads, transitivity, reciprocity, cliques, components, and cut vertices (Kolaczyk & Csárdi, 2014; Wasserman & Faust, 1994). Density refers to the ratio of ties between actors to the maximum number of possible ties. Diameter is the greatest distance between any pair of vertices. Dyads refer to the possible relationships between pairs of nodes. Transitivity occurs when three actors are interconnected. Reciprocity describes the tendency for actors to return an initiated contact more frequently than they would by chance. Cliques and components help to identify cohesive and connected subgroups within the network. And cut vertices are single points, that if removed, disconnect a graph.

The quantitative structural analysis also evaluated node centrality and node assortativity (Kolaczyk & Csárdi, 2014; Wasserman & Faust, 1994) to better understand the CoP formation and how members interact with each other. Centrality describes the importance of an actor in terms of their location in the network and can reveal power, prestige, popularity, dominance, visibility, or other attributes. Centrality measures can be calculated at the actor level (e.g. degree) or at the global level (e.g. closeness, betweenness, eigenvector). Degrees refer to the number of direct connections of a vertex. Closeness takes into consideration the shortest distances from a given vertex to all other vertices in a graph. Betweenness defines centrality in terms of the level of dependency of a vertex to other actors to stay connected. Eigenvector centrality uses

eigenvalue solutions of linear systems of equations to express status, prestige, or rank. Finally, node assortativity or homophily refer to the strong preference of actors to interact with other members who are similar to them in social networks.

In the second phase of the study, participants of the CoP were purposefully interviewed based on their unique characteristics/positioning in the network, either as a core contributor, a peripheral observer, or a broker between subgroups (Barab et al., 2003; Barab, MaKinster, et al., 2004; Granovetter, 1981; Wenger, 2000). Semi-structured interviews were examined using thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006) to deepen and elucidate the results obtained by the quantitative structural analysis. At the end, meta-inferences (Teddlie & Tashakkori, 2003) were discussed based on both the quantitative and qualitative findings.

The diagram of procedures in Figure 9 uses Creswell's notation system (2014) for mixed methods. The arrows show a sequential design and indicate the order of procedures. The uppercase letters in "QUAL" represent priority of the qualitative phase, whereas the lowercase letters in "quan" indicate less emphasis of the quantitative methods. This study was qualitatively oriented (quant → QUAL) since the structural analysis serves to "map" cases for further qualitative analysis (Hollstein, 2014). In the diagram, boxes are used to show the data collection and analysis phases and circles are used to describe procedures and interpretation.

Site Selection

Participants for this study were members of the online teacher platform that CLASE launched in summer 2016 (http://instructionalconversation.ning.com/). A total of 382 educators from about 100 schools in 24 districts joined the CoP. See membership growth by date in Figure 10. Most teachers were from Georgia with only seven members being from out of state or international. The gender distribution was 352 females (92.1%) and 30 males (7.9%). The CoP

was comprised of 265 elementary school teachers, 56 middle school teachers, 10 high school teachers, 28 school administrators, and 23 CLASE staff members and other guests. Members of the CLASE platform taught a variety of content areas including art, English language arts, English for speakers of other languages, math, physical education, science, social studies, Spanish, and special education.

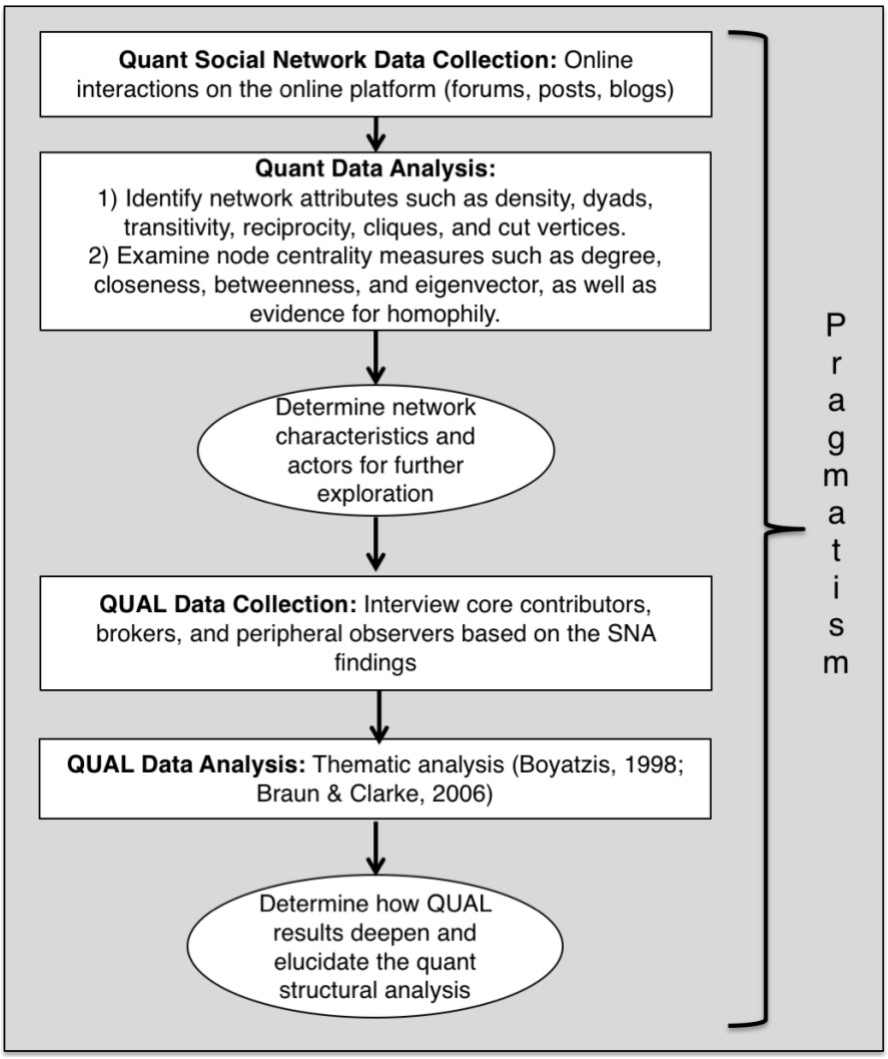

Figure 9. An Explanatory Sequential Design to Study an Online Teacher Community of Practice from a Social Network Perspective

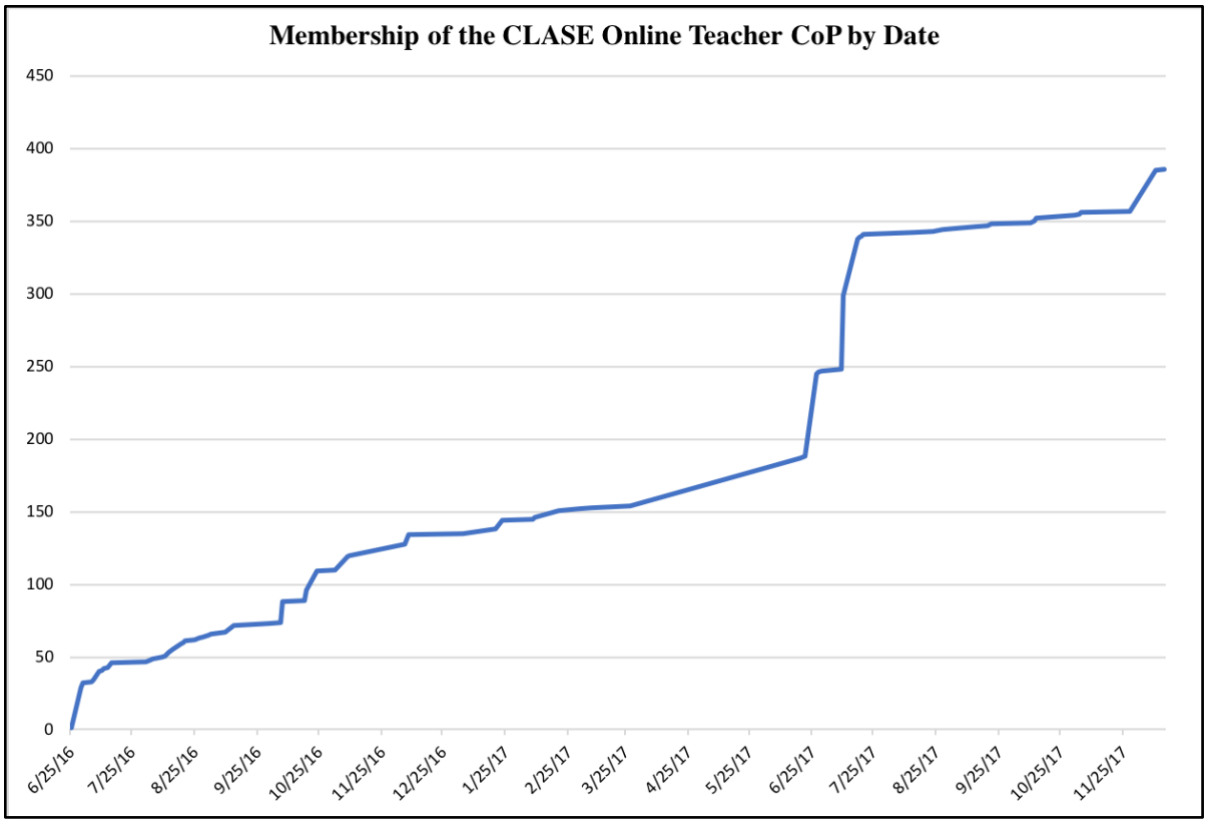

Figure 10. Membership of the CLASE Online Teacher CoP by Date

Although the IC pedagogy was designed with English language learners in mind, the method has shown to improve the academic achievement of other students as well. For this reason, some schools have adopted the methodology across classrooms and grades and many general education teachers have been trained as well. All teacher members had participated in the CLASE summer institutes, which consist of 30 hours of intensive training on the IC pedagogy. The overarching goal of the CoP was to reduce isolation and facilitate collaboration for sustainable change. Research has shown that blended or hybrid models of professional development can be more effective than fully online or fully face-to-face programs (Borko, 2004; Dede et al., 2009; Penuel, Fishman, Yamaguchi, & Gallagher, 2007).

Sample Selection

For the first phase of the study, any teacher who joined the online CoP was eligible to participate in this study on a voluntary basis. All 384 members consented to have their posts or online interactions analyzed for research purposes. In the second phase, the structural analysis maps particular cases for further qualitative analysis (Hollstein, 2014). Six members were invited for in-depth semi-structured interviews regarding their perceptions and interpretations of the network dynamics and the online CoP. Teachers were also asked about the value of their participation in the CoP as they implemented the IC pedagogy.

Case selection for in-depth interviews was driven by cases of particular interest. Specifically, two core contributors, two peripheral observers, and two brokers were selected. These types of actors may provide information about the formation and evolution of the network and the CoP (Barab et al., 2003; Barab, MaKinster, et al., 2004; Granovetter, 1981; Wenger, 2000). This sampling approach is known as purposeful sampling (Creswell, 2013) because the selection is made on the basis that participants can purposefully inform the research problem. Sample size was determined by the notion of saturation (Creswell, 2013), that is whenever new data are not contributing to the themes identified during analysis, or whenever the data are not informing the understanding of the research problem in a meaningful way.

Centrality measures and cut vertices were used to identify participants for interviews. Node degree, closeness, and eigenvalue scores were sorted from high to low to identify core contributors and peripheral observers. Cut vertices and betweenness centrality scores were used to identify brokers connecting subgroups. Table 3 shows a sample of high and low node centrality scores in the Teacher Network. Notice that there might be multiple core contributors,

brokers, and peripheral observers in the network. For that reason, additional decisions were made for further participant selection. Such decisions were driven by the following criteria:

1. Demographic characteristics guided case selection to guarantee representation of different genders, age ranges, sociocultural backgrounds, and teaching experience.
2. Different types of relationships were represented among the cases chosen, including help giving, help seeking, sharing of lesson plans, and social sharing.
3. Teachers from across grades, content areas, and school districts were represented in the sample.
4. Teachers from urban, suburban, and rural school settings were represented given their unique context and access to technology.

Data Collection and Instruments

Data collection procedures in SNA depend on whether the network is sociocentric (whole) or egocentric (individual) (Wald, 2014). For a complete network, the researcher first needs to define the system, relevant actors, and possible relationships before collecting data. Then participants are surveyed and asked about the actors with whom they interact and their relationships. When the researcher has little prior knowledge about the network under investigation, there is a risk to exclude relevant factors, which affects the validity and trustworthiness of the study. This is particularly true when then analysis only uses quantitative data and the researcher and the actors assign different and subjective values to certain phenomena or relationships. Wald (2014) suggested that researchers should always explain the relation content to the participants and only use "confirmed" network data to increase validity. For example, participants may have different ideas about what constitutes friendship or an important flow of information, so they need clarification from the researcher.

Table 3

Sample of High and Low Node Centrality Scores in the Teacher Network

Participant	Degree	In-degree	Out-degree	Betweenness	Closeness	Eigenvalue
Instructor 1	133	66	67	16946.00	1.0×10^{-3}	1.00
Instructor 2	55	26	29	5443.50	9.6×10^{-4}	0.33
Teacher 1	37	15	22	3244.55	9.2×10^{-4}	0.30
Instructor 3	26	11	15	3267.29	8.5×10^{-4}	0.04
Instructor 4	24	12	12	2775.00	7.9×10^{-4}	0.03
Teacher 2	24	12	12	1522.23	8.6×10^{-4}	0.07
Teacher 3	22	11	11	1168.00	8.4×10^{-4}	0.06
Teacher 4	21	10	11	1362.87	8.7×10^{-4}	0.07
Teacher 5	18	9	9	2268.89	9.1×10^{-4}	0.25
Teacher 6	16	9	7	1137.79	8.9×10^{-4}	0.35
Teacher 7	15	8	7	2034.84	9.3×10^{-4}	0.24
Teacher 8	15	8	7	634.39	9.1×10^{-4}	0.35
Teacher 9	14	7	7	1715.03	9.0×10^{-4}	0.13
Teacher 10	14	7	7	1183.52	8.1×10^{-4}	0.06
Teacher 157	1	0	1	0	7.8×10^{-4}	0.02
Teacher 158	2	1	1	0	3.7×10^{-5}	0
Teacher 159	2	1	1	0	3.7×10^{-5}	0
Teacher 160	2	1	1	0	6.7×10^{-4}	0
Teacher 161	2	1	1	0	6.7×10^{-4}	0
Teacher 162	2	1	1	0	6.8×10^{-4}	0
Teacher 163	2	1	1	0	6.9×10^{-4}	0
Teacher 164	2	1	1	0	7.0×10^{-4}	0
Teacher 165	2	1	1	0	7.0×10^{-4}	0
Teacher 166	2	1	1	0	7.0×10^{-4}	0

In this study, a whole network analysis was conducted using data from teachers' interactions on the online platform through blogs, posts, and discussion boards. The system and actors were defined by the virtual community and the teachers' request for membership. The relationships examined included help giving and help seeking, sharing of lesson plans and resources, and social sharing. The study uses multiple sources of information:

a) **Teacher characteristics (network nodes)**: Data on teacher gender, their workplace, and the grade levels and content areas they teach were collected as part of the platform sign-up process. This information served to understand whether actors in the network clustered based on any of these criteria.

b) **Online interactions**: The online platform had three main sections where members can interact: IC blog, Teachers' Corner, and Lesson Plans. In the "IC blog", instructors and coaches shared advice or posed a question for teachers to reply and discuss. In "Teachers' Corner", members could introduce themselves, share ideas and resources, ask for help, share their stories and concerns, ask a question about the IC or about the website, etc. Under "Lesson Plans", teachers could share their lessons, give each other feedback, suggest ways to adapt a particular lesson to a different context, etc. By December 2017, the "IC blog" had 5 instructor-initiated entries with replies and comments from teachers, 126 discussions under "Teachers' Corner" and 219 posts in "Lesson Plans".

c) **Semi-structured interviews:** Six teachers were identified to participate in the second phase of the study. Semi-structured interviews allowed the researcher to use probes and elicit the most possible amount of data to inform the research questions. Interviews were conducted on a one-on-one basis for about 40 minutes. All

interviews were audio recorded, transcribed, coded, and analyzed. The interviews covered areas such as perceptions on the social network dynamics, value of participation in the CoP, and feedback on the online platform (see Appendix B).

Coding Procedures for Network Data

Online interactions were coded and analyzed using two different strategies. The first coding approach used a STIN lens and included both human and non-human actors. The second coding approach focused only on teacher-to-teacher exchanges and used the structural/semantic coding procedures for SNA suggested by Manca, Delfino, and Mazzoni (2009). In the STIN network, three technological actors were included for the structural analysis: IC blog, Lesson Plans, and Teacher's Corner. These nodes (or actors) served a role as information hubs and helped to understand how teachers engage within and across platform components. This STIN network included 149 isolated nodes and 275 isolated posts. Isolated nodes refer to teachers who have never posted or participated in the online CoP. These members may be observers (or lurkers) who still benefit from their participation in the CoP, or they may be inactive members who are not engaged at all. Isolated posts refer to teacher-initiated discussions that did not get any replies from other members. Other members may have read an isolated post, but they chose not to leave a reply.

The second coding approach used the procedures described by Manca et al. (2009). Manca and his colleagues criticized how network analyses of computer-mediated learning environments typically relied on server log files, assuming that those data reflect how people interacted online. Manca et al. (2009) challenged that assumption by conducting an experimental study comparing the traditional coding method and an approach they suggested using semantic

coding. They concluded that the second approach allowed to detect a greater number of actors, interactions, and flows of communication that would be neglected otherwise.

Manca et al. (2009) argued that computer-mediated communication in educational forums requires a more thorough analysis because messages were rarely addressed to, received by, or responded to by a single person. Instead, messages tended to be directed to a group as a whole and responded to by many people. This technological affordance forces us to consider the intentionality of the sender and the receiver, and evaluate whether the interaction was direct, indirect, interpersonal, impersonal, as well as any other relevant attributes to the online communication. Table 4 summarizes how the structural/semantic coding procedures by Manca et al. (2009) were adapted for the network analysis of the CLASE teacher CoP.

Figure 11 shows a sample discussion thread that will serve to exemplify the differences between the STIN coding approach and the Teacher Network. From a STIN lens, the post by teacher A is directed to Teacher's Corner (A→TC), the reply by teacher B is directed to A (B→A), the reply by teacher C is directed to A (C→A), and the reply by teacher A is directed to C (A→C). The second coding approach focuses only on teacher-to-teacher interactions. From this perspective, the post by teacher A in Figure 11 is directed to both teacher B and C, and not to Teacher's Corner (A→B; A→C). Then, the replies by teachers B and C and directed back to A (B→A; C→A). Finally, the reply by teacher A to C is added (A→C).

Data Analysis

Data analysis methods for complete networks allow for a full range of mathematical analyses, hypothesis testing, and network description techniques (Wald, 2014). However, Wald (2014) warns that purely quantitative research methods may have a limited explanatory power in certain contexts. For this reason, this study adopted a mixed-methods approach to gain deeper

understand of the CoP formation and development. The quantitative network analysis described the CoP in terms of network and node attributes. Since this study is qualitative-oriented, the second phase held priority.

Table 4

Structural/Semantic Coding Procedures for SNA

Situation	**Procedure**		**Outcome**
	First Step	**Second Step**	
Sender "S" posts a message in the CLASE online teacher CoP	(a) If the posting is addressed to the whole group *and*	(a1) Nobody replies to the posting	The posting is ignored
		(a2) Participant "R" replies to the posting	The posting is treated as directed to the replier (S→R); The reply is treated as directed to the sender (R→S)
	(b) If the posting is addressed to a specific participant or a subgroup (either explicitly mentioned or inferable) *and*	(b1) Nobody replies to the posting	The posting is treated as directed to the addressee (S→A)
		(b2) Participant "R" replies to the posting	The posting is treated as directed both to the addressee (S→A) and to the replier (S→R); the reply is treated as addressed to the sender (R→S)
		(b3) The addressee "A" replies to the posting	The posting is treated as directed to the addressee (S→A); the addressee reply is treated as directed to the sender (A→S)

Adapted from Manca et al. (2009, p. 194)

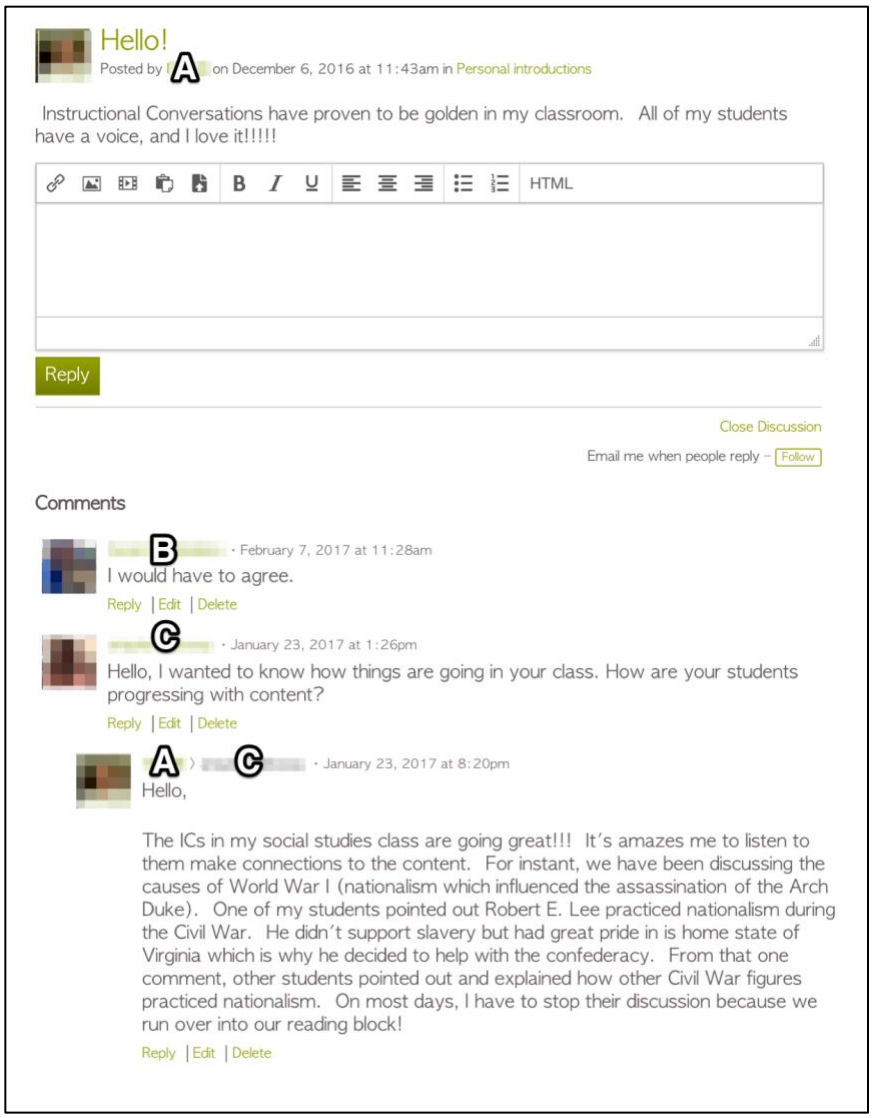

Figure 11. A Sample Discussion Thread Published in Teachers' Corner

In the qualitative phase, data collection and analysis occurred simultaneously. Thematic analysis was conducted to determine patterns and commonalities with-in and across participants (Boyatzis, 1998; Braun & Clarke, 2006). According to Boyatzis (1998), thematic analysis is a means of seeing, finding relationships, analyzing, systematically observing a case, and quantifying qualitative data. As an analytical strategy, thematic analysis serves to organize, manage, and summarize the interview data to focus on interpretation and to better understand the online CoP. The analysis followed an inductive approach in which coding and theme

development emerged from content of the data without any pre-defined categories. The six-step process delineated by Braun and Clarke (2006) was used to conduct the thematic analysis:

1. Familiarization with data: This phase involved transcribing and becoming immersed with the interview data and their content.
2. Generating initial codes: A preliminary set of codes were suggested based on interview and research questions. The dataset was coded using NVivo for Mac version 11.4.3.
3. Searching for themes: All codes and data extracts were examined to identify significant patterns of meaning.
4. Reviewing themes: Each possible theme was evaluated against the dataset which may involve clustering, splitting, combining, or discarding previously identified themes.
5. Defining and naming themes: The final themes were named, described, and analyzed in the context of the entire dataset. Each theme should "tell a story" and have a specific scope and focus.
6. Writing the report: The analytic narrative and data extracts were discussed and contextualized within the broader literature.

Finally, meta-inferences (Teddlie & Tashakkori, 2003) are discussed based on both quantitative and qualitative findings. In this explanatory sequential design (Creswell, 2014), qualitative data help to explain and elaborate on the quantitative results with the purposes of complementarity and triangulation (Greene, 2007). Meta-inferences may provide a deeper understanding of the online teacher CoP as a social network and professional development tool.

Legitimation of Meta-Inferences

Onwuegbuzie and Johnson (2006) discussed the complexity of assessing validity in mixed methods research and suggested using the term "legitimation" as a bilingual nomenclature, rather than using any terms typically associated to either quantitative or qualitative paradigm. Mixed research involves combining complementary strengths and non-overlapping weaknesses of quantitative and qualitative research, which results in a problem of representation, legitimation, and integration (Onwuegbuzie & Johnson, 2006). The problem of *representation* refers to the difficulty in capturing lived experiences using text in general and words and numbers in particular. The problem of *legitimation* refers to the difficulty in obtaining findings and/or making inferences that are credible, trustworthy, dependable, transferable, and confirmable. The problem of *integration* refers to the additive or multiplicative threat to validity when quantitative and qualitative components are brought together. For example, it might be misleading to triangulate, consolidate, or compare quantitative findings and inferences stemming from a large random sample on equal grounds with qualitative data arising from a small purposive sample.

Onwuegbuzie and Johnson (2006) proposed nine types of legitimation specific to MMR since traditional validity and reliability strategies associated with mono-method designs do not address integration and representation problems. Such legitimation types are: sample integration, inside-outside, weakness minimization, sequential, conversion, paradigmatic mixing, commensurability, multiple validities, and political. For this study, sample integration was vital to make sure that the relationship between the quantitative and qualitative sampling designs yielded quality meta-inferences. Weakness minimization was also of paramount importance because the weakness of quantitative results (i.e. depth of understanding of the phenomenon)

was compensated by the strengths from qualitative data. Finally, this study relied on multiple validities of methods to yield high quality meta-inferences.

Since this study used an explanatory sequential design (Creswell, 2014), strategies to safeguard the validity of findings for quantitative and qualitative phases are discussed separately, followed by a discussion on the legitimation of meta-inferences. Teddlie and Tashakkori (2003) used the term "meta-inference" to refer to the conclusions that emerge from the combination of quantitative and qualitative findings into a coherent whole. For the quantitative phase, the data for social network analysis were reviewed by one subject matter expert. The sample was also very heterogeneous, which provides higher individual difference and higher reliability. For the qualitative phase, interviews had follow-up member checks to enhance credibility, that is, the extent to which findings are congruent with reality (Creswell & Miller, 2000; Merriam, 1998). Data interpretations and analysis were shared with participants so that they could have an opportunity to clarify or contribute new or additional perspectives on the issue under study. Finally, an audit trail was used to ensure that results were dependable. Procedures were described in detail regarding how data were collected, how categories were derived, and how conclusions were drawn.

Delimitations

This study sought to understand how teachers interacted with each other to build an online community around the instructional conversation pedagogy. Data sources included online teacher interactions and in-depth interviews. The research questions were concerned with the overall structure of the network and the characteristics of the online CoP, and not with teachers' pedagogical knowledge or practice. For this reason, teachers' understanding and implementation of the IC pedagogy as mediated by the online CoP is outside the scope of this study. The

proposed network analysis can only provide information about teachers' online engagement, patterns of participation, and types of relationships initiated (e.g. help giving, help seeking, resource sharing, social sharing, etc.). Therefore, this study did not conduct a content analysis of teachers' online discussions, however some of the teachers' postings were used during interviews to help participants recall important ideas. Teachers' opinions and interpretations of the instructional conversation were their own and did not necessarily reflect the views of their trainers or supporters of the pedagogical model. An in-depth examination of teachers' online discussions remains of interest and should be further explored in future studies.

Ethical Considerations

This study abided by all the protocols designated by the Institutional Review Board (IRB) at the University of Georgia. Subjects were informed about the purpose of the study, and any possible risks or discomforts associated with this research. Involvement in this study was voluntary. Teachers were able to choose not to participate or to stop at any time without penalty or loss of benefits to which they were otherwise entitled. All information collected in this study will remain confidential, unless required by law. Pseudonyms were used for all participants. No individually-identifiable information will be shared with others without the participants' written permission. All research data will be kept on a private hard drive for five years that only the principal researcher can access. Identifying information of participants will be removed from any reports that are seen by anyone other than the principal researcher. The results of the research study may be published, but participants' names or any identifying information will not be used.

Researcher Subjectivities and Assumptions

In addition to my role as a researcher, I am also the lead instructional designer, website administrator, and a teacher member of this online CoP. Each role serves a different purpose and

affects the formation and evolution of the online community. It is critical to identify personal biases, beliefs, and assumptions in qualitative research since the researcher is the means through which data collection and analysis are conducted (Merriam, 1998). Next, I discuss my subjectivities and assumptions for each role I play as well as strategies to safeguard trustworthiness.

As a researcher, I assume that teachers have developed a true community through the online platform and not only an online peer-to-peer resource center. A community implies a sense of belonging, mutual support, and meaningful relationships (Kling et al., 2003; Wenger, 1998). Also, a CoP should be self-sustainable and needs to have mechanisms to grow and reproduce (Barab, Kling, & Gray, 2004). Secondly, I believe that the social network analysis is an accurate representation of teachers' online engagement. Human communication is complex and teachers converse with each other inside and outside the online environment. Although the social network analysis and sociograms oversimplify the context and richness of human relationships, such diagrams help to identify key members and ties among them. To address these concerns, I will constantly examine and look for evidence of community and advise readers to interpret the study findings with caution given the limitations of social network analysis.

As the lead instructional designer and website administrator, my role is to support sociability and be responsive to the community needs. Although I am aware that a community needs to emerge organically and cannot be designed, I may still encourage participation and deep thinking by replying to individual posts and acting as a moderator in some cases. To facilitate trust and sense of belonging, we have provided teachers with opportunities to interact face-to-face and get to know each other, on the assumption that these relationships will transfer and

continue to grow online. I believe that this online CoP will increase long-term effects and sustainability of the CLASE professional development initiative.

As a member and participant of the CoP, I bring my experience and expertise as an English teacher for speakers of other languages. In Colombia, I taught English in K-12, higher education, and adult education classrooms for over seven years. I have worked with students from diverse cultural and linguistic backgrounds and I bring my personal biases about what I consider to be good teaching practices. I assume that communicative methods, differentiated instruction, and culturally relevant teaching are the best approaches to meet the needs of English language learners. As a teacher who belongs to the CLASE CoP, I may read other teachers' ideas and offer advice or suggestions to other members. This community is a safe space where all comments are welcome, appreciated, and equally relevant.

In terms of my positioning in the social network, I may have a high degree of centrality since I have initiated a few discussions and blogs on behalf of CLASE to which many teachers have replied. I may also act as a bridge or broker to connect subgroups and reduce structure holes in the network. However, my positioning is not as central or visible as that of CLASE teacher trainers or instructional coaches. They work more closely with teachers and offer ongoing guidance and support. In SNA research, the instructor's data are typically left out given their weight and importance. For more information about how the online posts were coded, please see the earlier section on coding procedures for network data.

To document my levels of engagement in the CLASE CoP as well as any significant events and decisions as this study unfolds, I kept a researcher's journal (see Appendix D). This journal may offer insights about how my different roles overlap and help explain any possible outcomes or discrepancies. Each entry is dated and labeled whether I am mainly acting on my

capacity as a researcher, instructional designer, or participant. Additionally, I used member checks and an audit trail for my qualitative analysis to guarantee dependable results and make sure participants' voices are well represented.

Summary

The purpose of this study was to describe the formation, development, and evolution of an online teacher CoP as a sociotechnical network to support teacher's implementation of the IC pedagogy. Participants of this study were 382 educators who participated in the CLASE CoP between June 2016 and December 2017 (http://instructionalconversation.ning.com/). The CoP was comprised of 265 elementary school teachers, 56 middle school teachers, 10 high school teachers, 28 school administrators, and 23 CLASE staff members and other guests. Participants represented about 100 schools in 24 districts in Georgia. The gender distribution was 352 females (92.1%) and 30 males (7.9%). Members of the CLASE platform taught a variety of content areas including art, English language arts, English for speakers of other languages, math, physical education, science, social studies, Spanish, and special education.

This study followed an explanatory sequential design (Creswell, 2014). In the first phase, a Social Network Analysis (Kolaczyk & Csárdi, 2014; Scott, 2013; Wasserman & Faust, 1994) was conducted based on online teacher interactions. Structural attributes of the social network, node centrality measures, and evidence for homophily were explored. Based on the structural analysis, six members of interest were identified for in-depth interviews, specifically two core contributors, two brokers, and two peripheral observers. In the second phase, teacher interviews were conducted and examined using thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006). The purpose of the qualitative phase was to deepen and elucidate the results obtained by the

quantitative network analysis. Finally, meta-inferences were discussed based on both quantitative and qualitative findings (Teddlie & Tashakkori, 2003).

CHAPTER 4

FINDINGS

This chapter is divided into three sections. Each section addresses one of the three research questions. The first question is quantitative in nature and focuses on the network and structural analysis of the online CoP. The second question is qualitatively oriented using data from the interviews with teachers to understand the network dynamics and the value of their participation. The third question seeks to explore meta-inferences based on both quantitative and qualitative findings in this explanatory sequential design.

RQ1. How is the Online CoP Structured as a Sociotechnical Network?

Networks are represented by a graph with nodes (a.k.a. actors or vertices) and lines (a.k.a. edges, connections, or relationships) (Carrington, 2014). Two networks were created and analyzed using R statistical software, particularly the *igraph*, *sna*, and *networkD3* packages (see code in Appendix C). The first network, called Sociotechnical Interaction Network (STIN), is composed of 385 nodes and 630 connections. Three technological actors (IC blog, Lesson Plans, and Teacher's Corner) serve as information hubs and interact with human actors. The STIN Network also includes 149 isolated nodes and 275 isolated postings, that is, teachers who have never participated and postings that did not get any replies or comments from other members. As a consequence, the STIN network is more dispersed and not as dense as the second network, called Teacher Network.

The second network, or Teacher Network, ignores isolated nodes and postings and focuses only on teacher-to-teacher interactions. This network is composed of 166 nodes and 518

connections. Both networks report the same data and online interactions, but the coding procedures are significantly different (see details in Chapter 3). The networks were analyzed to understand how members engage with each other and with specific components of the online platform.

The types of interactions between network members were classified into 6 categories: 1) resource sharing, 2) help giving, 3) help seeking, 4) social sharing, 5) thanking or replying, and 6) posing a question or task. See Table 5 for examples of each relationship type and their frequency in each network.

To answer the research question regarding the structural network of the online CoP, network and node characteristics are explored. First, network attributes such as density, diameter, dyads, transitivity, reciprocity, cliques, components, and cut vertices will be described. Then, node centrality (i.e. degree, closeness, betweenness, eigenvector), and node assortativity will be discussed to better understand how the CoP members interact with each other.

Descriptive Analysis of Network Attributes

Graphs for both the STIN and Teacher networks (Figures 12 and 13) were created using the "igraph" package for R statistical software developed by Csárdi and Nepusz (2006). Node color represents role in the CoP: Teachers are blue, instructors are red, and platform components are yellow. The platform actors (i.e. IC blog, Lesson Plans, and Teachers' Corner) are only present in the STIN network and serve as information hubs where teachers post and interact with each other. The shape of the nodes indicate gender: females are circles, and males are squares. Finally, arrows represent the connections among members. The direction of the arrows indicates the direction of the communication and the thickness of the arrows represents frequency. That is, thicker lines connecting two nodes mean that the interactions are more frequent.

Table 5

Distribution of Edges by Relationship Type in the STIN and Teacher Networks

Type of Relationship	Examples	STIN Network	Teacher Network
Resource sharing	Sharing of lesson plans, websites, and educational materials, etc.	226 = 35.95%	40 = 7.7%
Help giving	Offering advice on how to set norms in the classroom, behavior management, sharing ideas and resources on how to integrate technology, etc.	22 = 3.5%	30 = 5.8%
Help seeking	Question about how to get started, how to group students, how to keep students on task, how to encourage students to talk, how to navigate through the teacher platform, where to find lesson plan templates, rubrics, checklists, etc.	9 = 1.4%	11 = 2.1%
Social sharing	Personal introductions, greeting, welcoming, reconnecting with old colleagues, expressing personal and professional goals to join the platform, replying, etc.	142 = 22.5%	170 = 32.8%
Thanking or replying	Thanking, responding to a question or comment, agreeing, building on a previous answer, etc.	168 = 26.7%	168 = 32.4%
Posing a question or task	A question or assignment posted by the instructors or coaches	63 = 10%	99 = 19.1%
TOTAL EDGES		630 = 100%	518 = 100%

The STIN network is composed of 346 female teachers, 29 male teachers, six female instructors, one male instructor, and three platform components. In total, 149 people are isolated nodes because they have never participated in the online CoP. The technology actors get most of the information flow and connections between nodes tend to be one-directional. On the other hand, the Teacher platform is composed of 145 female teachers, 15 male teachers, 5 female

instructors, and 1 male instructor. This second network is more cohesive and relationships between nodes tend to be bidirectional. As expected, instructors are core contributors and bridges between subgroups.

There are several ways to assess network cohesion or the extent to which vertices are connected in a graph. Social networks are not homogenous but typically grouped into subsets of strongly connected nodes. Cohesion can be evaluated at the local level (e.g. dyads) or at the global level (e.g. density, components). Also, subsets or groups can be explicitly specified (e.g. cliques) or implicitly inferred (e.g. clusters). This section discusses different measures of network cohesion to better understand the CLASE online teacher CoP (see Table 6).

Density. This measure of relative frequency helps describe the level of linkage among the nodes in a graph. A graph in which all nodes (a.k.a. vertices) are adjacent or connected to one another would have a density value of 1, which is very unusual (Scott, 2013). The density of a graph is the frequency of realized edges relative to potential edges. The density of a graph *G* with no self-loops and no multiple edges is defined as (Kolaczyk & Csárdi, 2014, p. 55):

$$den(G) = \frac{E_G}{V_G(V_G - 1)}$$

Where E_G is the number of edges present and V_G is the number of vertices in graph G. The density denominator is the maximum number of edges possible which is equal to the total number of pairs that *G* contains. Density is 0.4% for the STIN Network, and 1.9% for the Teacher Network. Note that isolated nodes in the STIN network do not affect density since these nodes have no edges or connections.

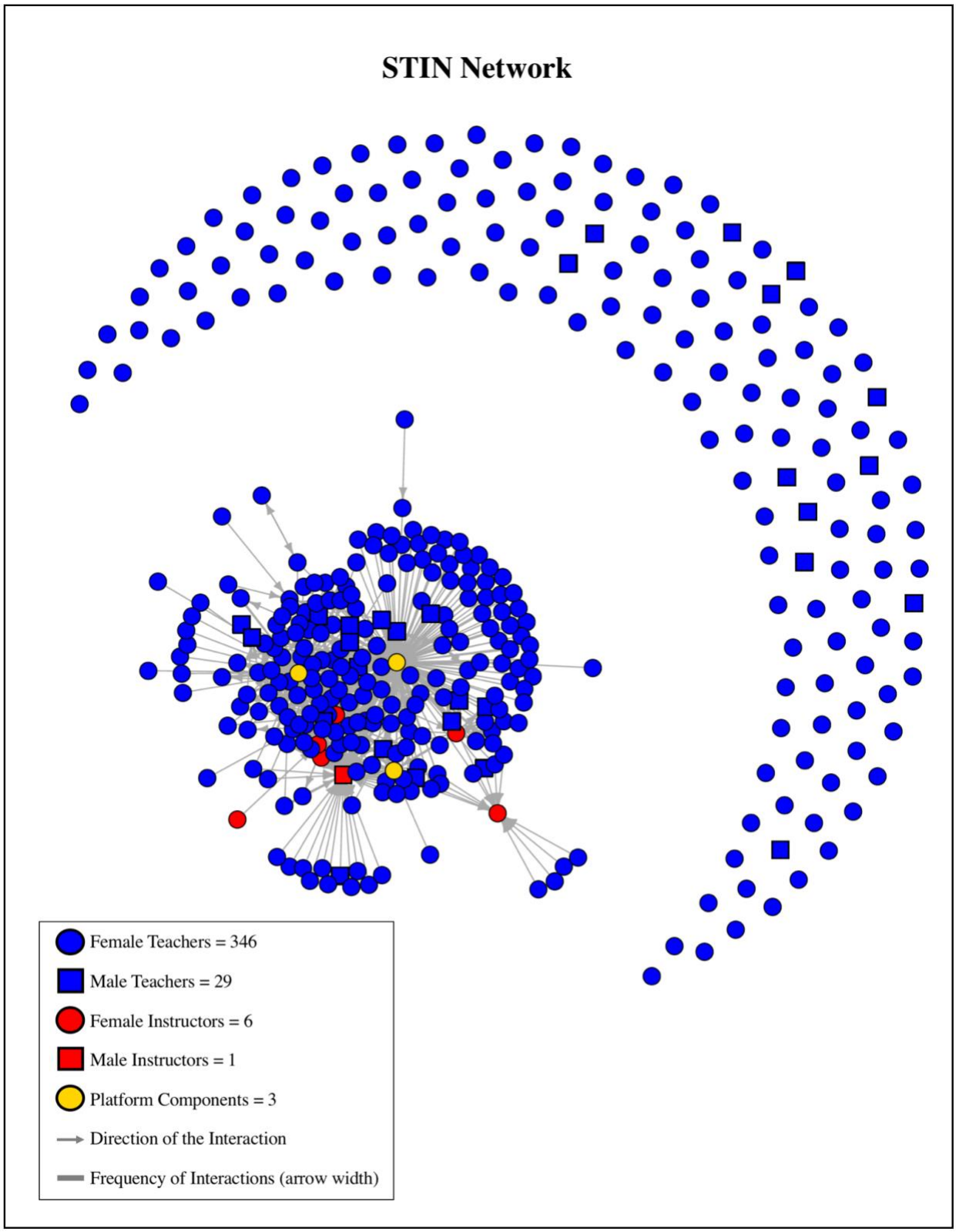

Figure 12. STIN Network

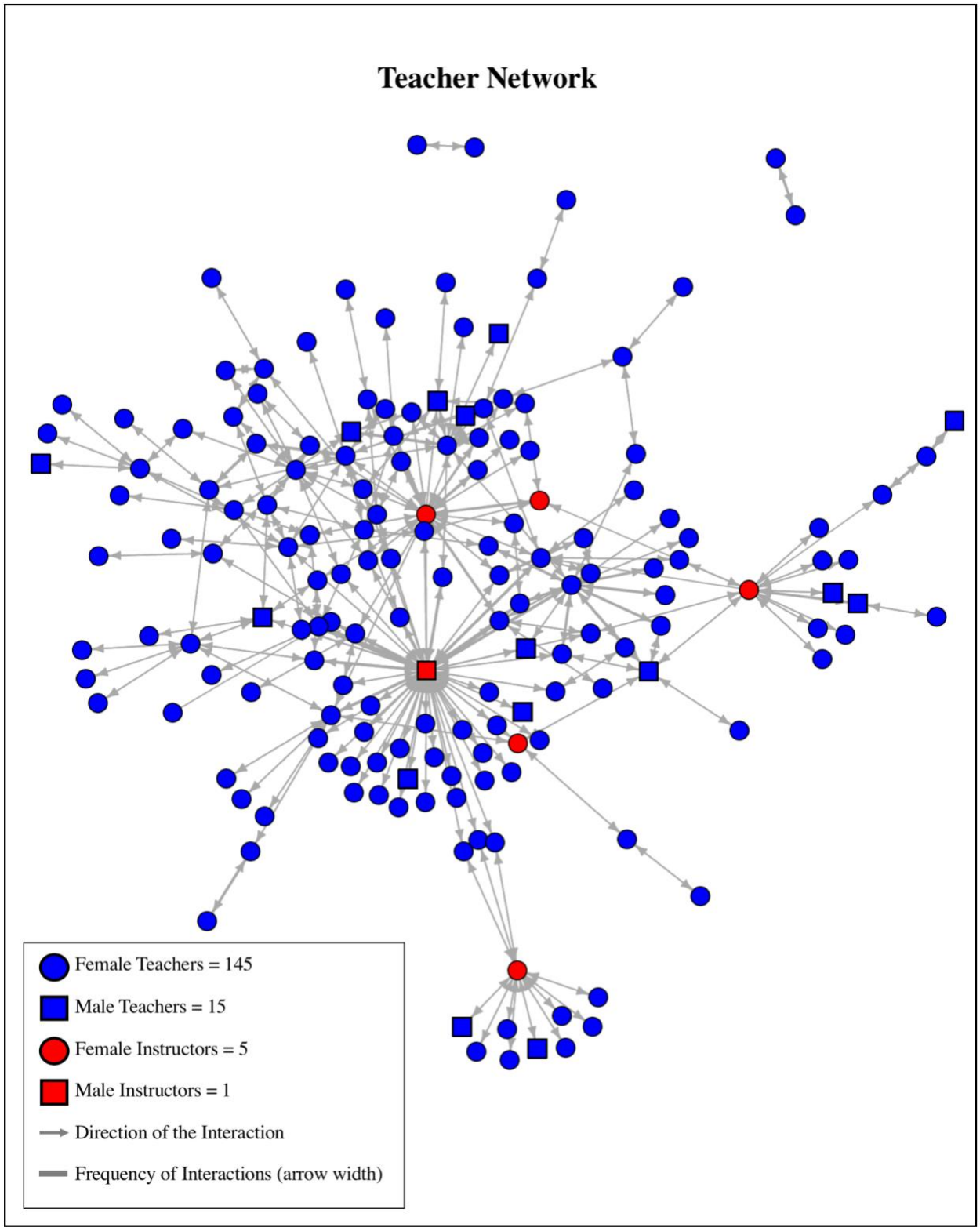

Figure 13. Teacher Network

Table 6

Summary of Network Characteristics

	STIN Network	**Teacher Network**
Description	Includes three technological actors (IC blog, Lesson Plans, and Teacher's Corner)	Focuses only on teacher-to-teacher exchanges
Directed	Yes	Yes
Nodes	385	166
Edges	630	518
Isolates Nodes	149	0
Isolated Posts	275	0
Density	0.4%	1.9%
Diameter	11	9
Average Path Length	3.88	3.56
Mutual Dyads	19	248
Asymmetrical Dyads	592	22
Transitivity	3.1%	2.9%
Reciprocity	6%	95.7%
Maximal Cliques	16 cliques of size 4	25 cliques of size 3
Components	150	3
Cut Vertices	14	33

Diameter. The diameter of a graph is defined as the greatest distance between any pair of nodes (Scott, 2013). In the STIN Network, the diameter is 11 and the average path length between vertices is 3.88. The average path length is the mean of the shortest distance between each pair of nodes in the network. The "small world" theory holds that the shortest path distance between pairs of vertices in a real-world network is quite small, even when the clustering is relatively high. In the Teacher Network, the diameter is 9 and the average path length is 3.56.

Dyads. Dyads are pairs of vertices and can take three possible states in directed graphs: null (no directed edges), asymmetric (one directed edge), or mutual (two directed edges) (Kolaczyk & Csárdi, 2014). A dyad census or a count of how many times each state is observed provides insights into the connectivity of a graph. In the STIN network, 19 dyads are mutual, 592 dyads are asymmetric, and 73.309 dyads are null. In the Teacher network, 248 dyads are mutual, 22 dyads are asymmetric, and 13.425 dyads are null. The vast majority of dyads in both networks are null given the low network density. However, we can see a major difference in terms of mutual and asymmetric dyads between both networks, which is a result of the coding procedures. Because in the STIN network teachers direct their posts to one of the three online platform actors, there are significantly more one-sided edges than bidirectional ones.

Transitivity. Transitivity, also known as the clustering coefficient, measures the probability that the adjacent vertices of a vertex are connected. The study of transitivity is based on triads (subgraphs formed by 3 nodes) and serves to explore whether members in a network are isolated, or if there is any tendency to form couples, structural holes, or clusters. Structural holes occur when one actor is connected to two others, but those two are not connected to each other. Some social researchers argue that the most fundamental types of social relationships can be observed in triads (Scott, 2013). For example, perfect transitivity implies that if a node *X* is connected (through an edge) to node *Y*, and *Y* is connected to *Z*, then *X* is connected to *Z* as well. Although perfect transitivity is very rare in real social networks, it is safe to assume that X and Z are more likely to be connected to each other than by chance. Transitivity is defined as the ratio between the number of transitive triads divided by the number of potentially transitive triads. The transitivity of graph *G* is (Kolaczyk & Csárdi, 2014, p. 56):

$$tran(G) = \frac{3t_{\Delta}(G)}{t_3(G)}$$

Where $t_\Delta(G)$ is the number of triangles in the graph *G*, and $t_3(G)$, the number of connected triples (i.e., a subgraph of three vertices connected by two edges). Transitivity is a measure of global clustering and it summarizes the relative frequency with which connected triples close to form triangles. The transitivity index is 3.1% for the STIN Network and 2.9% for the Teacher Network. Values between 3% and 6% are quite usual for social networks (Scott, 2013).

Reciprocity. This measure describes the extent to which there is reciprocation among ties in a directed network. For example, nodes *X* and *Y* are reciprocated when *X* is connected to *Y*, and *Y* is connected to *X*. Reciprocity is defined as the number of dyads with mutual, directed edges divided by the number of dyads with a single, unreciprocated edge (Kolaczyk & Csárdi, 2014). Reciprocity is only 6% for the STIN Network, but 95.7% for the Teacher Network. The reason for such significant difference is explained by the coding procedures of the network data. In the STIN network, teachers' postings were directed to either the IC Blog, Teachers' Corner, or Lesson Plans, which resulted in unreciprocated edges since the platform components did not have agency to reply back. In the Teacher Network, postings were not directed to the platform but to the teachers who replied to the original posting. For this reason, almost all postings were mutually directed or reciprocated.

Cliques. Identifying subgraphs may help to better understand the overall network cohesion, and more specifically how certain nodes interact with each other. A *clique* is a complete subgroup in which all vertices are fully cohesive and connected by edges (Kolaczyk & Csárdi, 2014). A census of cliques of all sizes may reveal how structured a graph is. In the STIN Network, there are 385 cliques of size 1, 520 cliques of size 2, 250 cliques of size 3, and 16 cliques of size 4. This means that the largest cliques in the network are 16 subgroups of 4 teachers who are completely interconnected. Note that the clique consensus is redundant since

the cliques of larger sizes necessarily include cliques of smaller sizes. A maximal clique is a clique that is not a subset of a larger clique. In the Teacher Network, there are 166 cliques of size 1, 237 cliques of size 2, and 25 cliques of size 3. A further exploration of cliques may be of interest to identify why and how all teachers in a given clique know each other.

Components. A graph is connected if every vertex is reachable from every other, in other words, if there is a path between any two given vertices. If a graph is not connected, it is possible to decompose it into subgroups of connected nodes, called *components*. A component is a maximally connected subgraph (Kolaczyk & Csárdi, 2014). Typically, there is one *giant component* that contains the vast majority of vertices in a graph. Sometimes researchers focus their attention on the giant component to conduct further analyses and statistical modeling. In the Teacher Network, there are 3 components: A giant component of 162 nodes, and two components of 2 nodes each. The smaller components correspond to the peripheral observers who are not connected to the giant component. The STIN network, on the other hand, has one giant components of 236 nodes and 149 other components of a single node. The one-node components correspond to the isolated nodes in the graph.

Cut Vertices. A single vertex that disconnects a graph is called a *cut vertex* or *articulation point*. Removing a cut vertex from a graph creates additional components. Identifying such vertices is necessary to evaluate where a network is vulnerable or identify which actors serve as brokers or bridges between subgroups. The STIN network has 14 cut vertices and the Teacher Network has 33 cut vertices. These network articulation points will help identify key participants to be interviewed in the second phase of this mixed methods study.

Descriptive Analysis of Node Centrality

Measuring the centrality of individuals in a social network can be done at the local level (i.e. node degree) or at the global level (i.e. closeness, eigenvector, betweenness) (Scott, 2013). A node is locally central if it has a large number of connections with other nodes in its vicinity. A node is globally central if it has a strategic position in the overall structure of the network, for example, as in a gatekeeper. An analysis of node centrality helps identify core members, brokers, peripheral observers, and other members of interest in the network.

Node degrees. Two vertices are adjacent if they are connected. The group of nodes to which a given vertex is adjacent is termed its *neighborhood* (Scott, 2013). The degree of a node represents the size of its neighborhood, or the degree of connection to its immediate environment. The degree d_v of a vertex *v*, in a network graph $G = (V, E)$, where V stands for vertices and E for edges, equals the number of edges in E incident upon *v* (Kolaczyk & Csárdi, 2014, p. 44). Degree is considered to be a local measure of centrality because it ignores any indirect connections that a vertex may have. In the case of directed networks, node degrees can be decomposed into in-degrees and out-degrees. The former refers to incoming edges or connections and the latter refers to outgoing edges. Comparisons of node degrees among members of the same network are helpful to show how well -connected nodes are with their local environment, however, node degrees fail to summarize local centrality relative to the size of the network. For example, a vertex with a degree of 25 in a graph of 100 nodes is not as central as one with degree 25 in a graph of 30 nodes.

In the STIN Network, in-degrees ranged from 0 to 227 with a mean of 1.6, and out-degrees ranged from 0 to 17 with a mean of 1.6. In the Teacher Network, in-degrees ranged from 0 to 66 with a mean of 3.1, and out-degrees ranged from 1 to 67 with a mean of 3.1. Figures 14

and 15 show the STIN and Teacher Network as a function of node degree. In the Figures, node sizes are proportional to their total degree (i.e. sum of in- and out-degrees). Because the degrees of the instructors and platform components are so large that they would cover the whole graph, their total degrees were reduced to one sixth of the actual size for visualization purposes.

Closeness. This measure defines global centrality in terms of distance between nodes. A vertex is central if it lies at short distances from many other vertices (Scott, 2013). Distance is the length of a path that connects two given vertices. The shortest path between two vertices is called *geodesic* distance. Closeness of a node refers to the sum of the geodesic distances to all other nodes in the graph. A node with a low of sum distance is "close" to a large number of other nodes, and therefore, more globally central. The standard approach to calculate closeness was introduced by Sabidussi and defines closeness as (Kolaczyk & Csárdi, 2014, p. 47):

$$C_{Cl}\,(v) = \frac{1}{\Sigma_{u \epsilon V} dist(v,u)}$$

"Where $dist(v,u)$ is the geodesic distance between the vertices $u, v \,\epsilon\, V$" (Kolaczyk & Csárdi, 2014, p. 47). This measure is usually normalized to lie in the interval [0, 1] through multiplication by a factor $N_v - 1$ to allow for comparisons across graphs. Closeness centrality was close to 0 for all the nodes in both the STIN and Teacher Networks. In the STIN Network, closeness ranged from 6.76×10^{-6} to 1.73×10^{-5}. In the Teacher Network, closeness ranged from 3.67×10^{-5} to 1.01×10^{-3}. These results suggest that none of the nodes are significantly more globally central than others as defined by their closeness.

Betweenness. This measure uses the concept of local dependency to define global centrality. For example, node A is dependent on node B if the paths that connect A to other nodes pass through B. In this case, node B acts as a bridge to close the structural hole, which

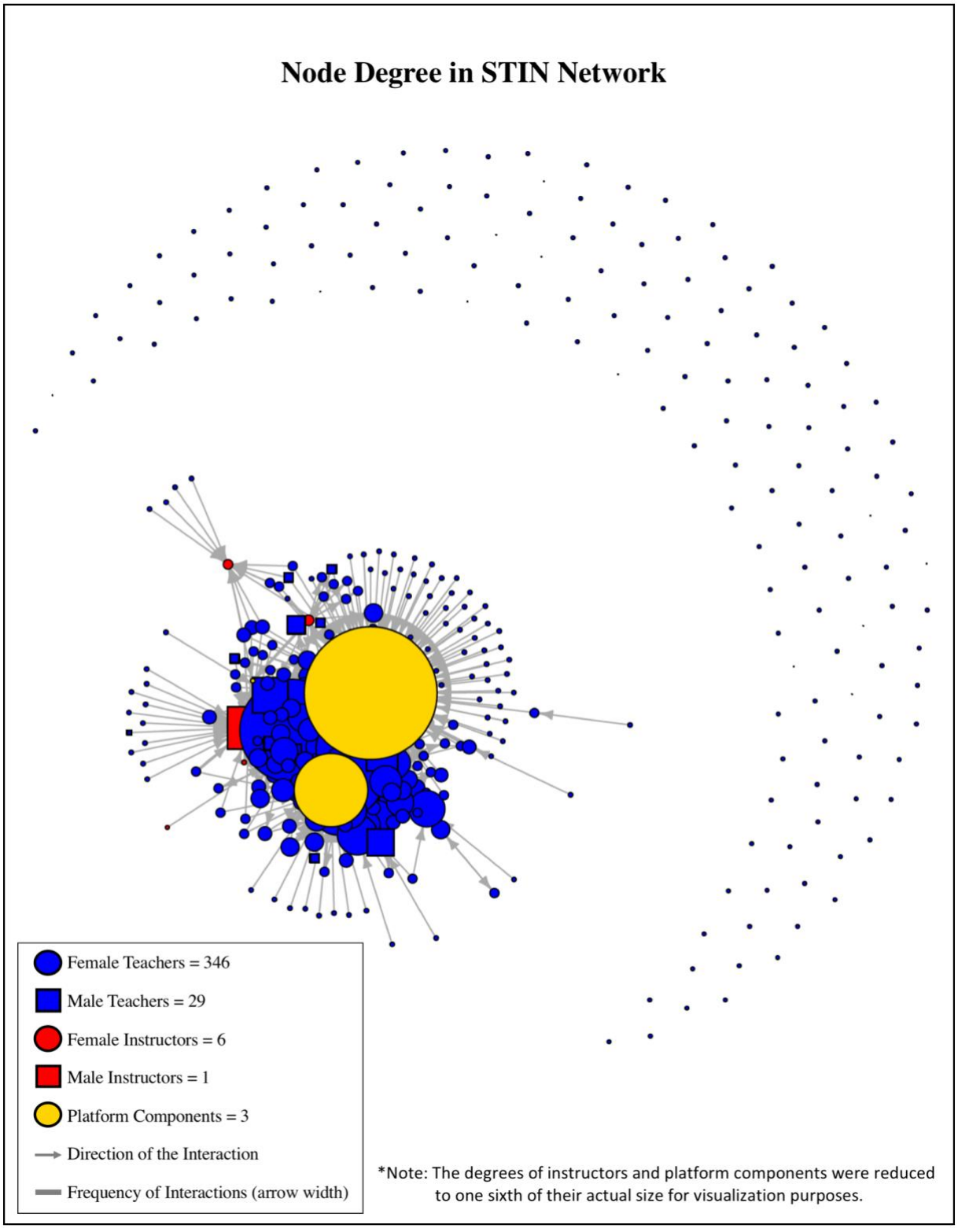

Figure 14. Node Degree in STIN Network

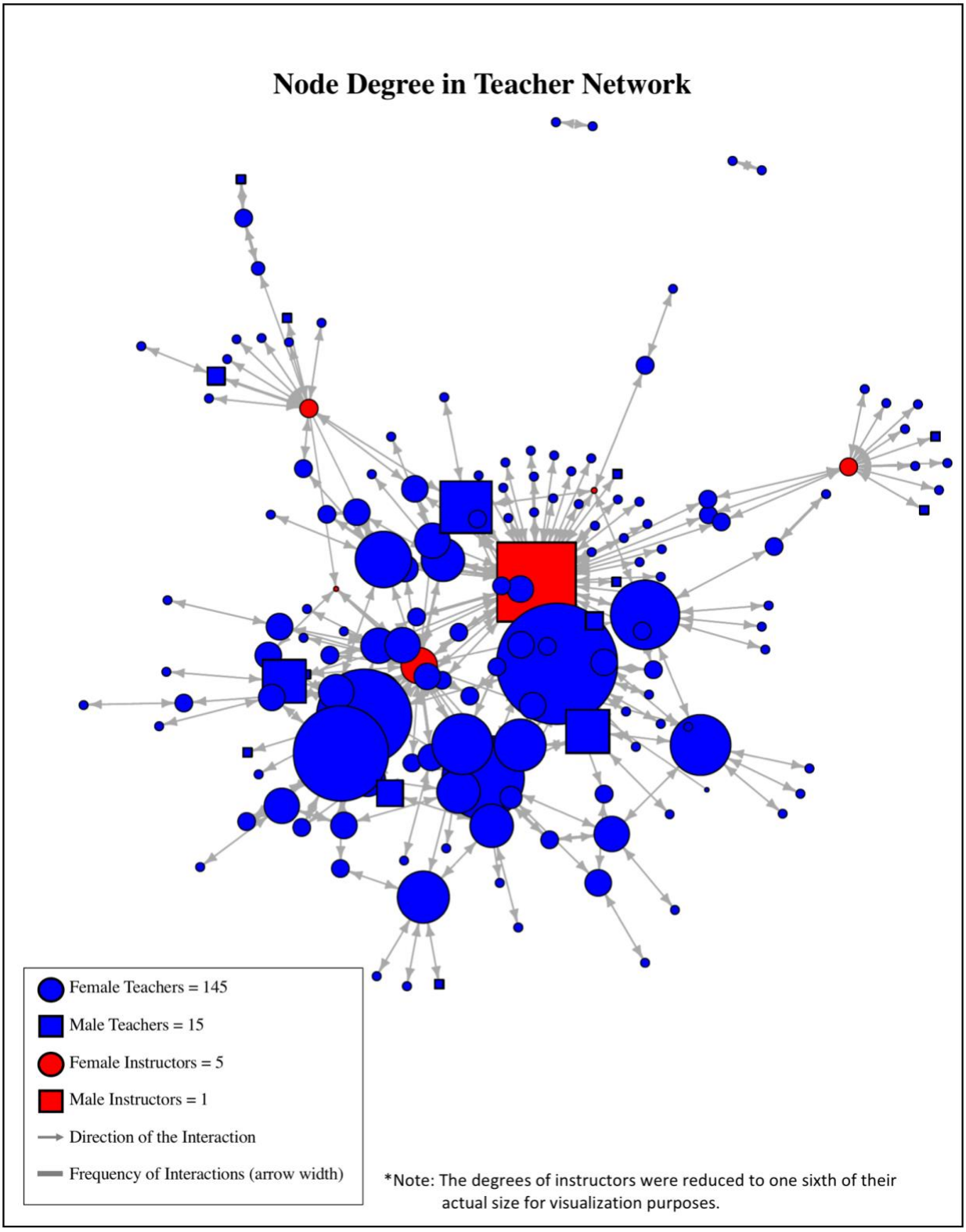

Figure 15. Node Degree in Teacher Network

exists whenever two nodes are connected at distance "two" but are otherwise separated by a long path (Scott, 2013).

The betweenness proportion of a node Y for a particular pair or nodes X and Z is defined as the proportion of geodesics connecting that pair that passes through Y (Scott, 2013). The pair dependency of X on Y is the sum of the betweenness proportions of Y for all pairs that involve X. Then, a local dependency matrix is created showing the dependence of each row element of each column element. The overall betweenness of a node is calculated as half the sum of the values in the columns of the dependency matrix (Scott, 2013).

The most commonly used betweenness centrality measure was introduced by Freeman and is defined as (Kolaczyk & Csárdi, 2014, p. 48):

$$c_B(v) = \sum_{s \neq t \neq v \epsilon V} \frac{\sigma(s,t|v)}{\sigma\ (s,t)}$$

"Where $\sigma(s,t|v)$ is the total number of shortest paths between *s* and *t* that pass through *v*, and $\sigma(s,t)$ is the total number of shortest paths between *s* and *t* (regardless of whether or not they pass through *v*)" (Kolaczyk & Csárdi, 2014, p. 48). Betweenness centrality for the STIN Network ranged from 0 and 3585.54 with a mean of 42.35. Betweenness centrality for the Teacher Network ranged between 0 and 16945.99 with a mean of 393.63. The extent to which a particular vertex lies between other vertices may reveal actors with potential control over others such as brokers or gatekeepers to be interviewed for the second phase of this study.

Eigenvector centrality. This measure uses eigenvector solutions of appropriately defined linear systems of equations to express status, prestige, or rank (Kolaczyk & Csárdi, 2014). The centrality of an actor is proportional to the sum of centralities of those actors around him/her. The assumption is that the more central the neighbors of a node are, the more central that node

itself is. There are many eigenvector centrality measures, but one of the most commonly used ones was introduced by Bonacich and is defined as (Kolaczyk & Csárdi, 2014, p. 48):

$$c_{Ei}(v) = \alpha \sum_{\{u,v\}\epsilon E} c_{Ei}(u)$$

"The vector $c_{Ei} = (c_{Ei}(1), \dots, c_{Ei}(N_v))^T$ is the solution to the eigenvalue problem $Ac_{Ei} = \sigma^{-1}c_{Ei}$, where A is the adjacency matrix for the network graph *G*. Bonacich argues that an optimal choice of $\alpha^{-1}$is the largest eigenvalue of A, and hence c_{Ei} is the corresponding eigenvector" (Kolaczyk & Csárdi, 2014, p. 48). Eigenvector centralities are reported using absolute values and lie in the interval [0, 1] by the orthonormality of eigenvectors.

The eigenvector centrality for the STIN Network ranged from 9.62×10^{-4} and 1 with a mean of 0.04. The eigenvenctor centrality for the Teacher Network ranged between 0 and 1 with a mean of 0.06. Because nodes with higher eigenvector centralities are those connected to other nodes which are, in turn, connected to many others; actors in large cliques or high-density substructures will have the highest eigenvector centralities.

Figures 16 and 17 illustrate target plots showing centrality measures for both the STIN and Teacher Networks. The plots use a radial layout and display more central nodes closer to the center. The four measures (i.e. degree, closeness, betweenness, and eigenvalue) define importance or centrality based on different approaches and provide multiple perspectives. In the STIN network, for example, "Lesson Plans" are the most central vertex based on its degree and eigenvalue, however this node is not identified as central based on its betweenness and closeness. Taken all together, node centrality measures serve to identify key actors to be invited for qualitative interviews in the second phase of this mixed methods study.

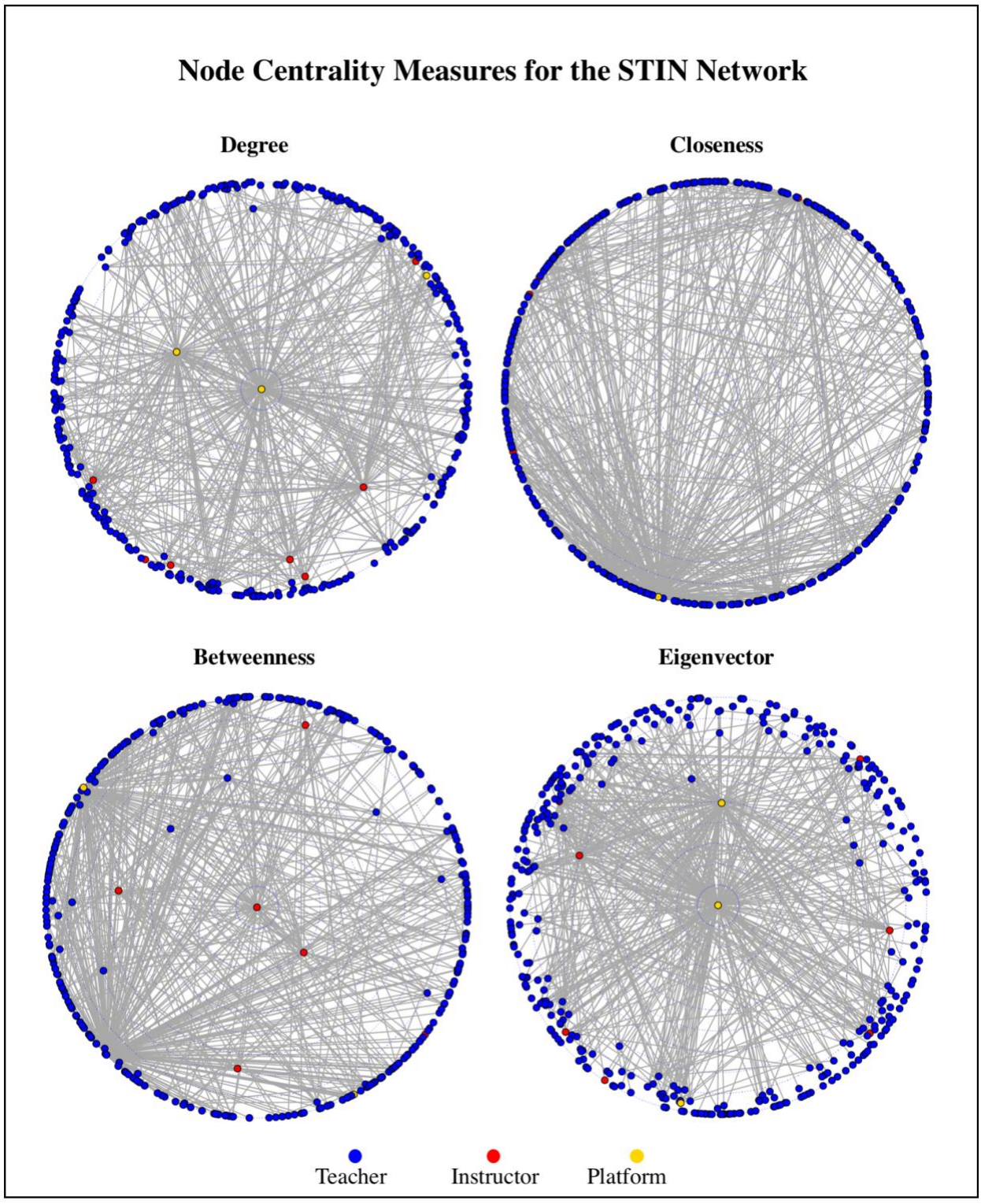

Figure 16. Node Centrality Measures for the STIN Network

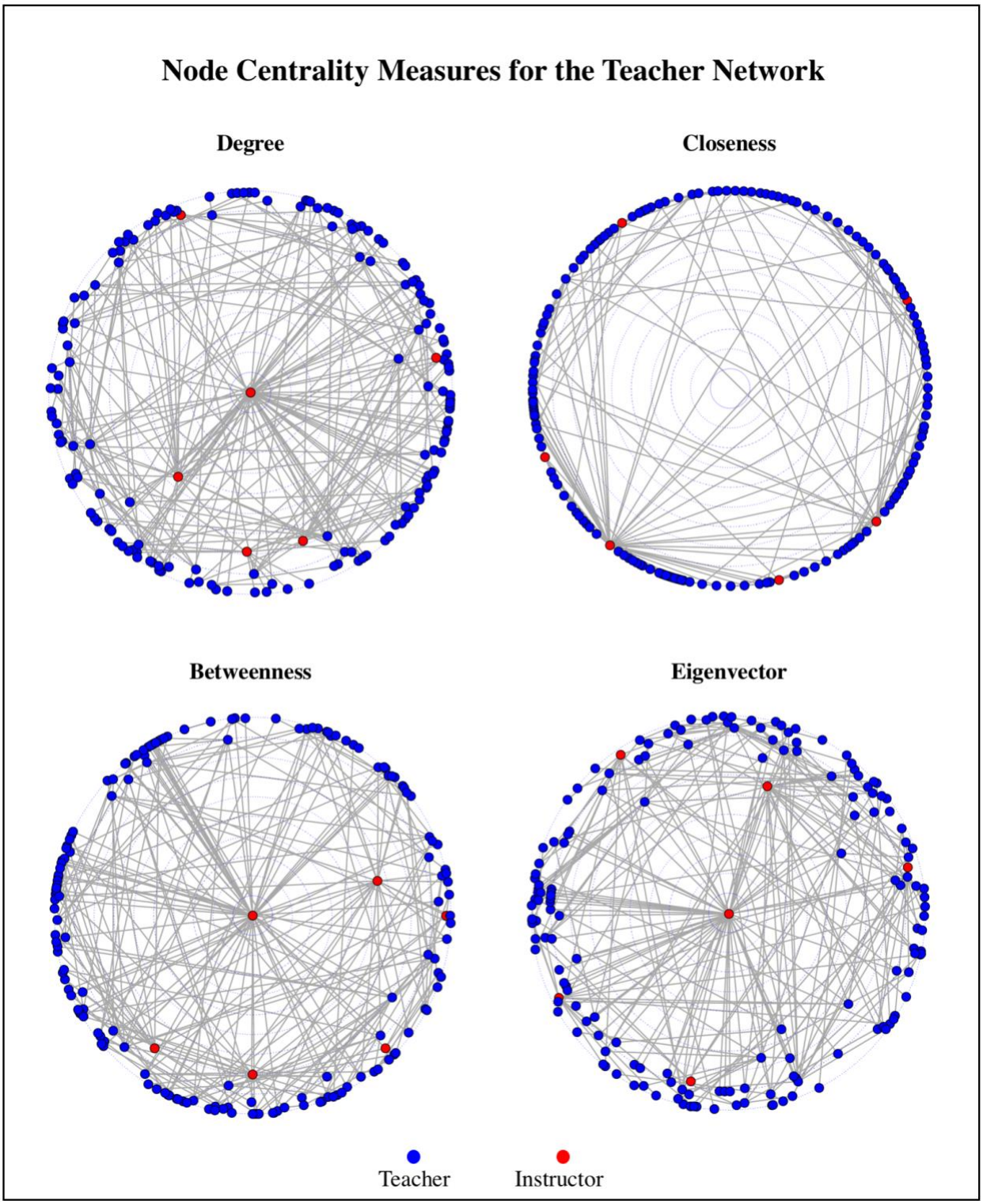

Figure 17. Node Centrality Measures for the Teacher Network

Assortativity and Mixing

Assortative mixing, or *homophily*, refers to the strong tendency of selective linking among nodes in a social network, that is, when vertices tend to associate with others that share similar characteristics (Newman, 2003). For example, actors in a network may choose to group based on their gender, age, race, nationality, or personal interests. A social network may also exhibit disassortative mixing (although not as common) when nodes tend to link with others that are dissimilar (Newman, 2003). For example, in a dating network, most connections will tend to occur between people of opposite genders.

Assortativity can be calculated for categorical, ordinal, or continuous variables using correlation coefficients (Kolaczyk & Csárdi, 2014). The assortativity coefficient ranges from -1 to 1. The value is 0 when the mixing in the network is no different from that obtained by chance. The coefficient is 1 when nodes only connect to others of the same category, or -1 when the opposite is true. The assortativity coefficient for a categorical variable is defined as (Kolaczyk & Csárdi, 2014, p. 66):

$$r_a = \frac{\Sigma_i f_{ij} - \Sigma_i f_{i+} f_{+i}}{1 - \Sigma_i f_{i+} f_{+i}}$$

"Where f_{ij} is the fraction of edges in graph G that join a vertex in the *i*th category with a vertex in the *j*th category, and f_{i+} and f_{+i} denore the *i*th marginal row and column sums, respectively, of the resulting matrix" (Kolaczyk & Csárdi, 2014, p. 66).

The nodes in both the STIN and Teacher networks were assigned the following categorical attributes:

- Role: 375 teachers, 7 instructors/coaches, and 3 platform components.
- Gender: 352 females (92.1%) and 30 males (7.9%)

- School name: 98 schools (all schools are located in Georgia and only seven are from out of state or international)
- School district: 24 school districts
- Level: 265 elementary school teachers, 56 middle school teachers, 10 high school teachers, 28 school administrators, and 23 CLASE staff members or other guests
- Grade: 185 members reported teaching from kindergarten through ninth grade with the majority of the sample in elementary school grades. The other 200 teachers did not report a specific grade because they teach across grades or serve as instructional coaches, school administrators, etc.
- Subject: Members of the CLASE platform teach a variety of content areas including art, English language arts, English for speakers of other languages, math, physical education, science, social studies, Spanish, and special education.

Assortativity coefficients were calculated for each categorical variable. Results are reported in Table 7. Most coefficients are close to 0, which suggests that the mixing in the network is no different from that obtained through a random assignment of connections preserving the marginal degree distribution. The biggest assortativity coefficient found (-0.24) was for the "role" variable in the Teacher Network suggesting that there is a slight tendency for teachers to interact with non-teachers (i.e. instructors or coaches). The lack of evidence for homophily implies that there is no strong correlation in the connections teachers form solely based on their gender, school, grade, or subject. The qualitative phase of this mixed methods study may provide insights into why and how teachers choose to interact with one another.

Table 7

Assortativity Coefficients for Node Attributes in STIN and Teacher Networks

Variable	STIN Network	Teacher Network
Role	-0.02	-0.24
Gender	-0.07	-0.14
School Name	0.03	0.04
School District	0.03	0.07
Level	0.03	0.07
Grade	0.05	0.09
Subject	0.01	0.03

RQ2. How do Teachers Perceive the Social Network Dynamics and the Value of Their Participation in the Online CoP?

Qualitative interview data were collected, coded, and analyzed to better understand teacher's perceptions of the social network and the online teacher CoP. Based on the structural network analysis, two core contributors, two brokers, and two peripheral observers were purposefully identified to inform the research question. Interviews were individually conducted through the virtual classroom on the teacher platform and lasted 45 minutes on average (see Appendix C for interview protocol). All interviews were transcribed and coded using NVivo for Mac version 11.4.3. Thematic analysis was conducted to determine patterns and commonalities with-in and across participants (Boyatzis, 1998; Braun & Clarke, 2006).

A preliminary set of codes were generated deductively based on the research and interview questions. All codes and data extracts were examined to identify significant patterns of meaning. In the second stage of coding, broader codes (or themes) were generated inductively. Such themes were evaluated against the data and clustered, split, combined, or discarded as

necessary. The final themes were named, described, and analyzed in the context of the entire dataset. Tables 8 and 9 show examples of the deductive and inductive coding approaches used.

The discussion of the qualitative findings is divided into two main sections. First, each qualitative case is introduced (i.e. core contributors, brokers, and peripheral observers), followed by a with-in case analysis. This first section uses the same subheadings for each member type to facilitate comparisons across cases. Each case follows this structure: Description of the participants; evidence for their role within the network; their personal definition of a teacher CoP; motivation to join a CoP; homophily evidence; use and value of the CoP; concerns, challenges, and low engagement; and extended network.

The second section discusses a cross-case analysis. Overall, eight themes were derived and identified from the dataset: 1) The online CoP was characterized by collaboration and mutual support; 2) community members needed to set norms and expectations; 3) the online CoP helped to reduce isolation and provided ongoing support; 4) access to high-quality instructional materials as the main reason to join the online CoP; 5) teachers found personal and professional value by participating in the online CoP; 6) preference to reach out in person to members of the online CoP at the workplace; 7) time as the main constraint to participate in the online CoP; and 8) mixed evidence found regarding homophily in the CoP.

Core Contributors

Two of the most active members in the online CoP were interviewed as indicated by the SNA. “Nicole” (pseudonyms are used to identify all participants) was the lead English for Speakers of Other Languages (ESOL) teacher in her elementary school. According to the node centrality analysis, Nicole engaged in 37 online exchanges (15 in-degree and 22 out-degree). Her betweenness, closeness, and eigenvalue scores were 3244.54, 9.21×10^{-4}, and 0.29

Table 8
Examples of Deductive Coding Procedures

Code	Description	Examples
Broker evidence	The dataset was evaluated for evidence concerning the role of each member within the network (core contributor, broker, peripheral observer). In the case of brokers, instances in which teachers acted as a bridge or connection between subgroups were coded. Brokers also help the community grow by reaching out to new members.	"*I was the first person to be trained on ICs, but I brought it to two teachers who I thought would really enjoy it and really jump in and try it and then those teachers have kind of spread it to their grade level in surrounding areas*" *"We really kind of work to get people in our building interested in learning about ICs. We just did a workshop at our staff development Monday, and we talked about some ways to integrate ICs (...) So, we're trying to spread the word"*
Community evidence	This code highlights instances regarding how teachers perceive the CLASE platform as a community of practice.	"*CLASE seems more like a higher resource than 'Teachers Pay Teachers.' You're just buying something, but the CLASE platform is more like a community where you have the resources as well, but you can ask questions and engage with others. As an educator, it's more of a professional website that you can go to, versus 'Teachers Pay Teachers' is more of a consumer-driven thing."*
Motivation	This code was used for quotes that illustrate the reasons why teachers choose to join an online community of practice.	*"The top reason for me would be ideas and resources. I'm always looking for a new way to reach my kids, a new way to teach something that might help them understand it a little bit better."* *"I think for me, it's having someone to bounce ideas off of. And also, I've been doing this for over twenty years, over ten years in ESOL, and so I really feel like I like to share what I've learned in my time with people who have questions, especially newer teachers."*

Table 9

Examples of Inductive Coding Procedures to Identify Themes

Themes	Subcategories	Examples
Access to high-quality instructional materials as the main reason to join an online CoP	Reasons to join CoP, motivation, engagement with the CoP, and benefits of participation.	*"The top reason for me would be ideas and resources. I'm always looking for a new way to reach my kids, a new way to teach something that might help them understand it a little bit better."* *"I would say to get resources because, sometimes it's just hard to find- there's so much stuff out there, especially in (name of county), we are blessed with an overload of information and materials and resources, so it's nice to have a place where you could go to and get good ideas and stuff that people have tried and used and it's worked for them."*
Preference to reach out in person to members of the online CoP at the workplace	Extended network, community at the workplace, peer-support, and attitude towards online communication.	*"I'm fortunate enough to have someone at my school who's IC trained, so in my mind it's quicker for me to go down the hall and be like 'hey I have this issue, do you have any suggestions?' than it would be for me to try and get on the platform and set up a time to meet with somebody (…)but if I was the only one at my school, then I probably would definitely utilize that option (online CoP) more often."*
Time as the main constraint to participate in the CoP	Challenges, concerns, time constraint, low engagement, and reasons for low participation.	*"I think teachers just get overwhelmed by all the six million things that they have going on in their brain, all the time. It's not that they would necessarily choose one or the other, or ignore one or the other, but teachers are very overwhelmed, we do ask a lot of them, on a daily basis."*

respectively. The second core contributor was "Chandler," who also worked as the lead ESOL teacher in a different elementary school. She engaged in 15 online exchanges (eight in-degree and seven out-degree). Chandler's betweenness, closeness, and eigenvalue scores were 634.39, 9.07×10^{-4}, and 0.35 respectively.

Nicole worked at a school where the majority of teachers were trained in the IC pedagogy. She said that instructional conversations had become "the culture of our school." The school administration, in an effort to support the implementation of the IC pedagogy, appointed Nicole as the school's IC coach in addition to her role as an ESOL teacher. Nicole had 13 years of teaching experience and she had been using instructional conversations for the last five years. As an IC coach, Nicole visited other teachers' classrooms, particularly newly trained teachers, and helped them create lessons and offered feedback. However, most of Nicole's time was spent teaching ESOL and special education segments, so she could only visit teachers a couple of times per week. Nicole became a member of the CLASE online teacher CoP two years ago and she described her engagement level as "medium," even though she was one of the most active members. Nicole was not a member of other online teacher communities and she did not think of herself as a "technologically savvy" person.

Nicole was also identified as an IC leader in her school district. She was part of a leadership team composed of four teachers from different schools in the county. She was the "go-to person" in the building in case other peers had any questions regarding the IC pedagogy or if they needed additional support. According to Nicole, the mission of the leadership team was to support teachers who were already implementing ICs. The team also sought to engage new teachers and "spread the word" so that ICs could become a county wide initiative. The leadership

team met both face-to-face and online to discuss lesson plans, task cards, video lessons, and report on what was happening at their schools.

The second core contributor, Chandler, was also part of the leadership team in the school district. Chandler first learned about Instructional Conversations two years ago. She participated in the training and joined the CLASE online CoP at the same time. There were five teachers in her school who were trained in ICs. Chandler met twice a week with one of those teachers, who was recently trained and whose classroom was across the hall from hers. They planned lessons together and tried to incorporate ICs whenever they taught together. Chandler thought that "proximity" made it really easy for both of them to work together, as opposed to other teachers in her building that she did not see very often. Chandler considered her engagement level in the online CoP to be "medium-high" and in general, she felt comfortable using technology. She typically logged on to the online CoP to share resources and participate in any open questions.

Chandler was a member of another teacher community on Twitter. This was a weekly educational chat on Twitter where teachers agreed on a given time and day to answer a question posed by one of the leaders. Educators from all over the world and from across levels interacted with each other by using hashtags. Chandler learned about this EdChat through a podcast and she decided to join the EdChat to learn about what K-16 educators were doing across the world. Pre-service and retired teachers also participated in the EdChat. Because the Twitter EdChat was highly interactive, Chandler wished members of the CLASE online CoP engaged more actively in discussions.

Evidence for core contributors. Nicole and Chandler were identified as leaders at the school and district levels regarding the implementation of the IC pedagogy. In her school, Nicole

was appointed as the IC coach, a position that the administration created for her to support other teachers:

> *"My principal wanted to make sure that we kept up the momentum and several teachers evidently, they look up to me and so he said, you know, 'we'll create this position, so you can go out and support the other teachers in the building, the newly trained teachers', because I think we sent five teachers this past summer and also check in with the other teachers who were trained previously and it's been kind of a little community, so everyone in the school knows that hey, we're all in this thing together, and there are resources in the building so if you have any questions- I'm not saying that I'm an expert, but he kind of puts it out there- that if you have any questions, you can ask Nicole. If I have questions about what's going on, or how can I support you, I have that opportunity to do that in this position."*

Regarding her participation in the district-level leadership team, Nicole stated:

> *"It's just being that person in the building, that go-to person. Again, we have I want to say, maybe twenty teachers that have been trained in this pedagogy in my building, so they know that there's someone in the building that they can go to if they feel like they've gotten stuck or they're not quite sure what's the next step. So I'm like that go-to person, and again because we want this to become the culture of our school, and ultimately, I think the culture of the county."*

Nicole also served an important role in motivating new teachers to learn about the IC pedagogy and join the community of practice:

> *"We started talking about it (ICs) in my school, the other teachers that are on the Instructional Conversation Leadership team, they talk about it at their school and then*

word kind of travels and then other teachers start thinking 'oh, what is this Instructional Conversation about?' then that allows us to go into different schools and talk about Instructional Conversations with the hopes that now they will come on board, so I think that's pretty much what they're doing, trying to build a platform so that it can become a county wide initiative."

Chandler was also a member of the county-level leadership team. This is how she described her participation:

"I was really interested in it (the leadership team), because again, I really think this is a really good thing for our students, and I don't know how other counties are doing, but I know in (name of the county) we have a lot of classroom teachers who serve ESOL students themselves, they don't have a pullout ESOL or a push-in ESOL teacher, so I feel like using this pedagogy with those students who are not seeing a dedicated ESOL teacher is something really important. So, I was really interested in sharing that with others, so if I need to do extra work and be filmed and do extra cards and things like that- then that would be worth it, because that's what's most important, doing what's best for the kids and not what's easiest for me".

Personal definitions of online teacher CoP. Nicole and Chandler described an online teacher community as a space where educators can interact and support each other, share resources, ask questions, and offer help and advice. Nicole compared a teacher community to a support group such as Alcoholics Anonymous:

"My personal definition of an online teaching and learning community is pretty much educators getting together, talking about what they're implementing in class, going to other teachers who may be in similar situations, getting feedback, just like a kind of

support group for teachers, almost like an AA meeting but for teachers. We all have interesting situations on a daily basis and it feels good to know that you're not the only one experiencing that, so I think that would be the main goal of an online platform."

Chandler compared her experience in the CLASE CoP to the Twitter EdChats in which she served as a co-moderator:

"For me, it's (an online teacher community) a place where you can go and ask questions, find resources, sometimes help others with their questions. I'm part of a Twitter chat weekly, so I feel like the CLASE platform is just a more contained version of the same thing where you can just kind of put out questions and get answers from others who are similarly trained and have similar interests, similar knowledge."

Both Nicole and Chandler agreed that it was important to set norms and expectations for all teacher members in a community. Chandler pointed out that setting norms was an important part of implementing instructional conversations. Therefore, teachers in the CLASE CoP may have used or transferred the same conversational norms that they taught their students:

"I think pretty much the same norms that we have in our, for the CLASE platform, where you know- assume goodwill, listen to understand not to respond, try to build off other's ideas. The same things that we talk about with our students in ICs, and the things that we have in our platform, I think that's what we need to have, and that's probably part of the problem with Twitter, is that people don't assume good will and listen to understand and respond. So, I think that would actually go a lot way, if all online platforms had those same norms."

Motivation to join an online teacher CoP. Nicole and Chandler listed collaboration, finding and sharing resources, and offering advice to novice teachers as the main reasons they

would want to join an online teacher CoP. Nicole emphasized the convenience of meeting teachers who are geographically spread out via the virtual classroom:

> *"The main reason I go to the platform is to one: first, look for lesson plans so I don't have to reinvent the wheel, or you know two: if I've created something that I feel would be beneficial to others I'll go on there and upload it. Also, collaboration, like if I have questions or concerns, I know that I can always go to the online platform and reach out to you or another educator that may be on the platform to get feedback and not have to drive, you know twenty, thirty miles. It's like a skyping session right at my hands, and I can do it from my home."*

Chandler indicated an online teacher community was a great resource for novice teachers to get feedback and advice from more seasoned educators:

> *"I think for me, it's having someone to bounce ideas off of. And also, I've been doing this for over twenty years, over ten years in ESOL, and so I really feel like I like to share what I've learned in my time with people who have questions, especially newer teachers. I feel like sometimes they don't get as much support as they need. So really trying to help out and offer support to them."*

Evidence for homophily in the social network. Nicole and Chandler were asked to recall specific interactions they had with other teachers on the online platform. The purpose was to determine if there was any tendency for Nicole and Chandler to communicate with teachers from the same school, grade level, school district, or teachers they personally knew. Chandler was not able to remember any information about the teachers with whom she engaged on the online platform. She stated that she replied to comments and questions if she had anything valuable to say, regardless of whether or not she knew the teacher:

> "*I think because I'm kind of used to interacting with people I've never met in real life. If I see someone has a question, it doesn't bother me to respond and throw in my two cents. Even if I don't know you."*

Nicole was able to identify and provide additional information for five of 11 teachers with whom she interacted on the online platform. Nicole was able to recall the five teachers because she had met them in person, or she admired them and had heard about their work, or they had been former colleagues. Nicole was able to recall a lot of background information about the five teachers, including previous conversations, email exchanges, school name, grade level, place where she met them, etc. Regarding the seven teachers Nicole did not remember, she said she would look up their profile on the platform to recall who they were. Nicole explained that she had probably interacted with those teachers because they taught the same level or content area than she did:

> *"Um, I don't know that person, it's probably something that they posted, if it was social studies related, I probably looked at it, or if it's fifth grade I probably looked at it, because I'm coming from being in the classroom as a fifth-grade teacher. It could have been a particular topic that I was about to review? But I'm not- I don't know who that friend is."*

Use and value of the online teacher CoP. Nicole and Chandler used the CLASE CoP in similar ways to share resources and engage in opportunities for collaboration and peer feedback. However, as part of their district-level leadership team, Nicole, Chandler, and a few other teachers met in the virtual classroom on a regular basis to discuss ideas to support their peers and provide mentorship. In Nicole's words:

"We talk about our lesson plans, we talk about what's the next step, how are things going in your building- it's kind of refreshing, I would say, to hear that well, some things that are happening at my school, it's also happening in other schools. So, it allows us to kind of trouble through it, and discuss it. It also gives us the opportunity to say 'okay, you know what, I was thinking about this, what are your thoughts on this? maybe this should be our next step' and again, you can have the opportunity to speak with others about something that you're passionate about and not have to drive in your car to do it."

Nicole also used the CLASE CoP to find resources and support other teachers in her school:

"I try not to reinvent the wheel. Especially now that I'm not in a classroom, because I'm also the IC coach at my school. There's a fifth grade teacher that I push in and I support, so when there are particular topics that they're discussing in class and she kind of wants to figure out where her students are, I go to the platform to see if there's something on the platform that's already created and if not, then I'll just comb through my resources and create something for her, so yes I go to the platform I try and work smarter not harder."

Nicole believed the online platform was intuitive and user-friendly, and in case she had any questions, she knew she could email one of the CLASE staff members for support:

"Well, I could just speak from the teachers at my school, there are several teachers there that are not really into technology, I mean they know enough to of course have engaging lessons for their students, but some of the same teachers are kind of hesitant to try something new with technology and they've been able to maneuver through the platform, so that speaks volumes!"

Concerning changes in her teaching practice, Nicole believed instructional conversations changed her as a teacher by allowing her to empower her students and give them a voice:

> *"I have always known it's important to have a voice, but this (IC) just solidifies it because my students, they're in a risk free environment because of the community we set up and they know it's okay to speak out, you know, of course in a respectful manner, and it's okay to not know everything because guess what, there's someone else in your group that would help you along the way and so my students don't feel like they're left out without any support and they just have to sit there trying to figure out 'dang, how do I even attack this problem' but if I give an activity to my students, that same activity that they were doing independently, they know that they can bounce ideas off each other, and then it also helps my students to think as well, because they are able to see multiple perspectives and they kind of think outside the box."*

Nicole also believed that her participation in the online teacher COP helped her to be more reflective of her own practice and more intentional when sharing resources with others. For example, when she created a lesson plan, she used to omit certain sections because she knew exactly what to do. However, whenever she wanted to share that lesson plan in the online CoP, she had to be more explicit and provide more detailed instructions:

> *"One thing that I have to constantly think about, is that contextualization in my IC lessons, because to me, it's automatic because I'm always thinking about that, but I understand that if I am posting something on the platform, everyone doesn't think the way I think, so it reminds me to make sure I put that contextualization piece because someone who doesn't think the way I think, they would need that if they were to choose and use a*

lesson that I post online. It's always a gentle reminder of you know, why I'm doing what I'm doing and why it works."

Chandler went on the online teacher CoP whenever she had something to share or when she got a notification that someone had posted a reply to something she said. She also thought the platform was very intuitive and user friendly. Instructional conversations helped Chandler realize that even students with limited language proficiency can still participate and engage in discussions. Participating in the online CoP provided Chandler with lots of teaching resources and ideas that were accessible anytime and anywhere:

"I can go on there and find the resources, like if I'm at home, my laptop wasn't working today, so I had to get on my personal laptop, but having the resources, the downloads there, so I could still get my hands on what I needed to get. So I think it has helped me interact more, it's not just something I do every once in a while, anytime I think of it I can go on there and say 'okay let me look up and see if there's any one putting anything like this on there, we're about to start talking about this, are there any ICs or JPAs (joint-productive activities) that are already uploaded that are similar that I can just take a piece from for my new one."

Concerns, challenges, and low engagement. Nicole and Chandler were asked if they had faced any challenges while participating in the CLASE teacher CoP and why they thought some teachers may not be as engaged as they were. Nicole and Chandler believed teachers got very excited when they first received the training, but their energy and engagement levels started to decrease as the school year progressed due to the many demands and their busy schedules. Nicole explained that because she really believed in instructional conversations, she always

found opportunities to integrate ICs into her teaching, even when she did not have much time to participate in the online community:

> *"The demands, the daily demands of the classroom. I mean, there's always something that's due, there's always something that's past due, there's always something that's coming up that needs to be addressed."*

Chandler believed that ICs and participating in the online community were not a priority for some teachers, especially if the school administration did not value such things:

> *"I think it's not a priority, just to be honest. You know, we have that long to do list, and what's the first- what's something I can cut out that my administration's not necessarily checking that I've done."*

Another concern that Nicole expressed regarding the implementation of ICs was administrative and grade level support. Typically, teachers tended to plan their lessons in grade-level teams and it was important for all teachers to be "on-board" to plan and allot time for ICs. Additionally, the vision and expectations of the school administrators needed to support what teachers were doing in the classroom. Nicole believed that teachers needed to be "self-motivated" to participate in the CLASE CoP and needed to be reminded about the resources available to them and the value of their participation:

> *" I think for some teachers, the online platform might just be one additional thing, but I guess that- emphasize that it's already created for you, you don't have to reinvent the wheel, and I think if teachers buy into that, there may be more usage, but right now it's just like, 'okay yeah I know it's there, I interacted with it during my initial training, and that's it'. You know, so it's kind of like out of sight out of mind, and some people may actually forget that it's actually available to them."*

Extended network. Nicole and Chandler used the CLASE online CoP to connect with peers, find resources, and support each other as they implemented instructional conversations. However, teachers belonged to different networks and had access to other resources and communities, both online and at their work place. Nicole, for example, said and that there were about 20 teachers in her school who were trained in ICs and they frequently talked and supported each other to implement ICs. Such face-to-face interactions were not captured in the online community although the actors or community members were the same.

> *"I can just send them an email, or they'll stop by my class because they know I'm in the building. Or again, they'll send an email 'hey Nicole, can you come and watch me do this and give me your feedback?' and I'll just walk down to their room, because we're in the same building, it's just convenient."*

Similarly, Chandler worked with a fourth-grade teacher in her school and they planned instructional conversations together. Such type of collaboration was not represented in the online platform. Chandler explained that although four teachers were trained in her school, she did not interact or work with all of them, either because they taught different grades or because their classrooms were not located close to each other. Chandler thought the online community offered a valuable opportunity to interact with teachers from other schools, who may have similar goals:

> *"I would like to be able to talk to people more through the platform, to talk with some of the other county people because I feel like they are in similar situations, they would have similar instructional calendars, so if we were talking more regularly we would all be in the same place and could really plan some things together."*

In addition to the CLASE CoP, Chandler was also a part of other teacher groups and communities. For example, she served as a co-moderator for a weekly educational chat on Twitter:

> *"There is an EdChat, well there's a lot of EdChats- education chats, actually, on Twitter, but there's the one that I participate in, I'm a co-moderator for the weekly EdChat, it's on Tuesday nights at 7pm Eastern time. And so, on Monday one of the leaders sends out the question, and just tweets it out, and then we retweet it and then we all from 7:00 to 8:00 on Tuesday nights, we just answer the questions, interact with each other, and make sure that we use the hashtags so that people can follow along with the discussion. We have pre-service educators, we have retired educators, all different levels. We have from kindergarten all the way through college participate."*

Brokers

Two members who acted as *bridges* and connected subgroups within the online CoP were interviewed as indicated by the SNA. "Anna" was the lead ESOL teacher in her elementary school. According to the node centrality analysis, Anna engaged in 18 online exchanges (nine in-degree and nine out-degree). Her betweenness, closeness, and eigenvalue scores were 2268.89, 9.12×10^{-4}, and 0.24 respectively. The second broker was "Christina," another ESOL teacher from a different elementary school. She engaged in 15 online exchanges (eight in-degree and seven out-degree). Christina's betweenness, closeness, and eigenvalue scores were 2034.83, 9.28×10^{-4}, and 0.23 respectively.

Anna taught kindergarten through fifth grade English Language Learners as a pull-out class. She had thirteen years of teaching experience. Before ESOL, Anna used to teach kindergarten, first-grade and self-contained early intervention. She heard about the IC pedagogy

at a district level ESOL meeting and she got very interested. She was the first teacher in her school to be trained and joined the CLASE online CoP two years ago. Since then, two fourth-grade teachers became interested and received training. At the time of this study, there were more teachers in her school who are on the waiting list to participate in the IC training. Anna's role was important in helping other teachers learn about the IC pedagogy.

Anna was very familiar with the use of online environments for professional learning because she was pursuing an online doctoral program. She also participated in other district-level communities for ESOL teachers. Anna considered the CLASE platform to be very user-friendly, intuitive, and easy to navigate. She logged onto the CLASE CoP once or twice per week and described her engagement level as "medium." She wished she could become a more active member in the CoP but she spent most of her time teaching and studying for her doctoral program.

Christina had 20 years of teaching experience. At the time of the interview, she was teaching kindergarten, first, and second grades. She had also taught middle grades in the past. Christina worked at the same school than Chandler (who was a core contributor). Christina and Chandler were the only two teachers in their school who did instructional conversations. There was another teacher who got recently trained and had started to implement ICs, however the adoption of the IC pedagogy across the school was still at the beginning stages. Christina participated in the IC training and joined the CLASE online CoP two years ago. Christina was part of the same district-level leadership team than Nicole and Chandler. Christina worked with Chandler to get people at their school interested in learning more about ICs. They led teacher workshops at the school's staff development meetings on how to integrate ICs into the curriculum.

Christina did not belong to other online teacher communities different from the CLASE CoP. She was part of an ESOL cluster website in her district where they logged in for messages and blog posts, but Christina did not consider this webpage to be a community at the same level as the CLASE CoP. Christina felt comfortable navigating the CLASE CoP and described her level of engagement as "medium." She logged in at least once per week to look for ideas for different grades and adapt those lesson plans to fit her students' context and developmental age. Christina thought the CLASE CoP was user-friendly and easy to navigate. She said she was not very "technologically savvy" and if she was able to use or operate a device, then everybody could. However, Christina acknowledged that she was used to online learning environments because she completed an online graduate program and she also had access to other online platforms through her school district.

Evidence for brokers. Anna and Christina were among the first teachers in their school to start implementing instructional conversations. They had a vital role in connecting groups of teachers and promoting and expanding the community of practice. Anna learned about ICs in a district level meeting and brought that idea to her school:

> *"I was the first person to be trained on ICs but I brought it to two teachers who I thought would really enjoy it and really jump in and try it. And then those teachers have kind of spread it to their grade level in surrounding areas, so I've gotten a lot of other teachers emailing me, asking to be trained. So, they're on the waiting list to get approval to be trained. So, it's kind of spread that way."*

The academic growth of Anna's students also helped to spark interest in other teachers regarding the IC pedagogy:

"Two of the teachers that I had their students in an EIP class that I was doing the Instructional Conversations with, they were asking me 'what are you doing, why?' like 'what is happening, these kids LOVE to come to your room, they're loving reading, they're improving', and so I kind of shared it out 'you've got to see what we're doing' you know, 'come and watch us to do it' and so it spread very naturally."

Other teachers came to Anna for support and ideas on how to implement instructional conversations and how to deal with any roadblocks or concerns:

"Since I was trained first, I'm kind of more of the 'resource' I guess. When they get stuck they'll come to me and be like 'how do I do this lesson with IC?' or I'll follow up with them on 'how's it going? how are you using ICs? can I help you with anything? are you feeling confident?' and we kind of troubleshoot different things. I was doing an IC and I have this one student who's still not participating, what else can we do to get him to participate?', so we'll troubleshoot things like that as well."

Christina, as mentioned before, was also part of the district level leadership team with Nicole and Chandler. The team offered a lot of support to other teachers and contributed greatly to the expansion of the community:

"Right now, we are meeting with the other teachers who are in the (county name) leadership team. I think there's like six or seven of us. So, we've met a couple of times, I think we have a meeting coming up on the twentieth of March. And Chandler and I really kind of work to get people in our building interested, you know learning about ICs. We just did a workshop at our staff development Monday, and we talked about some ways to integrate ICs, especially in like reader's workshop. And so, we're trying to get- spread the word, I guess, about it, through that platform."

Personal definitions of online teacher CoP. Anna and Christina identified different characteristics of an online teacher community, including opportunities for collaboration and interaction, as well as ease of use and interaction that may be synchronous or asynchronous. This was Anna's definition:

> *"I guess my personal definition of an online teacher community would be any platform that allows teachers to collaborate. Either face to face or through text. That allows teachers to share ideas or share resources. It can be at the same time, like we're doing now, or it may be, I post something and somebody comes and looks at it later. Any way that connects teachers that may not be in the same building."*

This was Christina's definition of an online teacher community:

> *"A place where you could post ideas, answer questions- answer and ask questions, but it would be kind of very fluid, and people could get on there and you know, feel free to post a question and then other people could answer it and if you had lesson plans or suggestions for ways to teach a particular AKS (Academic Knowledge and Skills) or whatever, so it would just kind of be very like, user friendly. It wouldn't be hard to log on, it wouldn't be hard to post things, it would be easy to access materials, and that would be my definition."*

Christina compared the CLASE CoP to other teacher websites. For example, she used "*teachers pay teachers*" to get resources but she did not consider that website to be a teacher community but rather a "shopping website." In her opinion, a community needed to provide opportunities for professional development:

> *"I would consider teacher pay teachers shopping. I guess you can- some people can use it as an online community? But I consider it more of a you're going in with the mindset*

that you're going to buy something or use something from there? CLASE, it seems more like it's a more like, I don't know how to explain this, but more of a higher resource, like teachers pay teachers, you're just buying something, but your CLASE website is more like a community where you can ask questions, you have articles, you have videos. You have the resources as well, but it's kind of more educational, I guess. As an educator, it's more of a professional website that you can go to, versus teachers pay teachers is more of a consumer-driven thing."

Christina did not find norms and expectations to be very important for a teacher community because educators already carried themselves in a professional demeanor:

"I think that teachers are- we're like, you know, we're used to all of those 'you be respectful' and so it's a little bit different than just putting random people on a platform. I feel like as teachers we kind of know, you have to be respectful of other's ideas, you don't just post a mean comment, I mean, so you know when you deal with teachers you don't have all that other stuff that you have, I think I would hope in my opinion, that you might have with like a public forum or something like that."

Anna, on the other hand, argued that teachers came from different backgrounds and it was fundamental to set norms to value and respect everyone's opinion. Another important expectation was that members of a teacher community should not only take ideas and resources but also contribute:

"I think norms would be to definitely be respectful of other people's work at all times, I think that's an important norm, that you don't know what their experience is, or what their classroom is like, or what kind of background knowledge they have coming into the platform and so being respectful of other's ideas and sharing and you know, valuing the

ideas of others. Just like in an IC where we teach children to listen to each other and everybody has something to share. I think respecting that on the online platform is important as well. I also think it's important to participate both ways. To not always be the person that comes and takes the ideas, but also to share out ideas and thoughts on different things as well."

Motivation to join an online teacher CoP. Anna and Christina mentioned access to resource as the main reason they would want to join an online teacher community:

Anna: *"The top reason for me would be ideas and resources. I'm always looking for a new way to reach my kids, a new way to teach something that might help them understand it a little bit better. I get bored, so I may not teach the same thing every year, it may not be to the same students, but I'm always looking for a new way to do it, a new way to present it, so I think ideas would be the number one reason for me."*

Christina: *"I would say to get resources because, sometimes it's just hard to find- there's so much stuff out there, especially in (name of county), we are blessed with an overload of information and materials and resources, so it's nice to have a place where you could go to and get good ideas and stuff that people have tried and used and it's worked for them."*

Evidence for homophily in the social network. Christina and Anna were given a list of teachers with whom they had interacted on the online platform. They were asked to provide any background information about those teachers to explore whether there were any trends regarding how teachers chose to interact with one another. Christina was not able to recall anything about the teachers she had talked to. She jokingly said she was lucky if she could remember what she

had for breakfast. Christina explained that some of her comments and replies to other teachers were short and did not entail a full conversation:

> *"It might be something like, 'hey I liked your lesson plan,' but I haven't gone on and be like 'hey let's talk about how you did this' or anything like that. If I do respond to a post, it's usually a 'great lesson idea, thank you so much' and that's it. So, it's not like we're having like a conversation or anything like that."*

Christina suggested that whenever she was not able to find instructional resources for the grade level she taught, she looked at other grades and adapted those ideas and resources to fit her classroom and students' needs:

> *"I do kindergarten and first grade and there's not as many plans for that as there are for the upper grades, which I guess is kind of normal. But what I am able to do is take some of the ideas that they have and kind of tweak them to fit for my little friends- my younger students."*

Anna was only able to recall one teacher because they had both participated in the foundational training for instructional conversations. Anna had a vague memory of two other teachers, but she was unable to recall anything about other teachers on the platform. Anna stated she would typically search for teachers in the same grade level or content area:

> *"Usually it's somebody within a grade level that I'm looking to work with. Because I work K-5 I tend to get sometimes stuck on 'okay what is first grade learning right now?' or 'what do I need to be doing with third grade?'. It's hard to keep all that curriculum in my mind. And so, I will search out people who work in that particular grade and see what they're doing and ideas that they're using with that grade, to kind of give me an idea of*

'oh yeah I can do that with my third graders' or that kind of thing. So, I think it's very grade-level based."

Anna was asked how important it was for her to know someone in person before having an online conversation, to which she replied:

"I think I'm more likely to chat with them in the chat feature if I know them in person or know them personally. But as far as interacting, sharing ideas and lessons, no I don't think I need to know them personally."

Use and value of the online teacher CoP. Anna and Christina heavily relied on the online CLASE COP to access and share teaching resources. Christina believed resources were one of the main reasons teachers decided to join the community and she was aware that she also needed to contribute resources and give back to the community:

"If I come up with an IC or a JPA (joint-productive activity), I do like to post it, because I think that that's the one biggest thing everyone else is on there for, looking for resources too. And then I don't really do a lot of blogging anyway, so I don't really use that resource, so I would definitely just mostly say for like um, the lesson plans? So, I feel like if I'm using a lesson plan, then I need to post something too for someone else to use."

Christina thought instructional conversations changed her mindset regarding the role of the teacher and the importance of allowing children to speak to each other.

"We've always been taught you know, kids need to talk to each other about their learning, but I think it has definitely opened my eyes to the fact that they need to be the ones doing all the talking, and not me. So, they need to have more opportunities to have conversation and more opportunities to talk about things and I need to really take a backseat."

Christina believed that her participation in the CLASE online CoP helped her to implement the IC pedagogy better by allowing her to use materials, ask questions, and get feedback:

> *"I definitely think it has helped me implement them better, because I'm able to go online and look at what other teachers have posted, or the lessons that other teachers have, and I can look at their questions and look at their lesson plans and look at their materials and it has helped me with implementation of course."*

Christina described the online CoP as a great resource to support teachers and provide sustainable professional development, unlike other teacher programs that did not follow up or provided any assistance:

> *"I think that you guys have done a good job at making it sustainable. Most of the time when you go to like a professional development, they just give you the materials and say 'here you go'. And then you never hear from them again, or you're supposed to implement it, but if you have a question you can't ask somebody or whatever. So, I think you guys have done a wonderful job of that- providing that, you know, constant support, and if you had a question you could do this, versus typically most of the training that you go to, it's kind of like - here's your stuff, here's a copy of the PowerPoint, you know if you had a question you could go back and look at the PowerPoint. But you know, there isn't that support so it is kind of like you get trained but then you're not really trained and so you're not comfortable on doing it on your own and then there's nobody following up with you, helping you out or providing you assistance or anything like that."*

In addition to her role as a teacher, Anna used the CLASE CoP as a researcher to learn more about the IC pedagogy and find resources. As part of her doctoral dissertation research, Anna was exploring the impact of instructional conversation on students' writing skills:

> *"I have gone in there, under the Pedagogy tab, when I first started my dissertation, kind of get some 'where do I need to be researching?' 'what do I need to be researching about?'. I've directed people to the information on the Pedagogy page when they've asked me, or I've taken stuff from the Pedagogy page and shared it with other people when they've asked me about ICs and what's the philosophy behind that, so I've used it in that way as well."*

As a teacher, instructional conversations helped Anna to rethink her role from an "information giver" to a "facilitator." She became more aware of the importance of engaging students in academic discussions and giving them a voice:

> *"I think Instructional Conversations have really made me realize how little I was allowing my students to talk. And of course, my students have always had the opportunity to turn and share with a partner or to work in a group, but I didn't realize before this training how important it was to give my students the space to really talk about and to work through something. And I think it's changed how I view what teaching is. I've gone from more of a 'I'm teaching, you're listening and responding' to 'I'm structuring, you're doing the work'. So, I think it's changed how I view my role, as a teacher. From the information giver, to the facilitator."*

Participating in the CLASE CoP helped Anna to implement ICs, particularly since she was the only ESOL teacher in her school and did not have other colleagues to share and discuss ideas:

"I think the ideas that I get from the online platform allow me to think outside the box about IC a little bit more than I would have on my own. I get stuck sometimes being the only ESOL teacher. I don't have a grade level to bounce ideas off of, so the online platform allows me to kind of look at a lesson or look at an idea in a way that I might not have presented it. So, it broadens my thoughts on curriculum and how I might present things and the IC format."

Concerns, challenges, and low engagement. Christina and Anna were asked if they had any concerns regarding their participation in the online community and the implementation of ICs in their classrooms. They were also asked why some teachers may not engage as much in the online community. Both Christina and Anna alluded to time constraints. Christina also thought that teachers needed to feel comfortable using the online platform and have a basic understanding of how to perform basic tasks:

Christina: *"I think it might be time constraints for them. Because sometimes it can be overwhelming, like if you have lots of other things that you have to do, to have to post something maybe following a format. It could be the time- I would say time might be the biggest constraint (…) And also, if you don't have a little bit of a technology background to be able to post stuff and to be able to navigate the site."*

Anna: *"I think once you kind of leave the IC training and go back to reality, so to say, that it almost gets forgotten. Not that they don't want to, it's just that your day gets so busy. And then, you're like 'okay I'm going to look' and then something comes up and you don't look, or if you're not using ICs in your classroom as much as you would hope, then it's not fresh in your mind and you're not thinking about it. So, I think it's very easy*

to get caught up in the daily task of teaching and forget that a resource is available to you."

According to Anna and Christina, teachers needed to see the value of their participation in the online community, experience some of the benefits, and be reminded about the many resources that are available to them. In terms of sharing instructional materials, it was important to make sure that all materials were complete and ready to be used by other educators. Otherwise, teachers would not find as much value:

Christina: *"It's also something that you would have to really see the value in it? And realize that once you get into it and you do it a couple times, it's easy to use (...) Sometimes I've noticed this, in using the platform, you'll have teachers who just post like their idea, but there's nothing with it. There's no card, there's no materials, there's no- that kind of stuff."*

Anna: *"I think teachers that really want to participate or that value what they find on there, will. I think maybe reminders every now and then of 'hey, these great resources are out here' or 'we just got new lesson plans uploaded'. Those kinds of things serve to put it back out for teachers to say 'hey, if you haven't done an IC in a while, here's some great ideas."*

Another crucial factor that Christina identified regarding the implementation of ICs was teacher isolation. It was important for teachers to feel supported in their building and be able to collaborate with others:

"It's nice that I have other people in my building who I can go to if I have a question as well and I think that's another issue that maybe some people might have, is if they're the only one in their building who's been trained, and they don't have anybody to kind of talk

to about it or run ideas by or to kind of keep the momentum going. You know then that's kind where they might fall short as well."

Anna, for example, was the only ESOL teacher in her school and she sometimes felt isolated. However, she used the online community to interact and get support from other peers:

"I get stuck sometimes being the only ESOL teacher I don't have a grade level to bounce ideas off of, so the online platform allows me to kind of look at a lesson or look at an idea in a way that I might not have presented it."

Extended network. Christina and Anna used the CLASE CoP to support their implementation of instructional conversations, but they also relied on other resources and individuals outside the online community. For example, Christina was a part of a northeast cluster ESOL community in her school district. To find instructional materials, Christina typically searched on the internet, asked a colleague for help, or created her own resources:

"I usually look online, and then sometimes - I can just google it like 'lesson plan for teaching whatever' and then a bunch of stuff will come up. Sometimes I use like teacher resources materials like books that you can- like I have that have materials in them that I've used before. Sometimes I just go and talk to another teacher and say 'hey do you have something that I can use to teach this?' Or 'what are you using in your class to teach this?' Sometimes I just make it up."

Christina admitted that she preferred to seek advice and support from other IC-trained teachers at her school than to seek support through the online platform:

"I'm fortunate enough to have someone at my school who's IC trained, so in my mind it's quicker for me to go down the hall and be like 'hey I have this issue, do you have any suggestions?' than it would be for me to try and get on the platform and set up a time to

meet with somebody. But that's just me personally. Now it might be easier for someone else to kind of talk over some problems that they might be having, and again I am fortunate enough to have somebody here at my school but if I was the only one at my school, then I probably would definitely utilize that option more often."

Anna also relied on other IC-trained teachers in her school for support and ideas. If she could not find what she needed, she would search on the CLASE online CoP or contact other fellow ESOL educators:

"If I need help, I will go to them first (IC-trained teacher in the building), just for ideas. Especially since they just went through the training, it's fresher in their mind. Or it might be something they talked about in their follow up sessions recently. If they don't know, then I generally will go to the platform or I will email fellow ESOL teachers and say 'okay, I'm trying to do this, what are your ideas'. Even if they haven't been trained on Instructional Conversations just on ideas in general."

Peripheral observers

Two members who were either disconnected from the giant social network component or who never interacted in the online CoP were interviewed as indicated by the SNA. "Brandon" was an instructional coach and a curriculum support teacher at his elementary school. According to the node centrality analysis, Brandon was located in the periphery and only engaged in three online exchanges (one in-degree and two out-degree). His betweenness, closeness, and eigenvalue scores were 0, 6.03×10^{-4}, and 5.24×10^{-5} respectively. The second peripheral observer was "Becky," a fourth-grade teacher at a different elementary school. She did not engage in any online exchanges, and therefore did not get any node centrality measures.

As a curriculum support teacher, Brandon led the collaborative planning for first, second, and fourth grade teachers. This was his first year in that particular role, but he had 15 years of teaching experience. As a coach, Brandon provided one-on-one coaching, observed teachers in their classroom, modelled instruction, gave feedback, provided resources, and helped teachers to set goals. Brandon led staff development meetings in the building with two other coaches who worked with different grade levels. The instructional coaches served as liaisons between teachers and the school administration. They communicated expectations from the administration and helped realize the vision of the school in terms of instructional and academic goals. Coaches did not evaluate teachers' performance, they only helped them build their capacity as educators.

Most of the teachers Brandon worked with were trained in the IC pedagogy. The new teachers had already signed up to receive training in the summer. Brandon first learned about instructional conversations and joined the CLASE online CoP one year ago when he was offered a position as an instructional coach at his current school. Although Brandon was introduced to ICs a year ago, he was already using collaborative teaching strategies before:

> *"I was introduced to the formal language, of calling it Instructional Conversations, last summer when I came to the training. But in terms of I guess, parts of the process, things I had done as a science- I was a science teacher the previous two years, in a departmentalized grade level in fourth grade- I did a lot of collaborative tasks. So, when I came to the training, I learned some new things, and then I thought back on my previous practice as a teacher, I was thinking 'okay so I was doing a lot of great things with collaboration already, now I can put it into a more formalized structure for students' because I did not do the goal setting, did not do the goal cards and whatnot and then expanding it outside the subject"*

Brandon felt very comfortable using technology and believed his generation was raised on technology, which gave him an advantage over other teachers. He tried not to advertise his technological skills because he already had "quite a full plate as an instructional coach" but he still tried to help and support other teachers whenever he could. Brandon did not belong to other online teacher communities different from the CLASE CoP. However, he followed education-related topics and authors in social media as well as TED Talks and blogs (e.g. Edutopia). Brandon admitted that the way he used technology for professional purposes changed in the last year given his new role as an instructional coach.

Becky, the second peripheral observer who was interviewed, taught fourth grade at a school in a rural setting. Her school was departmentalized so she taught two different groups of students. In addition to her homeroom, Becky taught reading, social studies, ELA, and writing. Becky had eight years of teaching experience. She spent five of those years teaching fourth grade. She learned about instructional conversations two years ago. She was part of the first group of teachers in her county to receive the training. Becky said she learned about the CLASE CoP in the last few months when she got an invitation for a Webinar. The online CoP was briefly mentioned during the summer institute that Becky attended but it was not actively incorporated in the training due to poor internet connectivity at the meeting facility, which may explain why she thought the CLASE CoP was new.

Becky's school was very invested in the IC pedagogy. Representatives from every grade level were trained. She said faculty asked themselves: "how can we turn this into an Instructional Conversation?", at every general or grade-level meeting. The school administration was very supportive. Becky did not belong to other online teacher communities in addition to the CLASE CoP. However, she used other educational technology tools such as *Google classroom* and

Seesaw to create student-driven digital portfolios, keep track of their learning, and interact with parents. Becky found the CLASE CoP to be user-friendly and easy to use but she admitted that she preferred face-to-face interactions:

> "*In getting my degree, I never wanted to take online classes because I'm a visual learner, and am very personal, so I like to have people to talk to face-to-face. But of course, our world is moving in the direction of more technology and online communication. But I'm still learning, and with the platform (the CLASE CoP), I'm still learning different parts of it."*

Evidence for peripheral observers. Brandon and Becky were not active members of the CLASE CoP but they still used the platform for different purposes. Becky described her engagement level in the CLASE CoP as "low" in terms of posting and sharing with other teachers. However, she said her engagement was "high" when it came to using the resources on the platform, watching videos, and attending Webinars. Becky logged onto the online CoP at least once per week to find ideas and plans for the following week's instructional conversations. Becky's response provided evidence that she was a legitimate peripheral observer, or *lurker*, in the CLASE CoP.

Becky met with other grade-level teachers and they planned their lessons as a group. Only one of the teachers shared the lesson plan on the CLASE CoP, which may have been interpreted as an individual post but in reality, it was a collective effort:

> *"I know Mrs. Schneiders across the hall has shared some of the plans that we've done as far as ICs. But we're doing [inaudible] things, so if she says, 'I'm going to share this on the platform,' I don't normally do it as well because we're doing the same thing. But I know I haven't been good at posting the plans on there."*

Brandon, on the other hand, used to be more active on the CLASE CoP when he was first taking the training. However, his participation diminished during the school year given his role as an instructional coach. He did not work with students directly and he was not in need of many instructional resources. The teachers that Brandon supervised did use the online CoP to find resources and lesson plans prior to meeting with him:

> Diego: *Do you use the platform at any point during the lesson planning with your teachers?*
>
> Brandon: *Some do, more independently. Collaboratively, not quite as much, just because we do meet for lesson planning, we're only together for about thirty-five minutes. So typically, a lot of the work that would go into that is done outside that collaborative process, when we're together. So, when teachers come, they're prepared to actually analyze and discuss what they've already looked at. So, that's more probably an independent or individual task before teachers come into our meetings.*
>
> Diego: *What has been your level of engagement with the platform, would you say it low, medium, or high?*
>
> Brandon: *When I first got into it last summer, I used it a lot. I looked at it quite a bit, because when we were using some of the resources during our little breakout sessions, there were other things that I wanted to click on that we weren't supposed to click on yet. So, I went ahead, and I went home and basically played with it (…) I was transitioning into a new job and I wanted to have as many resources in my toolkit as possible.*

Brandon sometimes used the CLASE CoP to find resources to support his teachers:

> *"I was going through and looking at the resources that had been shared, that had been uploaded last summer. I was working with one teacher who had been through the*

training last summer but wanted some support, and another teacher who had not been through the training, and so I went through and was pulling resources (from the CLASE CoP) to kind of help them organize the structure of an IC, I guess more effectively, so that they could use it in small groups in their classrooms. So, it was really so that I could provide resources or build their capacity to be able to do it in their classrooms."

Personal definitions of online teacher CoP. Brandon and Becky described online teacher communities in terms of collaboration, peer-feedback, and communication. In Brandon's words:

"An online teacher community, for me, would be one in which not only, where you can share resources and like where you can collaborate on best practices, it would be one where you can communicate or receive feedback from your peers in the field about a particular instructional strategy, either the best way logistically to introduce it or getting feedback from those who have tried a strategy would also be an opportunity where you could even upload instructional practice- a video of instructional practice, receive feedback, give feedback, or use it to share with someone else who's trying it for the first time, basically just a communication hub of sorts."

Becky emphasized the convenience and flexibility of online environments to collaborate with other teachers:

"The first thing I think of is collaboration. I feel like teachers stay so busy already. It's a way for us to communicate without having that face-to-face time. We're able to communicate just like - everybody outside of education communicates via social media. I kind of feel like it's a social media platform for teachers to communicate from home

without having to set up a face-to-face meeting. Or to go to a special training and have a substitute in place and things like that."

Brandon and Becky agreed that the same norms and expectations that students used in instructional conversations also applied to teachers participating in an online community:

Brandon: *"I think it's the same thing you would expect of our students. You have to be respectful, note that everyone's experiences are not the same as yours, so you have to come in with a non-judgmental mindset and an open mindset, that you're not necessarily always going to be the expert, that you have something to learn from the online platform, don't come in just thinking it's there to provide you with resources, as much as sometimes I go into professional development and I think 'well I already know this'. And so, then my mindset has to change 'well if I know this, then I need to be turning around and sharing it with others who are learning it."*

Becky: "*Well I definitely think, just like we teach our students to be respectful when we're giving feedback to each other. I think feedback is important, whether it's negative or positive feedback. I think either way, feedback is impactful (…) So just to share your ideas and be willing to give people feedback. And accept feedback. Sometimes it's hard as adults to accept criticism."*

Motivation to join an online teacher CoP. Brandon and Becky listed resources as the main reason they would want to join an online teacher community:

Brandon: *"For me, the giving and sharing of resources, would probably be number one. But it would be great to be able to go and see video of instructional practice from teachers who are trying it, and the video is authentic teaching, you know sometimes when you watch a video of someone teaching, it's like, 'oh that doesn't look anything like my*

classroom, or my school', or 'that is not how I would do that' or 'it looks a little too perfect, like a movie'. So, it would be awesome to have those videos of real teaching and real time and be able to see some things in action. I would love that. That's hard to come by, because some teachers don't really want to be filmed, you know."

Becky: *"There are so many resources on there from other teachers. It's always nice to be getting new ideas on how to teach the same standards from different people. Everybody has their own lesson plans or something new that you could try. It's free and we're able to go on there and pull lessons and watch video tutorials and things like that. That's very beneficial to us in fourth grade."*

Evidence for homophily in the social network. All interviewees were given a list of teacher names with which they interacted online and were asked to recall any information about those teachers. The objective was to explore any possible trends regarding how teachers chose to engage with one another in online settings. Becky had never posted or replied to any comments on the online platform, therefore she could not inform this specific research question. Brandon had only interacted with one teacher who was also in the periphery of the social network and both of them were disconnected from the main network. When asked about this specific teacher, Brandon explained she worked at a different school; they had met during the foundational training on Instructional Conversations and became friends. Brandon and his new friend engaged in a few online interactions through the CLASE CoP, but now as personal friends, they mostly interacted face-to-face, or via email, or text. Brandon also said that the face-to-face training allowed him to make some friends and connect with teachers from the school where he was about to start a new job:

> *"I made three friends at the CLASE training, so that was great! And I actually got to meet some people from my new school, so the training was great in terms of actually being able to communicate and collaborate and join the IC community. It was a great forum for that."*

Use and value of the online teacher CoP. As discussed earlier, Brandon and Becky were peripheral observers, but they still benefitted from their participation in the CLASE CoP. Brandon used the teacher platform as an instructional coach to support the teachers he supervised. Becky downloaded resources and participated in the webinars. Although Becky did not appear to share any resources on her own, she met with other grade-level teachers in her school to plan lessons collaboratively, but only one teacher shared the materials on the platform.

In Brandon's opinion, instructional conversations fostered collaboration and communication skills in students that were vital for their future success:

> *"I think collaboration and communication, they're vital skills in the job market, they're vital skills for success and in the real world, and in the world of employment. Kids need to be able to do that, and adults need to be able to do that successfully (...) As a teacher, being able to incorporate that and bring that into what I do, and giving the kids the opportunity to communicate with people that they wouldn't normally and be best friends with, to learn that they can work with all types of people who have different mindsets and different goals, and even different work habits from them. I think it's extremely valuable, moving forward, and then as a coach, being able to say 'okay, I've done some of this work and seen through a lot of the logistics of what worked and what didn't work', being able to share that moving forward, to impact someone else's students is powerful."*

Brandon believed the online CoP was a valuable resource to support teachers throughout the year and make sure they had everything they needed to implement instructional conversations "successfully and with fidelity":

> *"I think one of the biggest things that people who go to professional developments struggle with is, 'how do I take this back to my classroom and actually put it into practice and do it successfully and with fidelity?' And so, just knowing that there is an online community where you can get support as you're implementing the process, and you know you don't have to be perfect at it, if there are resources available, and resources are not just things to click on, but people that you can interact with, I think is extremely helpful."*

Becky found the screencasts and video tutorials on how to navigate through the teacher platform particularly helpful. She also pointed out that ICs became part of the culture in her school and the online community was a great resource to help new teachers transition to her school and get familiar with the IC pedagogy and its specific terminology:

> *"The norms and what an IC is and what a JPA is. We found ourselves having to explain it a lot when we were getting new teachers and things like that. Because it's become so fluent here in our school - before so many people had been trained - and we'd be referring to ICs and JPAs, we would forget that the newer teachers had no idea what we were talking about. Now we can just refer them to the online community."*

Becky thought instructional conversations helped her as a teacher to become more patient and empower her students to find answers by themselves and work more independently:

> *"It's changed me as a teacher because... I've learned that I have a really hard time with letting go of the reigns. At first, I was a teacher that wanted to, 'well, you're not gluing that straight. Let me do it for you.' Just the urge to answer or to fill in a sentence for*

them when they are trying to speak. It's just taught me to give them that wait time and to let them be problem solvers, whereas the teacher, sometimes we feel like we need to solve those problems for them. Or 'here, let me do that for you because you're not doing it fast enough.' So, it has taught me to be patient and to have high expectations from my students. Because they can do it 99.9% of the time if you just give them the time, they're going to figure it out and they're going to do it. Even letting them argue a little bit as long as they're doing it respectfully is teaching them to work with others. So as a teacher, it has taught me to be patient and to be intentional in the IC planning."

Becky believed that the online CoP helped to provide sustainable professional development for teachers and made the implementation of instructional conversations more "attainable and doable." Becky and other teachers in her school enjoyed using the virtual classroom because it was convenient and "more time effective" since teachers did not need to commute and could log in from anywhere:

"I think the importance to making it sustainable, especially for educators and just from hearing my fellow teachers talk, is just to make it attainable and doable. I feel like the platform does that. I know when we did the online webinar that I was involved in a couple months ago, I heard several people at work say, "I really liked that. We didn't actually have to take the day off to go and do something, we all communicate and share ideas and things online and not have to even leave our classroom." So, I think everybody enjoys being able to do things online. It just makes it easier. More time effective."

In a discussion with a colleague, Becky pointed out that the online teacher community was updated on a regular basis and it was much more flexible than for example, a resource book:

"I went and talked to my team teacher today, and I said, 'is there anything you guys want to add before I interview with Diego?' His take was that he wished he had... he got a math resource book out of his bag and said, 'I wish I had a book of resources.' And I said, 'but the thing about a book is that it stays the same. The book is printed, it stays the same. The resources in that book don't change. It's not like people are going to add to that book as time goes. Whereas the platform, people are adding new things every day.'"

Concerns, challenges, and low engagement. Becky and Brandon were asked about any challenges or concerns regarding their participation in the CLASE CoP, as well as why they believed other members were not active in the community. Both Becky and Brandon alluded to time constraints. Becky said she could not always participate in the live webinars because the sessions were typically scheduled right after school when she needed to take care of her children:

"I know other people probably feel different about that, but for me personally, I feel like time has been an issue for me with it (webinar) being right after school. And a lot of teachers are just so exhausted by that point, that they'll just watch the virtual - when you share the webinar later from home."

Becky suggested that teachers should be given more time at school to participate in the online community and other professional learning activities. She believed the online community was a great resource and she felt supported to implements ICs. She thought teacher trainers were also constrained by teachers' busy schedules, which should be an important consideration when planning for additional activities:

"We have a lesson planning time of 50 minutes every day, but usually we're in meetings or we're in professional learning. I feel like if maybe we had a professional learning block where we just could spend time on the platform. Even if it was just 15 minutes a

day. This is your platform time to post plans, share plans, give people feedback. If we had that time, I think it would be used a lot more (…) I think you guys are doing a great job. I don't think it's your fault at all that we're overloaded and that there's not enough time to really sit down and engage with each other the way that would be beneficial in the platform."

Brandon agreed that teachers were overwhelmed with all the tasks they were required to complete on a daily basis. However, he believed teachers would find the time to engage in the online community as long as they saw the value of their participation and felt comfortable navigating on the platform:

"I think they just get overwhelmed by all the six million things that they have going on in their brain, all the time. It's not that they would necessarily choose one or the other, or ignore one or the other, but teachers are very overwhelmed, we do ask a lot of them, on a daily basis. Just going through the lesson planning process, they meet with us (instructional coaches) three times a week to do lesson planning and other tasks. So probably just a case of time management, I think. Once they're in there and you facilitate getting them into that platform, that it is- they see the value, it's just taking the time to do that."

Brandon shared a similar perspective with Becky regarding the role of teacher trainers and how they were also constrained by teachers' busy schedules. Brandon suggested it was important to keep reminding teachers about the online community and the many ways in which they could benefit:

"I don't know if there's anything more on your end, it could be more on our end, just utilizing that more as a resource and just creating that reminder, that awareness, that it

is- that platform exists and making sure that they know how to access it, how to get in, and how to locate the resources that they need (…) I think sometimes teachers forget, once they get bogged down in the work, and everything else they're asked to do within the local district or the local school, so just 'hey don't forget you have this great resource' or even highlighting a particular something on that CLASE platform 'hey we have this great resource, don't forget this is available'. Teachers are going to be like 'oh', almost like an advertisement, 'oh that IS there, I forgot about that, let me go log in, I want to go check that out.'"

Extended network. Brandon and Becky benefitted from the online community as peripheral observers, but they also relied on their own personal and professional networks to support their teaching. For example, Brandon belonged to other online teacher groups and communities in his school district. In his building, Brandon typically paired new teachers with teachers who had experience doing ICs so that they could learn from each other. As an instructional coach, Brandon's job was to build teachers' capacity and provide them with as many resources as possible:

"I follow quite a few things on social media, mostly educator related blogs like Edutopia, which I love, TedTalks, everything's not education related necessarily but I get a lot out of that. I follow a couple of authors that have written books in our field, things like that."

Brandon's school was heavily invested in instructional conversations and most teachers were trained in the pedagogy. If Brandon had a question or needed supports about ICs, first he would go to a colleague in his building before going to the online community:

"So we have, in our building, "Nicole" whose video is used at the training. I call her 'our IC guru'. She's kind of my- right now- she's my go-to resource, face to face. But of

course, we have the online community as well, so it's nice to know that there's not just one resource, that there's online, that there's face-to-face, I feel very lucky to be at this school where IC has been embraced so enthusiastically."

Similarly, Becky used the human resources in her school to support her implementation of instructional conversations and find instructional materials:

"If we can't find resources on the online platform, we check with somebody else in the school. We just have a network here at (school name) where we're able to share resources and ideas. But for the most part what we've gone on the platform to look for, we've found. Talking with my grade level, their biggest thing was just the time of going on there and searching for stuff and having the time to do that. It's there, it's just finding the time to use it."

Becky was also used to planning her lesson collaboratively in grade-level teams, where everybody contributed ideas and supported each other:

"We meet on Wednesdays and each of us has a subject. Like I plan reading and then we rotate who plans writing and also plan out a word study. And then we have a teacher who plans math and we have a teacher who plans social studies and science. But we come together on Wednesdays and discuss 'okay, these are the standards coming up. These are some ideas I have as far as delivering the standard.' And then, we collaborate and share our plans on Google Drive so everybody can access them."

Cross-Case Thematic Analysis

Through a cross-case analysis for each type of social network member, eight themes were identified regarding teachers' perceptions of the social network dynamic and the value of their participation. Thematic analysis serves to organize, manage, and summarize the interview data to

focus on their interpretation and better understand the online CoP (Boyatzis, 1998). The analysis followed the steps delineated by Braun and Clarke (2006) in which codes were examined to identify significant patterns of meaning, then themes were reviewed, defined, and labeled. During the process, themes were evaluated against the interview data and clustered, combined, split, or discarded as necessary.

Online CoP was characterized by collaboration and mutual support. Teachers defined a community of practice in terms of opportunities to collaborate, share best practices and resources, ask questions, offer help and advice, and interact with peers. Online interactions may be synchronous or asynchronous and the platform needed to be easy to use and conducive to conversation and communication. Although teachers expected to find educational resources in an online CoP, a community differed from other "resource websites" because the former provided opportunities for professional development and mutual support as opposed to other "consumer-driven resource websites".

Teachers emphasized the convenience and flexibility of participating in an online CoP for professional development. Members could engage with other peers, join live webinars, or watch a recorded session anytime and anywhere. Teachers did not need to commute or find substitute teachers to engage in the CoP. They could also meet with other educators who may live or work in different geographical areas. This was particularly important for a small group of teachers who were trying to collaborate internationally.

Community members needed to set norms and expectations. Norms and expectations were important for the community to be sustainable and to guarantee that everyone's voice was heard. Conversational norms were a fundamental aspect of the instructional conversation pedagogy and teachers were encouraged to set those norms with their students at the beginning

of the year, and constantly review and adjust those norms. Given their training in the IC pedagogy, teachers may have been more aware of the importance of setting norms than other educators. With the help of the teacher trainers, members of the CoP set the following norms for their online interactions:

- Do not overuse capital letters or exclamation points.
- Use standard grammar and punctuation.
- Listen to understand and not to respond.
- Try to build off each other's comments and ideas.
- Be purposeful, considerate and professional. What is the purpose of your comment? Would you say this to someone's face?
- Assume good will.
- Explicitly explain your procedures. Do not assume people know what you're talking about. Spell out acronyms.
- Share lesson plans and materials that are ready to be used by other teachers. If you're using any specific books or materials other teachers may not have access to, please list a few alternatives.
- If you use someone else's materials, leave a note to thank this person. You can also say how you adapted or expanded the lesson.
- Make sure you participate and use the platform on a regular basis (maybe set a day to make it a habit).

Only one educator did not find setting norms and expectations to be as necessary for a teacher CoP as it would be for other public or broader communities. She believed that teachers

were already used to carrying themselves in a professional manner and they were not likely to engage in disrespectful behavior.

The online CoP helped to reduce isolation and provided ongoing support. Teachers believed that the online CoP helped them implement the IC pedagogy after attending the foundational training over the summer as they felt supported throughout the year. The online CoP allowed teachers to ask questions, get feedback, share instructional resources and samples of students' work. The CoP was particularly helpful for teachers who felt isolated in the building because they were the only educators teaching a specific content area or the only ones implementing ICs at the school. When teachers were the only ones in their building doing instructional conversations, it was difficult to keep "the momentum going." Teachers appreciated having an online community to "bounce ideas" and seek support.

Teachers found the CoP made implementation of the IC pedagogy doable by providing sustainable professional development. Teachers compared the CLASE CoP to other professional development programs they had attended and concluded that the CoP made ICs attainable throughout the year. Other professional initiatives did not provide any further assistance or support beyond the required face-to-face training sessions. Teachers argued that when they are left alone, any type of systemic change or pedagogical innovation is set up for failure.

Access to high-quality instructional materials as the main reason to join the online CoP. Access to high-quality instructional resources was one of the top reasons teachers decided to join a CoP, followed by opportunities for collaboration, mentorship, and peer feedback. Educators were always looking for new and innovative ways to teach and help their students understand the content a little better. Teachers expressed that looking at other peers' work helped them to think "outside the box" and come up with new strategies to teach. Teachers would even

look for ideas across grades or subject areas and adapt those ideas to fit their students and their context.

Also, teachers valued having access to high-quality materials that others had tried and found to be effective. Sometimes teachers had access to an overload of resources and information, but it took a lot of time and effort to review and select high-quality materials that were appropriate for the teacher's context. Having access to materials that others had used and vetted was beneficial and helped teachers not to have to "re-invent the wheel." To facilitate the lesson plan sharing, the CLASE coaches created a standardized lesson plan template for the purposes of consistency and ease of implementation. Additionally, teachers had the opportunity to consult with coaches one-on-one and receive feedback on their lesson plans.

Teachers were aware that they could not only download resources, but they also had to contribute their own teaching materials and give back to the community. Sharing lesson plans that could be implemented by other educators involved a process of self-reflection and awareness. Sometimes, teachers omitted specific steps or components of a lesson plan when they were planning for themselves. However, all procedures needed to be clearly stated for other educators to be able to implement a lesson plan with fidelity.

Teachers found personal and professional value by participating in the online CoP. Teachers used the online CoP to share advice and resources, seek support, and collaborate with peers. Both of the core contributors interviewed and one of the brokers were part of a district-level leadership team to support other educators in the county to implement instructional conversations. The leadership team regularly met through the virtual classroom to discuss ideas, share joys and concerns, and define action steps to support their peers. Teachers indicated that the online community was a great resource for novice teachers to get feedback and advice from

more seasoned educators. Experienced teachers expressed their desire to help and share what they had learned with others who may be new to the profession.

The online CoP was a great resource to introduce new teachers to the IC pedagogy. In schools in which the majority of the staff was trained in the IC, grade-level teachers shared a common understanding of the pedagogy when planning their lesson collaboratively. New teachers coming to the school were advised to join the online CoP to get familiar with the pedagogy before attending the foundational training. Having so many online resources facilitated co-teaching and lesson planning at the school level.

Teachers also reported changes in their practice as a result of the IC pedagogy and their participation in the online CoP. Teachers became more aware of their role as facilitators and the importance of letting their students do most of the work, even if they struggled in the process. One teacher stated she learned that students could almost always find a solution to an instructional problem by themselves if they were given enough time to think and discuss. She also learned to have high expectations of all her students and step back whenever appropriate. Students with limited language proficiency could still participate in instructional conversations and benefitted from them. Another teacher claimed ICs helped her empower her students, give them a voice, and cultivate a risk-free learning environment.

Participants also suggested that participating in the online CoP helped them to become more reflective of their own practice and more intentional when sharing resources. Because lesson plans were to be shared and implemented by other educators, teachers needed to be more explicit about all the instructional procedures, transitions, and each component of the lesson plan. Sharing teaching materials allowed teachers to reflect about "why they were doing what they were doing and why it worked."

Teachers who were pursuing graduate degrees used the resources in the CoP to guide their research efforts. Teachers would either peruse the website to better understand the philosophy behind the IC pedagogy and formulate their own research questions; or they would contact members of the CoP for guidance and direction. The online CoP offered a space for researchers to share articles and literature regarding the IC pedagogy that novice researchers found helpful.

The CoP was a valuable asset for instructional coaches at the school level to support the teachers they supervised and provide them with high-quality resources. One of the peripheral observers who was interviewed, Brandon, worked as a coach but did not appear to be an active member on the online CoP. He explained he used to read and explore the CoP very often when he was first introduced to instructional conversations. As the academic year progressed, Brandon started to redirect his teachers to the online resources in the CoP prior to meeting with him, which facilitated the lesson planning process. In Brandon's experience, when teachers attended professional development programs, they sometimes struggled to take what they had learned back to their classroom and implement it successfully and with fidelity. The CLASE CoP provided enough support and resources, not only in terms of instructional materials but also human resources; teachers were able to ask questions and interact with peers.

At the personal level, teachers were able to form connections during the foundational training and through their participation in the online CoP. One teacher became close friends with a member of the CoP that he met during the summer. They both taught at different schools and their friendship strengthened throughout the year. Interestingly, teachers' online interactions moved away from the online CoP to other means of communication as their relationship became more personal and not exclusively professional.

Preference to reach out in person to members of the online CoP at the workplace. When teachers were in need of support, they expressed a preference to first contact other peers in their building who had also been trained in the IC pedagogy before using their online CoP. This was true for all teachers except for those who were isolated in their schools. Teachers found that physical proximity made it much easier to interact and work with other peers than online environments. For example, teachers in the same school were able to visit each other's classrooms, model best practices, and discuss ideas.

Some teachers were also used to planning their lessons collaboratively in grade-level teams to support each other and distribute the workload. As a result, teachers built strong CoPs at their workplace and they relied on them as their first choice. People in the school building were always the first resource when a teacher was facing a roadblock or needed assistance. Unfortunately, face-to-face teacher interactions and collaboration were not represented in this study, even though both the online CoP and the CoP at the workplace may have shared the same members.

One of the peripheral observers explained that she would never consider online graduate programs because she was very personal and enjoyed seeing and talking to other people. However, she admitted that online communication was becoming more prominent and it could sometimes be more time efficient. For example, she found the virtual classroom in the online CoP to be extremely convenient to meet with teachers from other schools and districts without having to commute or look for substitute teachers.

Time as the main constraint to participate in the online CoP. All interviewed participants unanimously agreed that finding time to engage in the online CoP was the main challenge. As one teacher put it: "There's always something that's due, there's always something

that's past due, there's always something that's coming up that needs to be addressed." In addition to the time spent in the classroom, teachers had to prepare their lessons, assess their students, and comply with the many demands from their school administration. Because time was scarce, teachers tended to prioritize the tasks that their principal valued the most. If professional learning was not a priority for the school administration, then such opportunities were left aside or were not given enough attention. The vision and expectation of the school administrators needed to support what teachers were doing in the classroom.

Teachers also agreed that they were more likely to find time to engage in the online CoP if they could see the value of their participation. Sometimes, they may have forgotten what resources were available to them or how they could benefit from the CoP. For this reason, participants suggested that teachers needed to be periodically reminded of how and why the CoP could support what they did in the classroom. They needed to "experience the benefits" to want to come back on their own. One teacher suggested that school administrators should provide teachers with more time to spend on professional learning activities. She claimed that having that extra time would make it easier to participate in the CLASE CoP and other professional activities.

From a logistical point of view, teachers needed to feel comfortable navigating the online platform and performing simple tasks online. Making the online platform a priority during the face-to-face foundational training may have facilitated teachers' use and engagement in the online CoP throughout the year. One of the participants believed that the online CoP was a new initiative because she did not receive enough exposure to it during the face-to-face training. The platform was briefly mentioned during the workshop, but teachers did not become familiar with the website given Internet connectivity issues at that specific training site.

Mixed evidence found regarding homophily in the online CoP. The qualitative findings provided mixed evidence concerning whether there was assortative mixing in the social network/CoP. Assortative mixing, or homophily, refers to the tendency in most social networks for people to interact with others who share similar characteristics, demographics, or backgrounds. All participants interviewed were given a list of teachers with whom they had interacted online and were asked to recall any relevant information regarding those interactions. The purpose was to determine whether teachers were more likely to engage with other teachers from the same school, grade level, district, or teachers they personally knew. About half of the participants interviewed were not able to recall any information about their online conversations or the people with whom they had interacted. The other half of the participants were able to remember at least some of their online peers. One core contributor and one peripheral observer were able to describe in detail who their online peers were, how they had met, schools where they worked, and other background information.

Participants were asked explicitly how or why they had chosen to interact with specific members. Again, mixed evidence was found regarding assortative mixing in the CoP. Some participants stated that they would reply to any comments or questions if they had anything valuable to say, regardless of whether they knew that person or not. Others said they typically searched for teachers in the same grade level or content area to read their posts and lesson plans. One broker explained that she sometimes posted short comments to thank or congratulate someone but such interactions were so short that she did not have an opportunity to get to know the person. This broker also claimed that whenever she was unable to find a specific resource for her grade level, she would look across grades to find ideas and adapt those to her students. Therefore, interacting with peers who taught the same level or content area was not an important

factor to her. The other broker believed that interaction in the online CoP was based on grade level. She argued that personally knowing a member was not a determining factor to engage in an online conversation. However, she was less likely to chat with someone in real time if she did not know them personally.

RQ3. How do Teachers' Perceptions about the Online CoP Help Explain and Expand the Structural Network Analysis?

This research question seeks to discuss meta-inferences (Teddlie & Tashakkori, 2003) based on both quantitative and qualitative findings. In this explanatory sequential design (Creswell, 2014), qualitative data helped to explain and elaborate on the quantitative results with the purposes of complementarity and triangulation (Greene, 2007). Meta-inferences may provide a deeper understanding of the online teacher CoP as a social network and professional development tool. Overall, four meta-inferences were withdrawn from the analyses: 1) The roles of core contributors, brokers, and peripheral observers were confirmed in the qualitative analysis; 2) peripheral observers benefited from their participation in the online CoP; 3) face-to-face teacher collaboration was not represented in the online CoP; and 4) mixed evidence for homophily was found in the online CoP.

The roles of core contributors, brokers, and peripheral observers were confirmed in the qualitative analysis. In the SNA, node centrality measures (i.e. degree, closeness, betweenness, and eigenvector) were used to identify actors of interest in the network. Specifically, two core contributors, two brokers, and two peripheral observers were identified for in-depth interviews. Core contributors were highly active members who posted often and interacted with other peers in the CoP as indicated by their high centrality measures. Interview data revealed that the core contributors, Nicole and Chandler, were not only prominent members

of the online CoP but they were also identified as leaders in the IC pedagogy at the school and district levels. Nicole had been appointed as the IC coach at her school and both Nicole and Chandler were part of a district-level leadership team, whose goal was to facilitate the implementation and adoption of the pedagogy in the county.

Nicole and Chandler believed in the impact that the IC pedagogy had on their students' learning and the culture of their school. They were excited to be in a position to help other colleagues learn more about ICs and do what -they believed- was best for children. Nicole and Chandler had an important role in mentoring and motivating teachers to engage in the online CoP more often. The leadership team regularly met with the teacher trainers to discuss ideas and report concerns and challenges they had observed in their schools. Thus, the leadership team served as an important liaison between teacher trainers and teachers in the field. Through the work and feedback of core contributors, teacher trainers were able to inform their decisions and adjust their professional development efforts to respond to the needs of teachers in the field.

Brokers were members who served as a bridge to connect subgroups of teachers. In the SNA, brokers were identified based on their betweenness centrality measures. An analysis of cut vertices (i.e. nodes in the graph that if removed disconnect the network) further informed the identification of brokers. Anna and Christina were invited for in-depth interviews to understand their perceptions of the social network and the value of the online CoP. Both of them were confirmed as members who had a vital role in promoting the IC pedagogy in their schools and getting more teachers interested. Anna, for example, was the only ESOL teacher in her school and the first one to implement ICs. After participating in the foundational training, she started to share what she had learned with other colleagues in her school. Anna's peers also noticed academic and behavioral changes in her students, which encouraged them to approach Anna and

ask about what she was doing in the classroom. At the time of this study, many teachers at Anna's school were on the waiting list to participate in the IC foundational training the following summer.

Christina had an important role as a broker in the CoP as well. She was invited to join the district-level leadership team with Nicole and Chandler. The team contributed greatly to the dissemination and expansion of the CoP around the IC pedagogy. Christina believed that ICs transformed her teaching practice and the online CoP provided plenty of opportunities for support and ongoing professional development throughout the academic year. Christina often went online and left messages to other members in the CoP to thank them for their posts or to encourage them to participate more. Both Anna and Christina served a role as brokers not only in the online CoP, but also at their workplace.

Peripheral observers are members who are disconnected from the main network component and thus, located in the periphery. In the SNA, peripheral observers were identified based on their low centrality measures, specifically their degree, closeness, and eigenvalue scores. Through their interview data, Brandon and Becky were confirmed as *legitimate* peripheral observers (or lurkers) because although they did not appear to be active members, they still engaged with the CoP and benefited from their participation. Brandon used the CoP as an instructional coach to support the teachers he supervised. Becky attended webinars, downloaded materials, and participated in collaborative lesson planning sessions with other grade-level teachers at her school.

Peripheral observers benefited from their participation in the online CoP. Brandon and Becky attributed their low levels of engagement in the online CoP to different reasons. Brandon used to explore the CoP very often when he was first introduced to instructional

conversations, but as the year progressed, the way he used the CoP changed. As a coach, Brandon's job was to communicate the vision and expectations from the school administration, and helped teachers build their capacity as educators. During the academic year, he worked hard to cultivate a CoP at the workplace but given the lack of time, he assumed a more passive role in the online CoP. He still redirected his teachers to the many resources in the online CoP.

Becky thought of herself as someone who preferred face-to-face communication over online interactions. Also, she said she did not learn about the online CoP until recently. Although the CoP was introduced during the foundational training that Becky attended during the summer, she did not have enough opportunities to get familiar with the CoP. The training facility did not offer a reliable internet connection and as a consequence, the online CoP did not receive as much attention. Becky still benefited from the CoP and visited the website once per week to download resources, read teacher comments, and participate in the Webinars. Becky was used to planning her lessons with her grade-level team at her school. They planned different lessons for fourth-grade students but only one teacher shared the lesson plans in the online CoP. For this reason, Becky did not seem to be an active contributor in the online platform, when in reality, she created some of the resources being shared.

The SNA analysis of the Teacher Network revealed that four members were located in the periphery and 149 members never posted a comment or reply to the online CoP. Brandon and Becky were a very small sample of that subset of teachers. Through their interview responses, Brandon and Becky were found to indirectly engage in the CoP and benefit from their participation. However, very little is known regarding peripheral observers and isolated nodes in the CLASE CoP in general. Further research is required to explore the attitudes and participation of the CoP members at large, and peripheral observers in particular.

Face-to-face teacher collaboration was not represented in the online CoP. The online CoP was studied using two different networks. The first network, or sociotechnical interaction network (STIN), included three non-human actors as members of the CoP (i.e. IC blog, Lesson Plans, and Teacher's Corner), 149 isolated nodes, and 275 isolated posts. Isolated nodes were teachers who never posted or participated in the CoP. Isolated posts refer to online postings that did not generate any type of discussion and did not get any responses from other CoP members. The second network, or Teacher Network, only considered human actors and did not include any isolated nodes or posts. In total, the STIN network was composed of 630 online interactions among 385 members. The Teacher Network included 518 online interactions among 166 members.

A descriptive analysis of the STIN and Teacher network attributes was conducted. Furthermore, node centrality measures and homophily coefficients were generated based on the online interactions. Each online interaction was recorded along with the name of the sender, the name of the receiver, and the interaction type. Interactions refer to any posts, comments, or replies between members of the CLASE CoP (see Chapter 3 for coding details). Interactions were categorized into six types: 1) resource sharing; 2) help giving; 3) help seeking; 4) social sharing; 5) thanking or replying; and 6) posing a question or task.

The qualitative analysis of the teacher interviews revealed that teachers had a preference to reach out in person to members of the online CoP at their workplace whenever possible. Although a few teachers started implementing instructional conversations in isolation, most schools decided to adopt the IC pedagogy and more teachers were sent to participate in the IC foundational training. The adoption rate of the IC pedagogy across schools varied from a few teachers to most of the staff in schools with a lot of administration support. As a result, informal

communities of practice were formed at the school level. In the interviews, teachers expressed a preference to contact peers in their building for advice and support before reaching out to the online CoP. Physical proximity allowed teachers to visit each other, model best practices, share materials, plan lessons together, and collaborate more effectively.

Although the school CoPs may have shared the same members as the online CoP, face-to-face teacher interactions and collaboration were not taken into consideration for the current study. Therefore, the online CoP may underestimate how much teachers relied on their peers for support and professional learning. Research on how teachers navigate between online and offline CoPs may provide further insights into teacher learning and help to inform decision makers.

Mixed evidence for homophily was found in the online CoP. Assortativity coefficients were calculated during the SNA to assess the likelihood of teachers to interact with other peers who shared the same gender, workplace, county, grade, subject, level (i.e. elementary, middle, or high school), or role (i.e. teacher or instructor). The hypothesis was that teachers would tend to interact with others who shared similar characteristics. Correlation coefficients did not support such hypothesis. There was no evidence that mixing in the network occurred based on any of the categorical variables considered. The largest coefficient found (-0.24) was for the "role" variable, suggesting a small correlation for teachers to interact with instructors. The other variables yielded correlation coefficients close to zero. Note that instructors were part of the SNA analysis, so results must be interpreted with caution. Variables such as grade, level, or subject were undefined for instructors because they were not classroom teachers. Therefore, all the teacher-instructor interactions may have skewed the correlation coefficients and underestimated the tendency for teachers to interact with peers who worked at the same school or taught the same grades or content areas. Interactions involving instructors accounted for about

25% of all member interactions in the online CoP. Further homophily analyses need to exclude instructors and test assortative mixing only between teachers in the online network.

Teacher interviews in the qualitative phase provided mixed evidence regarding homophily in the social network. Some participants suggested that they answered questions or replied to discussion threads, regardless of who was involved. Other teachers claimed they searched for lesson plans and resources across grades and subjects and adapted those ideas to their context. For this reason, those teachers did not limit their searches to a specific grade level or content area. When asked to recall information about the people with whom teachers had interacted in the online CoP, about half of the participants were unable to remember who their peers were or provide any background information. This evidence supports the hypothesis that there is no assortative mixing occurring in the teacher network.

Participants were also explicitly asked how or why they chose to interact with others in the CoP and many of them believed it was based on grade level and content area. Since sharing resources was one of the main reasons why teachers joined the online CoP, they normally browsed discussion threads and blogs that were specifically related to their grade level and content areas. When asked about prior interactions, one core contributor and one peripheral observer were able to provide detailed information about their online peers, including school names, how they had met, how they had collaborated, etc. This evidence supports the hypothesis that there might be assortative mixing in the CoP and teachers may tend to engage with others based on common characteristics or prior personal encounters. The mixed methods lens in this study served to triangulate the data and homophily remains an area for further analysis.

Summary

In this chapter, findings for each research question were addressed separately:

1) How is the online CoP structured as a sociotechnical network?
2) How do teachers perceive the social network dynamics and the value of their participation in the online CoP?
3) How do teachers' perceptions about the online CoP help explain and expand the structural network analysis?

The first question explored the attributes of the STIN and Teacher networks in terms of their density, diameter, dyads, transitivity, reciprocity, cliques, components, and cut vertices. The STIN and Teacher Networks used the same data sources but differed regarding coding procedures (see Chapter 3), the conceptualization of network members, and the inclusion of isolated members and isolated posts. The STIN network included three non-human actors (IC blog, Lesson Plans, and Teacher's Corner), 149 isolated members who never participated in the CoP, and 275 isolated postings that did not get any comments from other members. The Teacher network only included human actors and excluded isolated members and isolated posts.

Node centrality was explored for both the STIN and Teacher Networks to identify core members, brokers, peripheral observers, and other members of interest. Measures of centrality were calculated at the local level (i.e. node degree) as well as the global level (i.e. closeness, eigenvector, betweenness). Then, the tendency for teachers to interact with others who shared similar characteristics (i.e. homophily or assortativity) was evaluated using correlation coefficients. Assortativity coefficients were calculated for six categorical variables: role, gender, school, district, level, grade, and subject. No evidence for assortative mixing was found,

suggesting that interactions in the network were no different from that obtained through a random assignment of connections preserving the marginal degree distribution.

The second question was qualitative in nature and examined teachers' perceptions of the social network dynamics and the value of their participation. In-depth interviews with two core contributors, two brokers, and two peripheral observers were analyzed. Deductive and inductive coding procedures were used during the thematic analysis to determine patterns and commonalities. The discussion of the findings was divided into a section for within-case analysis, and a section for cross-case analysis. In general, eight themes were derived and identified from the dataset: 1) The online CoP was characterized by collaboration and mutual support; 2) community members needed to set norms and expectations; 3) the online CoP helped to reduce isolation and provided ongoing support; 4) access to high-quality instructional materials as the main reason to join the online CoP; 5) teachers found personal and professional value by participating in the online CoP; 6) preference to reach out in person to members of the online CoP at the workplace; 7) time as the main constraint to participate in the online CoP; and 8) mixed evidence found regarding homophily in the CoP.

The third question was mixed in nature and discussed meta-inferences (Teddlie & Tashakkori, 2003) based on both quantitative and qualitative findings. The purpose of the qualitative findings was to deepen and elucidate the social network analysis. Overall, four meta-inferences were withdrawn from the analyses: 1) The roles of core contributors, brokers, and peripheral observers were confirmed in the qualitative analysis; 2) peripheral observers benefited from their CoP participation; 3) face-to-face teacher collaboration was not represented in the online CoP; and 4) mixed evidence was found for homophily in the CoP.

CHAPTER 5

DISCUSSION

The purpose of this mixed methods study was to describe the formation, development, and evolution of an online teacher Community of Practice (CoP) as a sociotechnical network to support teacher's implementation of the Instructional Conversation pedagogy. The research questions revolved around how the online CoP was structured as a sociotechnical network, how teachers perceived the social network dynamics and the value of their participation, and how teachers' perceptions helped to explain and expand the structural network analysis.

This chapter situates the research findings within the broader literature. The discussion is structured around four main areas: 1) CoPs and cultural-historical activity theory; 2) CoPs and social networks; 3) value creation in CoPs; and 4) CoPs and teacher professional development. Then, implications for theory, research, and practice are discussed as well as limitations and suggestions for future research.

Communities of Practice and Cultural-Historical Activity Theory

Cultural-historical activity theory (CHAT) serves as a framework to understand the mediation of material, symbolic, or cultural artifacts in human experience (Cole, 1996; Engeström, 2001; González Rey, 2011; Leont'ev, 1978; Vygotsky, 1978). Engeström's (1987, 2001) proposed three generations of CHAT: Vygotsky's cultural mediation, Leont'ev's activity system, and his own model. In Engeström's (1987) model, the subject and the object are mediated through tools, signs, rules, community, and division of labor (see Figure 5 in Chapter 2). Later, Engeström (2001, 2009) suggested that the unit of analysis should include at least two

interacting activity systems that construct a shared product (see Figure 6 in Chapter 2). The revised model represented how activity systems exist within a larger and interconnected social world.

The CLASE CoP provides empirical support to some of the components in Engeström's model, specifically how *rules* and *division of labor* mediate human activity. Rules define socially acceptable interactions and the division of labor guarantees that tasks, power, and responsibilities are distributed among stakeholders. Teachers in the CLASE CoP found that setting norms and expectations was of paramount importance to facilitate a sustainable community. With encouragement from their trainers, teachers in the CLASE CoP discussed norms and expectations to guide their online interactions. Teachers explored how norms that are typically used during face-to-face conversations needed to be adapted or modified for online settings. Teachers set norms regarding the use of written language, how to approach and interact with others online, and participation expectations. Note that teachers in the CLASE CoP may be more aware of the importance of *rules* and *division of labor* given their training on the instructional conversation pedagogy. Setting conversational norms, goals, and distributing tasks are fundamental aspects of instructional conversations.

The CLASE CoP offers support for Engeström's (2001, 2009) revised model as well. In his new conceptualization, Engeström argued that activity systems interact with each other to produce a shared product. The CLASE online teacher CoP is conceived as an activity system that is part of a larger sociotechnical network. Each teacher is a member of different communities and navigates through formal and informal learning networks. Teachers are able to access a vast network of resources and experiences not only in their immediate environment, but also at a global level through modern technology. Teachers sought professional support through the

CLASE CoP, their personal networks and the many resources available to them on the Internet. As Engeström (2001) suggested, activity systems have a dynamic structure and are characterized by multi-voicedness, which is represented by diversity in backgrounds, history, and interests in the system.

However, Engeström's model of activity theory has two major flaws. First, the model fails to represent historicity, or how cognition is distributed through time from generation to generation (Cole & Engeström, 1997). And second, the model is ontologically problematic when applied to communities of practice (Barab, Schatz, et al., 2004). The study of the CLASE CoP challenges Engeström's model in the context of a community of practice because *subject*, *object*, *artifacts*, and *community* are not separate entities. According to Engeström, the purpose of the subject is to transform the object through the mediation of artifacts and community. Community is understood as the group's complete collection of artifacts and rules over time. In a CoP, the notion of community is not only the mediator but also the subject, the object, and the artifact of the human activity. In other words, the community engages as an agent and mediator in a human activity where strengthening the sense of community is by itself, one of the goals. Such complexity troubles the role of community in Engeström's model as not only a mediation tool, but a more holistic component.

An important application of CHAT in instructional design is the study of the hierarchy of the activity to identify relationships and contradictions in the system (Yamagata-Lynch, 2010). These contradictions are not interpreted as dysfunctions, but rather as potential areas for intervention and improvement in a developing system (Cole & Engeström, 1997). The hierarchy of human activity can be decomposed into *motives*, *actions*, and *operations* (Leont'ev, 1978). The motive represents the object or direction of the activity. Actions refer to conscious goals to

achieve a purpose. And operations are the conditions or methods necessary to execute an action. The subject conducting the activity may not be aware of the true motive or operations. The study of such hierarchy may reveal relationships and contradictions that may not be evident otherwise (Leont'ev, 1978).

In the CLASE CoP, contradictions occur when activity systems conflict with each other or when stakeholders have different motives, actions, or operations in the pursuit of an activity. For example, teachers in the CLASE CoP belong to different communities and networks, and each of them may constitute a separate activity system. Given the limited time and resources, teachers need to make decisions regarding where to find professional support to implement instructional conversations. Sometimes, teachers resorted to their CoP at their school or decided to reach out to the online CoP. Different online platforms and websites may have competed with each other and teachers were forced to make decisions about where to find the best instructional resources that fit their unique context. Furthermore, stakeholders in the CLASE CoP may have had different understandings of the shared goals and how to achieve them. School administrators, for example, may have found more value in face-to-face collaboration to support instructional conversations than online interactions. Or teacher trainers may have planned professional events and activities without considering teachers' limited time. Examining possible contradictions in the activity system represented a valuable opportunity to inform decision making and the instructional design process.

Other applications of activity theory in teacher professional development include the conceptualization of an online teacher community (Barab, Schatz, et al., 2004), and the analysis of inner contradictions and tensions (Yamagata-Lynch & Haudenschild, 2009). Barab, Schatz, et al. (2004) facilitated a CoP around inquiry-based learning and learner-centered classrooms

involving school teachers, administrators, university faculty, and pre-service teachers. They designed a virtual space, the *Inquiry Learning Forum* (ILF), for teachers to reflect on their practice and share artifacts. The purpose of the study was to understand design principles for facilitating, sustaining, and scaling a CoP, and describe teacher's engagement. The CoP was conceptualized using activity theory to identify tensions within the system, and sociotechnical interactions networks to highlight the transactional nature between human and technological structures. The researchers concluded that both frameworks worked synergistically to offer a deeper understanding of activity design and community functioning.

Yamagata-Lynch and Haudenschild (2009) examined teachers' perceptions regarding sources of conflict in their professional development. The researchers used Engeström's (1987) four levels of inner contradictions in activity systems to guide their study. Primary contradictions occur when participants encounter more than one value system attached to an element. Secondary contradictions manifest when participants encounter a new element of an activity that generates conflict when assimilated into the system. Tertiary contradictions refer to the participants' conflict when adopting a new method for achieving the object. And quaternary contradictions occur when participants encounter changes to an activity that create conflict with adjacent systems. Based on interviews with four high school teachers and three administrators, Yamagata-Lynch and Haudenschild (2009) concluded that teachers' motivation and goals for participating in professional learning activities did not align with those of school administrators and teacher trainers. Such tensions developed into situational challenges and obstacles for teachers to improve their classroom practices. Using Engeström's framework, at level 1, teachers, districts, and trainers disagreed on how to spend time and money on professional development activities. At level 2, districts and teacher trainers did not consider how new

teaching expectations conflicted with teacher's daily responsibilities. At level 3, new teaching methods did not fit into teachers' daily classroom practices. And at level 4, teachers' new practice conflicted with other activities in the classroom and required additional changes.

In short, the CLASE CoP adds a new lens to the study of online teacher CoPs from a cultural historical activity perspective. First, the CLASE CoP provides empirical support for Engeström's third generation of activity theory (1987) and his revised model (2001), at the same time that challenges the role of *community* within the system. The CLASE CoP exemplifies how *rules* and *division of labor* mediate online teacher CoPs and how activity systems interact with one another. Community should not be considered an isolated entity but a holistic component of the system, where community serves as the subject, tool, mediator, and object of the activity. Second, the CLASE CoP adds to the literature on tensions and contradictions in teacher professional development (e.g. Barab, Schatz, et al., 2004; Yamagata-Lynch & Haudenschild, 2009). Identifying such tensions translates into valuable opportunities to inform instructional design decisions and facilitate activity and community functioning.

Communities of Practice and Social Networks

Members of the CLASE CoP defined a CoP as a professional group that provides opportunities to collaborate, ask questions, offer advice, interact with others, and share best practices or resources. The CoP should be easy to navigate and provide both synchronous and asynchronous means of communication. Previously, a CoP had been defined as "a persistent, sustained social network of individuals who share and develop an overlapping knowledge base, set of beliefs, values, history and experiences focused on a common practice and/or mutual enterprise" (Barab, MaKinster, et al., 2004, p. 55). The CLASE CoP exhibits those characteristics and has the potential to grow and persist over time. As a network, the CLASE

CoP allowed participants to engage in online conversations and share resources. Teachers found that the online CoP was flexible enough to accommodate their busy schedules, allowed for collaboration with peers across schools and districts, and reduced the need to commute long distances.

Wenger et al. (2011) distinguished between CoPs and social networks as separate but complementary aspects of the "social fabric of learning" (p. 13). The notion of CoP emphasizes the shared identity and the collective intention of a group, whereas a social network highlights the connections or relationships among participants (Wenger et al., 2011). A network does not imply a community or vice versa. For example, a group of individuals who do not know each other may be connected through someone's personal network, or members of a community may not be connected to each other from a network perspective. A CoP can foster trust and commitment towards a shared goal while networks may optimize connectivity and shared resources (Wenger et al., 2011). Being more interconnected correlates with higher sense of community and both constructs typically develop together. A community usually involves a network of relationships, and a network may exist because individuals share a common goal.

Both communities and networks enable social learning, provide value, and pose different risks and challenges (Wenger et al., 2011). Communities provide a formal or informal learning partnership among participants who share a collective intention. The shared commitment to a domain or practice along with the joint history of the group constitute valuable learning resources. The risk of a community is to become inward-focused by not being able to expand its history, membership, and established ways of doing things. The challenge of a community is to become self-sustainable and engage enough members to persevere as a social entity (Wenger et al., 2011).

Networks, on the other hand, do not require a sustained learning partnership or a commitment to a shared domain or practice (Wenger et al., 2011). Networks facilitate learning by providing access to information flows and resources. The value of networks consists in their ability to offer multiple perspectives and ease to disseminate ideas or resources. Such power of diffusion may also become a challenge as information can be distorted as it travels through the network. Therefore, the success of a network depends on the maintenance of its connections and the capacity of its members to evaluate the fidelity and reliability of the information. Members of a network need to strive for a collective intention to be able to take a common direction and advance a domain or practice.

Wenger et al. (2011) argued that communities and networks are complementary structures that can empower social learning. Both entities can build on each other's strengths, risks, and challenges. For example, members of a network that lacks a collective intentionality may benefit from community-building activities to see each other as learning partners and reach a common goal. Similarly, a community that has become closed and inward-focused may benefit from a broader network that may bring new perspectives, information, and human resources. Therefore, social learning is enhanced by the interplay and complementarity of both community and network processes.

An aspect that Wenger et al. (2011) did not consider in their characterization of networks and communities of practice is the role of technology to mediate social learning. Typically, social networks only involve human actors and disregard how technology can shape the way we interact with the world. Sociotechnical interaction networks (STIN) acknowledge the role of both human and non-human agents in a dialogic and symmetrical relationship (Kling et al., 2003). A STIN approach may reveal the transactional nature of activity systems by examining social,

economic and political interactions among human and non-human actors. Assigning agency to non-human agents is an area of tension within different philosophical traditions in network theory (Emirbayer & Goodwin, 1994). However, many defend the capacity of technology to influence and be influenced by the social world (Kling & Courtright, 2003; Latour, 1996).

Teacher CoPs have been studied from either a community or a network approach. For example, social network analysis has been used to study peer interaction and support networks in MOOCs for educators, concluding that technology can mediate and enable the process of knowledge construction (Kellogg et al., 2014; Kellogg & Edelmann, 2015). However, very little is known regarding the intersection between community and network in the context of teacher CoPs (see Macià & García, 2016 for a review of the literature). The study of the CLASE CoP explores how teacher communities and networks overlap and work together as complementary aspects of the "social fabric of learning" (Wenger et al., 2011, p. 13).

The CLASE CoP exemplifies how teachers belong to multiple networks and communities that overlap and transact, creating sociotechnical interaction networks. Participants of the CLASE CoP revealed during interviews that they were also members of other teacher communities and networks at the local, regional, and international level. For example, one of the teachers interviewed served as a moderator for an educational chat on Twitter that she joined because of a podcast. In the "EdChat," pre-service, in-service, and retired educators around the world answered questions, offered advice, and engaged in real time discussions through the use of Twitter hashtags. Members of this community/network agreed on a given time, day of the week, and topic to participate. In this case, technology served as an enabling agent for the community to exist through a sociotechnical interaction network. Each participant brings a unique set of tools, information, and experiences that are leveraged by their use of technology.

Additional research is necessary to further unpack the complexities of teacher networks and communities. Particularly, the study of the CLASE CoP suggests that educators cross boundaries between online and real-life communities and networks. Teachers in the CLASE CoP created informal CoPs at their workplace to support each other to implement instructional conversations. When teachers needed support, their first choice was to rely on the CoP at their local school. Proximity and stronger personal ties facilitated teacher interaction in real life. Note that the real-life and online CoPs may have shared many of the same members. Others have suggested that teachers' networks are more connected in real life than online, but both types of network complement each other and are necessary to foster teacher collaboration (e.g. Lin et al., 2016; Mackey & Evans, 2011).

Value Creation in Communities of Practice

Wenger et al. (2011) suggested a framework to assess the value creation in communities and networks. Value creation refers to the benefits that members find through their participation in a CoP, such as the acquisition of new knowledge, skills, or meaningful professional experiences. Understanding value creation may assist researchers to link specific activities to desired outcomes and evaluate the overall impact of a CoP as a tool for social learning. Wenger et al. (2011) argued that value creation needed to combine different types of data for triangulation purposes and be explored in the context of narratives. They suggested a specific genre of stories, called value-creation stories, to integrate personal and collective experiences and examine how different members and stakeholders negotiate value. According to Wenger et al. (2011), only narratives can reveal the history of a network or community and their short and long-term value for different stakeholders.

Value-creation stories involve multiple voices and perspectives and can be personal or collective (Wenger et al., 2011). In the case of networks, personal stories are told through ego-networks, which focus on an individual's connections; and collective stories emerge from sociocentric networks, which are connections among people in a group. Social networks may be interpreted as the aggregation of personal networks. In the case of communities, collective stories are formed through the group's shared history and identity; and personal stories are created through the participation of each member and their unique experiences. Similar to networks, a community is constituted by members who may be a part of multiple communities.

Wenger et al. (2011) suggested that community members are more likely to be aware of the collective narrative than network members. In a network, members can discover their collective story through external perspectives of the network dynamics. Network visualizations, for example, can be helpful to reveal the structure of the network and stimulate the creation of a collective narrative. In communities, members are usually more aware of the collective narrative because they share a common identity or practice. However, members of a community may interpret their collective story differently and thus, it is important for community members to get together and negotiate their goals and identity.

Building on Kirkpatrick's work (1979) on training and program evaluation, Wenger et al. (2011) distinguished five cycles of value creation for networks and communities:

- *Cycle 1: Immediate Value*. Members in communities/networks engage in activities and interact with each other. Examples include help seeking, help giving, meeting someone for the first time, sharing a story, seeking new approaches, etc.
- *Cycle 2: Potential Value*. The value of some activities and interactions may not be immediate but the acquired knowledge capital can be realized later. There is still

value even when such knowledge does not need to be applied in practice. For example, if a member learns from another peer how to behave during a critical situation, such member may find value in that knowledge even if he or she will never experience a similar situation. Knowledge capital in communities/networks can be expressed as human capital (personal assets), social capital (relationships and connections), tangible capital (resources), reputational capital (collective intangible assets), or learning capital (transformed ability to learn).

- *Cycle 3: Applied Value*. Knowledge capital is applied in a given situation and produces changes in practice. For example, reusing a lesson plan or trying a suggestion involves adapting and applying knowledge capital gained through a community/network, which may or may not lead to changes or innovations in practice.
- *Cycle 4: Realized Value*. The use of knowledge capital does not necessarily result in performance improvement. Realized value occurs when members engage in a reflective process and understand how and why their practice can be transformed through the application of knowledge capital acquired through the community/network. Performance improvement is achieved in this cycle.
- *Cycle 5: Reframing Value*. This cycle is exclusive to value creation in communities/networks. Social learning causes participants to re-evaluate their own learning and redefine success. This includes reframing strategies, goals, values, or performance metrics. The redefinition of success can occur at the individual, collective, or organizational levels.

Wenger et al. (2011) warned that the relationships among the value creation cycles are complex and should not be assumed to occur linearly or hierarchically. Learning is a dynamic process where phases of producing and applying knowledge may be indistinguishable. Also, the success of a community/network cannot be defined in terms of what specific cycles are reached. Different stakeholders may value some cycles more than others. In the context of teacher professional development, for example, teacher trainers may be more interested in successful activities and the creation of knowledge capital (cycles 1 and 2), teachers may seek changes to their teaching practice and reframe success (cycle 3 and 5), and school administrators may be more interested in performance changes (cycle 4).

The study of the CLASE CoP can be examined through the value-creation framework suggested by Wenger et al. (2011). Although the interview questions were not explicitly designed with this framework in mind, it appears that the CLASE CoP participants created value across all five cycles. In cycle 1, teachers participated in the online CoP and used the resources available to them. Teachers attended webinars, posted discussion threads, and engaged in professional conversations with other members. In cycle 2, teachers benefitted from different forms of knowledge capital that they acquired through their participation in the online CoP. For example, teachers gained better understanding of the IC pedagogy (human capital), were able to navigate the network and knew who to contact for help (social capital), had access to high-quality teaching materials (tangible capital), and gained recognition in their schools/districts as leaders in instructional conversations (reputational capital). In cycle 3, teachers were able to modify their practice by using resources and following advice provided by other peers through the online CoP. During teacher interviews, participants listed access to high-quality materials as one of the main reasons to join the CoP and reported adapting and implementing those resources in their

classroom. In cycle 4, teachers engaged in reflective practices to evaluate what they did in the classroom and why it worked, which may have resulted in improved performance. And in cycle 5, some teachers expressed how their views of teaching and their roles in the classroom changed based on their knowledge of the IC pedagogical model.

Wenger et al. (2011) cautioned that indicators within each cycle only act as proxies for value creation but they do not warrant causality. For example, improvements in students' academic achievement cannot be attributed to teachers' participation in a network or community of practice without further evidence that links specific activities with desired outcomes. For this reason, value-creation stories across cycles are necessary to make such connections evident and track how specific community/network activities lead to changes in potential, applied, or realized forms of value. The structural network analysis of the CLASE CoP can only offer evidence for value creation during the first cycle. Because value creation in the CLASE CoP was mostly explored through interviews and self-reported data, indicators of value for each cycle need to be interpreted with caution.

Other studies that have examined value creation in online CoPs include Cowan and Menchaca (2014) and Booth and Kellogg (2015). Cowan and Menchaca (2014) used mixed methods to investigate value creation in a hybrid master's program in educational technology. The program was built around Lave and Wenger's CoP model. The program was delivered 80% online and had a graduation rate of 84%. The researchers evaluated value creation using the framework suggested by Wenger et al. (2011) and collected data from 99 program alumni between 2000 and 2010. Data collection consisted of social network analyses of connections made with others prior, during, and after program completion, as well as a qualitative analyses based on focus groups, an alumni reunion, and archival data (program records, surveys, and

student reflections). Cowan and Menchaca (2014) found evidence of value creation across the five cycles and concluded that members remained connected to the network after graduation, which led to increased expertise, application of knowledge, and redefinition of success. Cowan and Menchaca's study (2014) used a unique approach by comparing structural networks over time (with and without instructors) and by using multiple sources of data for triangulation purposes. However, claiming causality across cycles may not be possible since the researchers did not provide enough evidence to link specific activities with desired outcomes.

Booth and Kellogg (2015) conducted a case study with teachers from four different online communities to examine cycles of value creation. The purpose of the study was to better understand the spectrum of value that teachers create through their engagement in online communities and identify specific tools and activities that facilitate value creation. A total of 35 community members participated in semi-structured interviews to produce value-creation stories. Booth and Kellogg (2015) found that the framework suggested by Wenger et al. (2011) provided a very detailed and nuanced understanding of how teachers find value in online communities. Concerning activities that can facilitate value creation, Booth and Kellogg (2015) highlighted the importance of providing enough opportunities for structured activities to: a) enable engagement and create a shared context, b) meet in small face-to-face groups to cultivate trust, and c) create tangible products to apply teachers' knowledge and share with others. Booth and Kellogg (2015) also found that members needed to assume leadership roles within the community to increase ownership and sustainability. From a technological perspective, online communities may enhance their value by providing members with robust tools to search, manage, and organize their collection of resources within the platform.

The study of the CLASE CoP adds to the body of literature on value creation by exploring online communities for teacher professional development. Prior research had examined value creation in a hybrid online program (Cowan & Menchaca, 2014) and in four pre-established online teacher CoPs (Booth & Kellogg, 2015). The CLASE CoP was built from the ground up in an effort to provide sustainable professional development. As such, this study is valuable to inform how teachers build a CoP and create value through their engagement. Consistent with previous findings (Booth & Kellogg, 2015; Cowan & Menchaca, 2014), this study suggests that CoPs require support at multiple levels and community development activities are of paramount importance to build trust and shared identity. Identifying teacher-leaders to cultivate and expand the community can also guarantee sustainability over time.

Another finding concerning how to facilitate value creation is that teachers need to experience immediate value soon after joining the CoP and be constantly reminded of concrete ways in which they can benefit from the CoP. Teachers joined the online CLASE CoP during the summer after participating in a 30-hour foundational training. Participants expressed feeling highly motivated to implement instructional conversations during the summer but once the school year started, some of them felt overwhelmed and their priorities and attention shifted somewhere else. During interviews, teachers underscored the importance of being reminded about the resources available to them through the online CoP, as well as the technical aspects of how to access and navigate through the online platform. Teachers agreed that once they experienced some of the benefits that the CoP offered, they were more likely to engage in the community and find more value.

Finally, this study provides limited empirical evidence that peripheral observers in the CLASE CoP may have created value through their participation. Lave and Wenger (1991)

described legitimate peripheral observers as those new members with limited knowledge who participate in the community from the outer boundaries. As those individuals gain more skills and knowledge, they tend to move from the outside toward the center of the community. The structural network analysis of the CLASE CoP helped to identify 149 members who had never engaged in any online interactions and four members who had interacted a few times but were disconnected from the main network. Two of those peripheral observers were purposefully selected for interviews during the qualitative phase of the study. Both teachers were found to engage directly and indirectly with the online CoP and found value through their participation. Although these two teachers are not a representative sample, their interviews helped to inform how peripheral observers may or may not create value in the CoP. Future research should examine the role of peripheral observers more closely to understand their motives and contradictions, with the goal to facilitate their transition as core members of the community.

Communities of Practice and Teacher Professional Development

Research on teacher CoPs has examined their effectiveness, differences between face-to-face and online communities, and teachers' perceptions and engagement (e.g. Barab, Schatz, et al., 2004; Elster, 2010; Mackey & Evans, 2011; Matzat, 2013; McConnell et al., 2013; Tsai et al., 2010; Wang & Lu, 2012). This body of literature suggests that CoPs can foster reflection, collaboration, and are conducive to positive effects on teachers' pedagogical and content knowledge. Also, teachers who engage in online CoPs experience the same benefits as those participating in face-to-face CoPs (McConnell et al., 2013). Consistent with prior findings, teachers in the CLASE CoP found that the community helped them to understand and implement instructional conversations better than they would be capable of by their own. Teachers also engaged in reflective practices through their participation in the online CoP. For example,

sharing resources and lesson plans that could be understood and used by other educators required detailed instructions, which involved a reflective process of their own teaching practice.

The study of the CLASE CoP reinforces the critical important of a face-to-face component in teacher CoPs to establish trust and community among members (Cowan & Menchaca, 2014; Matzat, 2013; McConnell et al., 2013). All cohorts of teachers in the CLASE CoP participated in a 30-hour face-to-face foundational training to get familiar with the IC pedagogy and the online platform. Face-to-face gatherings helped them to create personal bonds, set shared goals, and develop a sense of community. Although real-life interactions among teachers may strengthen online communities, Matzat (2013) found that not *all* members needed to personally know each other for the community to be successful. Facilitating a few personal relationships may suffice to sustain a teacher CoP. In the CLASE CoP, not all 385 teachers knew each other in person since they had participated in different training cohorts. Nonetheless, many of those personal connections transferred to the online environment. Interestingly, once professional relationships became more personal, teacher interactions tended to move away from the online CoP and started to occur via more personal means of communication such as email, texting, and face-to-face meetings.

Although online teacher CoPs benefit from real-life interactions (Cowan & Menchaca, 2014; Matzat, 2013; McConnell et al., 2013), this study offers mixed evidence regarding assortative mixing from a network perspective. Assortative mixing, or homophily, refers to the strong tendency for members in a social network to associate with others who share similar demographic characteristics or backgrounds (Newman, 2003). Assortativity coefficients were calculated to assess the correlation for teachers in the CLASE CoP to interact with peers who shared the same gender, workplace, county, grade, subject, level (i.e. elementary, middle, or high

school), and role (i.e. teacher or instructor). Coefficients were not significant, suggesting that assortative mixing did not occur in the network based on the categorical variables evaluated. The largest coefficient (-0.24) corresponded to the "role" variable, showing a small correlation for teachers to interact with non-teachers, that is, instructors. Overall, results suggest that teachers were not more likely to interact with peers that they personally knew or who worked in the same school or taught the same grades or content areas. Note that both teachers and instructors were included in the analyses, which may have underestimated the coefficients and the tendency for teachers to associate with others who shared similar characteristics.

Although the social network analysis did not support the hypotheses that teachers would mix selectively, the qualitative analysis provided mixed evidence regarding homophily. Some participants claimed that knowing someone or teaching the same grades or content areas were not determining factors to establish a connection with others in the online CoP. Teachers would participate in discussion threads if they had anything valuable to add, regardless of who had initiated such discussion. They would also look for lesson plans and resources across grades and subjects and adapt those ideas to fit their particular context. However, other teachers agreed that online interactions were driven by grade level and content area. Some teachers would narrow down their online exchanges to only members who shared similar professional roles or backgrounds. Approaching this study from a mixed-methods paradigm allowed to consider multiple perspectives and triangulate data. Homophily in teacher networks remains an area of interest.

Concerning teacher satisfaction and factors that affect teacher engagement in online learning communities, previous studies concluded that the quality, usefulness, and transferability of online discussions were critical aspects for teachers to find value (Francis & Jacobsen, 2013;

Prestridge, 2010; Reeves & Pedulla, 2011). Teachers in the CLASE CoP decided to join the community given the opportunities for collaboration, mentorship, and peer feedback. However, access to high-quality instructional resources was repeatedly one of the main reasons why teachers joined the CoP. Sharing resources allowed teachers to consider new ways to approach content and facilitated lesson planning. Also, teachers found helpful that resources in the CoP were vetted by peers, which reduced the need to look for high-quality teaching materials somewhere else. Clear guidelines and a standardized lesson plan format facilitated the dissemination and implementation of resources among community members. Having a consistent template helped teachers to quickly identify the main components of the lesson plan and implement it with fidelity.

Teachers have reported positive attitudes towards online CoPs (Barab, Schatz, et al., 2004; Elster, 2010; Mackey & Evans, 2011; Tsai et al., 2010; Wang & Lu, 2012). Members of the CLASE CoP appreciated the convenience of an online platform to engage in discussions, collaborate, and participate in virtual meetings. Teachers highlighted the benefits of not having to commute or find substitute teachers to engage in professional activities. The online CoP allowed teachers to reduce the isolation they sometimes felt in their building and enabled them to collaborate with peers across schools and districts. However, teachers expressed a preference to seek support through the CoP at their workplace before reaching out to members in the online CoP. Teachers would typically seek help from other peers at their school who were also trained in the IC pedagogy given the physical proximity. Others have suggested that educators may find more value in face-to-face interactions than fully online exchanges (Stone-MacDonald & Douglass, 2015).

A widely-used model to study teachers' perceptions and engagement in online learning environments is the Community of Inquiry framework (Garrison et al., 1999). This framework defines the educational experience as a dynamic process involving social presence, cognitive presence, and teaching presence (see Figure 8 in Chapter 2). Social presence refers to the participants' ability to communicate with the community of learners, create inter-personal relationships, and project their individual personalities. Cognitive presence refers to the extent to which participants are able to construct meaning and regulate their own learning. Teaching presence enables the social and cognitive processes by providing enough facilitation and scaffolding.

Using the Community of Inquiry framework, researchers have found that teachers' online presence is usually lower than expected given their busy schedules and multiple responsibilities (Al-Balushi & Al-Abdali, 2015; McFadden et al., 2014). The study of the CLASE CoP supports this finding and identified lack of time as the main constraint for teachers to participate in the online CoP. Teachers needed to comply with many demands from their school administration on a daily basis and they needed to prioritize where they focused their attention. When specific time slots for professional learning were not built within teachers' daily schedules or when the administration did not value teachers' engagement in such activities, teachers had no external incentives to spend time on the CLASE CoP. Support from the school administration is a crucial factor for the successful implementation of instructional conversations (Gokee, 2017).

In short, the present study reinforces the potential of online CoPs to foster teacher collaboration and reflection, which results in improved pedagogical and content knowledge. Technology provides specific affordances that leverage the community functioning and sustainability, such as the ability to connect with peers who are geographically disperse, or the

flexibility to engage in professional learning activities anywhere and anytime. This study supports the critical importance of real-life interactions to cultivate trust, social ties, and sense of community, but challenges how teachers decide to interact with one another in online settings. Mixed evidence was found regarding homophily, that is, the tendency for members in the online CoP to interact with others who shared similar backgrounds and characteristics. Access to high-quality resources was an important factor that encouraged teachers to participate more and helped them to create value, despite teacher's limited time. All this empirical evidence suggests that cultivating online teacher CoPs is a promising strategy to empower teacher learning and provide sustainable support over time.

Implications

Traditionally, online teacher CoPs have been studied from either a community or a network perspective, but very little is known about the intersection between both components to leverage teacher learning. This study explores an online teacher CoP as a sociotechnical network and provides insights about the formation, development, and evolution of both community and network. From a theoretical perspective, the study of the CLASE CoP adds a network lens to the literature on cultural-historical activity theory (Cole, 1996; Engeström, 1987, 2001; Leont'ev, 1978; Vygotsky, 1978) and online teacher CoPs (Barab, Schatz, et al., 2004; Elster, 2010; Mackey & Evans, 2011; Matzat, 2013; McConnell et al., 2013; Tsai et al., 2010; Wang & Lu, 2012).

This study offers empirical evidence that both supports and challenges Engeström's (2001, 2009) model of activity theory. Firstly, members of the CLASE CoP found *rules* and *division of labor* to be critical aspects that mediate community functioning. Without clear expectations and distribution of tasks and responsibilities, the community may not thrive and

become self-sustainable. Secondly, the CLASE CoP exemplifies the interactive nature of activity systems in Engeström's (2001, 2009) revised model. Teachers in the CoP belonged to different communities/networks, which transacted and produced a shared product. Technology played an important role in helping teachers access a vast network of resources and experiences through the internet. As Engeström (2001) suggested, activity systems interact with one another, are dynamic and characterized by multi-voicedness.

However, the CLASE CoP also challenges the role of *community* in Engëstrom's model. As others have suggested, communities of practice may not be ontologically consistent with this model of activity theory (Barab, Schatz, et al., 2004). Engeström defined *community* as the collection of the group's artifacts and rules over time. In a CoP, *community* is not only a mediator of human activity, but the *community* can also act as the subject, artifact, and object of the activity. Members of a CoP share their identity and intention around a common goal. Such goal, for example, could be to improve their professional practice and strengthen the sense of community. Therefore, the community may act as a collective group to transform the object of the human activity where community is also the artifact and the shared goal. In Engeström's model, *community* is only an isolated component that mediates human activity.

From a research standpoint, the study of the CLASE CoP suggests that homophily may not be a characteristic of teacher networks/communities. The social network analysis did not support the hypothesis that teachers were more likely to interact with each other based on similar characteristics such as teaching the same grades or content areas. Findings in the qualitative phase were mixed regarding how or why teachers chose to interact with one another. The lack of evidence for the presence or absence of homophily in the CLASE CoP deserves more attention.

Exploring how teachers engage in online environments may inform efforts on how to leverage the formation of denser teacher networks and more cohesive groups and communities.

This study contributes to the vision and mission of CLASE by expanding the reach of our teacher professional programs and providing suggestions on how to leverage the formation of a teacher community. From 2011 to 2015, CLASE researchers conducted a randomized controlled trial assessing the effectiveness of the Instructional Conversation pedagogy on upper elementary students (Portes & González Canché, 2016; Portes et al., 2018). The trial was funded by the Institute of Education Services (IES) and the pedagogical intervention was found to have positive effects on student achievement, particularly for students whose first language was not English. The study of the CLASE CoP may help strengthen the sustainability of our teacher professional programs, help teachers implement the pedagogy with fidelity, and reduce costs for larger-scale research interventions. Many have suggested a multi-stage approach to the design and evaluation of teacher professional development programs (Borko, 2004; Desimone, 2009; Hill et al., 2013). For example, Hill et al. (2013) proposed a programmatic research model including one-site studies, randomized controlled trials, efficacy trials, scale-up trials, and meta-analyses to better allow for comparisons across sites and contexts.

Another implication of the present study that warrants further research is that teachers navigate through online and offline communities/networks. Members of the CLASE CoP expressed a preference to reach out to the professional community at their school before using the resources on the online community. As schools started to adopt instructional conversations more widely, teachers created informal CoPs at their workplace to support each other. The real-life CoPs shared the same members than the online CoP, but teachers still preferred to work and collaborate with their peers at their local school given the proximity and convenience. Both real-

life and online teacher interactions need to be explored for a "complete picture" of the intersection between networks and communities.

From a practical perspective, several suggestions can be offered to instructional designers or those who seek to foster learning in teacher CoPs. Understanding the CoP as a synergy between *community* and *network* may be helpful to identify opportunities and challenges for each component. As others have indicated (Barab et al., 2001; Kling & Courtright, 2003), a community needs to emerge from the needs and interactions of its members. Because it is not possible to force a group of people to become a community, instructional designers can only leverage the formation of a CoP. However, facilitating networks and connections among members may be an easier task to accomplish. The overall design goal for CoPs is to create systems and structures that support sociability, particularly in online environments (Barab et al., 2001). *Sociability* refers to the social and technical structures that permit individuals in a group to interact and pursue a common goal (Preece, 2000). Instructional designers should evaluate which tools and online platforms will best support online sociability. For example, an online platform needs to offer simple yet powerful features for members to communicate with each other, such as blogging, group and private messaging, chat in real-time, videoconferencing, and personalized notifications for new posts and activities.

As a community, the goal of the CoP is to develop a learning partnership and create a shared identity around a domain or practice (Wenger et al., 2011). Therefore, the role of the instructional designer is to facilitate a collective sense of trust and commitment. Community members need to understand why they belong to that group, what they can learn from each other, and what they can achieve together. Real-life interactions among members may assist in establishing trust, social ties, and sense of belonging (Cowan & Menchaca, 2014; Matzat, 2013;

McConnell et al., 2013). Additionally, it is important to encourage community members to engage in open discussions about the norms, expectations, and division of labor that will guide their online participation. All of the above are fundamental aspects of the structure of an activity system and will contribute to a self-sustainable CoP.

As a network, the goal of the CoP is to optimize the connectivity among participants (Wenger et al., 2011). In this case, the role of the instructional designer is to strengthen the density of the network by enabling new connections and facilitating the flow of information. A social network analysis, for example, could help to identify core contributors, brokers, and peripheral observers to strengthen their involvement. Core members and brokers play a critical role in maintaining strong ties, disseminating new ideas, and facilitating mechanisms for growth and reproduction (Barab, Schatz, et al., 2004; Wenger, 2000). Welcoming new members and encouraging them to take on leadership roles may support the involvement of peripheral observers. As they gain more knowledge, peripheral members are expected to become more central actors in the community.

Limitations

Both communities and networks are very sensitive to their local contexts and the composition of their members. Therefore, this study should be interpreted with caution, particularly concerning the transferability of findings to other contexts. The first phase of this mixed methods study examined how the CLASE CoP was structured as a sociotechnical network. Networks are represented by a graph with nodes (a.k.a. vertices or actors) and lines (a.k.a. edges, connections, or relationships). Attention has been brought to the oversimplification of human interaction and communication in network models (Clarà & Barberà, 2013), as well as the structural determinism in social network analysis (Emirbayer & Goodwin, 1994; Hollstein,

2014). Network research should not only focus on identifying the structural organization of a group of individuals. Exploring how members make sense of the network, human agency, and cultural implications should be more central questions in network research (Emirbayer & Goodwin, 1994; Hollstein, 2014). Give those limitations, this study adopted a mixed-methods approach to better understand the structural network analysis and the perceptions and interpretation of its members. Others have advocated for the use of mixed methods in social network research (Domínguez & Hollstein, 2014; Engel et al., 2013; Hollstein, 2014).

Limitations regarding the qualitative phase of this study include case selection and sample size. Two core contributors, two brokers, and two peripheral observers were purposefully chosen and interviewed regarding their perceptions about the network and the value of their participation. Case selection and sample size were limited by the amount of time and resources available to conduct the research. Although participant selection followed specific criteria to identify members that could inform the research questions, participants' voices in the qualitative analysis are not representative of the entire CLASE CoP. For example, only two of 153 peripheral observers were interviewed. Therefore, any qualitative findings need to be interpreted with caution given the limited number of participants. More cases could have significantly contributed to the thematic analysis and understanding of the research questions.

Additionally, not all members who were invited for interviews were able or willing to describe their experiences. Core members and brokers were more responsive to emails and quickly agreed to participate in the interviews. Only one core contributor was contacted twice but never replied or acknowledged receiving our messages. Peripheral observers had a much lower return rate. One of them declined their participation due to lack of time and prior commitments. Four peripheral observers did not reply to our requests despite multiple attempts

to contact them. Teachers who did not find value in the CLASE CoP may have been more reluctant to participate in the study. Their experiences could have enriched the interpretation of findings and counterbalanced the responses of those who did create value. The inability to identify and include more peripheral observers or other participants who may not have benefitted from the CLASE CoP is a major limitation.

Participants' interviews may have also been affected by social desirability bias, that is, the tendency to answer questions in a way that others will deem favorable. Participants may have focused on the strengths and benefits of the CLASE CoP and not on its potential flaws or weaknesses. Furthermore, using the Value Creation Framework (Wenger et al., 2011) to analyze teachers' responses may have introduced another source of bias. By design, the framework intentionally looks for evidence where community/network members create value (Cowan & Menchaca, 2014). Instances were value is not created may be disregarded or not included in the analysis.

Finally, it is important to discuss limitations and challenges that may have emerged from my multiple roles as researcher, lead instructional designer, website administrator, and teacher member of the CLASE CoP. I used a researcher's journal (see Appendix D) to document my levels of engagement in the CoP as well as any significant events or decisions. Each entry is dated and specifies the main role in which I was serving. Eight entries were written from the perspective of the researcher and nine entries as the lead instructional designer. Interestingly, I never participated in the CLASE CoP as a teacher member to express an opinion or offer advice. All my online interactions were limited to community announcements and open questions as an instructional designer/website administrator. Because many teachers would respond to my blogs,

I had a very central position in the network as indicated by centrality measures. However, I never engaged in any personal or professional conversations beyond initiating a question.

A CoP requires support at different levels to grow and become self-sustainable. The CLASE CoP has benefitted from a strong online presence from teacher trainers and instructional coaches, who have taken upon themselves to serve as community leaders, post frequent blogs to share resources and advice, produce a monthly newsletter with community updates, interact with teacher-members, offer personalized feedback, plan and execute webinars, etc. All these activities may have a pivotal role in maintaining the community alive. The community will not thrive unless new teachers take on leadership roles and assume ownership of the CLASE CoP. For this reason, one of the main priorities for CLASE trainers and instructional coaches is to identify teacher-leaders and strengthen the involvement of core members, brokers, and peripheral observers.

Suggestions for Future Research

Online teacher CoPs have received a lot of attention given their potential to increase levels of support and reflection, reduce costs, accommodate teachers' schedules, and overcome geographical barriers (Dede et al., 2009). However, the study of the intersection between teacher communities and networks remains largely unexplored (Macià & García, 2016; Wenger et al., 2011). Advancements in research techniques, such as social network analysis, allow for new ways to organize, visualize, and analyze complex social phenomena. Many argue that network structures cannot be studied from an exclusively quantitative or qualitative lens, only mixed methods research can provide breadth and depth of understanding (Domínguez & Hollstein, 2014; Engel et al., 2013; Hollstein, 2014; Johnson et al., 2007). For this reason, future research in online CoPs should embrace mixed methods for the purposes of corroboration,

complementarity, and triangulation. Using both quantitative and qualitative findings may compensate for each other's weakness and increase the interpretability, validity, and significance of the findings.

In the case of the CLASE CoP, the social network analysis could be enriched by a content analysis of teachers' online interactions. An exploration of teacher's post and comments would serve to examine how well teachers understand the pedagogical model and how the CoP can mediate their learning. A content analysis of the online CoP would also help to assess the effectiveness of the professional development model and the extent to which teachers are able to implement instructional conversations. The current study can also benefit from more data collection to further explore how members may or may not have created value based on the Value Creation Framework (Wenger et al., 2011). This framework suggests five levels how members of a community/network can create value through their participation (i.e. immediate, potential, applied, realized, and reframed value).

In more general terms, researchers need to pay more attention to how teachers navigate between online and offline communities and networks. Studying how teachers cross boundaries between virtual and face-to-face CoPs may seem like a daunting task due to its broad scope, but such type of research would really inform how technology mediates learning and teacher professional development. Prior work in this area suggests that online and offline teacher interactions supplement and enrich each other (Lin et al., 2016; Mackey & Evans, 2011). The CLASE CoP suggests that teachers had a preference to reach out to community members in person, but teacher interactions and collaborations in real-life were beyond the scope of this study.

Another suggestion is to investigate how teacher's personal communities/networks affect the overall development and functioning of an online CoP. Each teacher is a member of multiple formal and informal learning communities/networks and brings a unique set of tools and experiences to the group. Additionally, modern technology enables teachers to access an infinite network of resources and knowledge online. Capitalizing on personal (or egocentric) networks and how each teacher adds value may provide insights into how learning occurs in an interconnected world. A learning theory, connectivism, defines learning as the ability to navigate networks, find patterns, and make meaningful connections (AlDahdouh et al., 2015; Siemens, 2005). Knowledge construction is then no longer a personal process but a collective endeavor.

Regarding the structural analysis of the community/network and how members create value, further research is necessary to better understand the role of peripheral observers. New members who join a community tend to engage from the outer boundaries and become more central actors as they gain more knowledge. Lave and Wenger (1991) referred to those participants as "legitimate peripheral observers." Based on a very limited sample size, the study of the CLASE CoP suggests that peripheral observers may have created value through their engagement in the online community. Because this finding cannot be generalized, more research is necessary to understand how, if at all, peripheral observers find value. A closer look at this issue may reveal contradictions and tensions between different stakeholders in the CoP, as well as provide insights into how to help peripheral observers transition into core members.

Finally, research on teacher professional development has rarely explored how teacher learning impacts student outcomes. This is an important limitation for a comprehensive assessment of teacher professional programs. Very few studies have included student achievement measures in their evaluation of the effectiveness of teacher programs (e.g. Dash et

al., 2012; Shaha et al., 2016). In the specific context of online teacher CoPs, improvements in students' learning cannot be attributed to teachers' participation in CoPs without evidence that connects specific activities with desired outcomes. Value-creation stories (Wenger et al., 2011) may be used to link teachers' professional growth to students' academic achievement for a more thorough assessment of the impact of online CoPs. Value-creation stories are a specific type of narrative that integrates personal and collective experiences of the members of a community/network to understand its history and how members negotiate short- and long-term value (Wenger et al., 2011). This research focus would expand what we already know about how teachers create value in online communities (e.g. Booth & Kellogg, 2015).

Summary

The purpose of this study was to describe the formation, development, and evolution of an online teacher CoP as a sociotechnical network to support teacher's implementation of the Instructional Conversation pedagogy. This chapter situated the research findings within the context of cultural-historical activity theory, CoPs and social networks, value creation, and teacher professional development. The study of the CLASE CoP adds a new perspective to activity theory (Cole, 1996; Leont'ev, 1978; Vygotsky, 1978) by exemplifying and challenging Engeström's (1987, 2001) model of activity theory. The CLASE CoP is an activity system that makes part of a larger sociotechnical network where different systems transact and interact with each other. This study also challenged the role of *community* in Engeström's model as just a mediator to become the subject, object, and artifact of human activity. Cultural-historical activity theory (CHAT) also served to identify tensions and contradictions within the system to guide the design and implementation efforts (Leont'ev, 1978; Yamagata-Lynch, 2010).

This study explored some of the nuances at the intersection between *community* and *network* as separate but complementary aspects of the "social fabric of learning" (Wenger et al., 2011, p. 13). Community emphasizes the shared identity and the collective intention of the group. Network focuses on the connections or relationships among participants. Both communities and networks are valuable to enable social learning and pose different risks and challenges. This study expands the discussion around communities and networks by introducing a sociotechnical perspective, where technology can shape the way we interact with the world. In sociotechnical interaction networks (STIN), human and non-human agents influence each other in a dialogic and symmetrical relationship (Kling et al., 2003). To date, very little is known regarding the intersection between community and network in the context of teacher CoPs (Macià & García, 2016).

The analysis of how teachers benefited from their participation in the CLASE CoP was approached using the Value Creation Framework (Wenger et al., 2011). Wenger et al. (2011) distinguished five cycles of value creation for networks and communities: Immediate value, potential value, applied value, realized value, and reframed value. It appears that members of the CLASE CoP may have created value across the five cycles. Based on a very small sample, peripheral observers may have also found value through their participation. Wenger et al. (2011) cautioned that indicators within each cycle only act as proxies for value creation but they do not warrant causality, unless researchers are able to connect specific activities with desired outcomes. Value-creation stories are a specific type of narrative that may provide evidence of how specific activities lead to changes in potential, applied, or realized forms of value. Value-creation stories explore the history of the community/network and integrate personal and collective experiences to determine short- and long-term value (Wenger et al., 2011).

The study of the CLASE CoP contributes to empirical research on value creation (e.g. Booth & Kellogg, 2015; Cowan & Menchaca, 2014) by exploring online communities in the context of teacher professional development. The CLASE CoP emerged as an attempt to provide sustainable professional development and can inform how to leverage the development of a CoP and how teachers create value. CoPs cannot be designed but facilitated and require support at multiples levels. For example, community development activities are of paramount importance to build trust and shared identity. Identifying teacher-leaders to cultivate and expand the community can also guarantee sustainability over time. Another important finding is that teachers need to experience immediate value soon after joining the CoP and be constantly reminded of concrete ways in which they can benefit. Teachers agreed that once they experienced some of the benefits that the CoP offered, they were more likely to engage in the community and find more value.

Research on teacher CoPs has examined their effectiveness, differences between face-to-face and online communities, and teachers' perceptions and engagement (e.g. Barab, Schatz, et al., 2004; Elster, 2010; Mackey & Evans, 2011; Matzat, 2013; McConnell et al., 2013; Tsai et al., 2010; Wang & Lu, 2012). The study of the CLASE CoP provides further evidence that online CoPs promote reflection, collaboration, and enhance teachers' practice. This study also reinforces the critical importance of real-life interactions to strengthen trust and sense of community in online communities (Cowan & Menchaca, 2014; Matzat, 2013; McConnell et al., 2013). However, mixed evidence for assortative mixing (or homophily) was found in the CLASE CoP after triangulating quantitative and qualitative data. In other words, members were not necessarily more likely to interact with each other based on factors such as gender, working at the same school, or teaching the same grades or content areas.

Concerning teachers' engagement, participants reported positive attitudes towards the CLASE CoP and agreed on access to high-quality instructional resources as one of the main reasons to join a CoP followed by opportunities for collaboration, peer feedback, and mentorship. This is consistent with prior research on factors affecting teachers' satisfaction in online learning communities (Francis & Jacobsen, 2013; Prestridge, 2010; Reeves & Pedulla, 2011). Teacher engagement in online environments has also been approached using the Community of Inquiry framework (Garrison et al., 1999). Teachers' online presence has been found to be lower than expected given teacher's multiple responsibilities (Al-Balushi & Al-Abdali, 2015; McFadden et al., 2014). Similarly, participants in the CLASE CoP identified lack of time as the main constraint for their participation. One last finding relates to teachers' preference to reach out to members of the CoP in person at their workplace before using the online community. Others have suggested that educators may find more value in face-to-face interactions than fully online exchanges (Stone-MacDonald & Douglass, 2015).

Implications of this study for theory, research, and practice were discussed. The CLASE CoP adds a sociotechnical network lens to the literature on cultural-historical activity theory and online teacher CoPs. For research purposes, this study suggests that both online and offline teacher interactions need to be explored to further understand the intersection between teacher communities and networks. From a practical perspective, this study offers several suggestions to instructional designers or those seeking to foster learning in teacher CoPs. The overall design goal for CoPs should be to create systems and structures that support sociability, particularly in online environments (Barab et al., 2001). Distinguishing between communities and networks can be helpful as well. For example, in a community, instructional designers need to facilitate a collective sense of trust and commitment. In a network, instructional designer need to strengthen

the density of the network by enabling new connections and facilitating the flow of information. Identifying core contributors, brokers, and peripheral observers would inform decision making and promote teachers' involvement to contribute to the overall growth and sustainability of the community/network.

Because communities and networks are very sensitive to their local contexts, this study should be interpreted with caution. Limitations of both the quantitative and qualitative phases of this study were discussed. In the social network analysis, the complexities of human interaction and communication may be oversimplified in network models and visualizations (Clarà & Barberà, 2013). In the qualitative phase, limitations included case selection, sample size, participants' ability or willingness to describe their experiences, and social desirability bias. A limitation of using the Value Creation Framework (Wenger et al., 2011) to interpret the study findings is that a positive bias may have been introduced. By design, the framework intentionally looks for evidence where members create value, disregarding instances where value is not created (Cowan & Menchaca, 2014).

Future research on online teacher CoPs should adopt network research methods, such as social network analysis, to better understand the synergies between community and network. Also, only mixed methods research can provide breadth and depth of understanding and serve the purposes of corroboration, complementarity, and triangulation. Concerning how teachers navigate between communities and networks, researchers need to pay closer attention to both online and offline forms of teacher interaction. Another suggestion is to investigate how teacher's personal communities/networks affect the overall development and functioning of an online CoP. In terms of value creation, little is known about the role of peripheral observers and the tensions and contradictions that they face in the activity system. This type of research would

be helpful to further empower peripheral observers to become more central members of the community/network. Finally, research on teacher professional development has rarely examined how teacher learning directly impacts student outcomes. Value-creation stories (Wenger et al., 2011) may offer a solution to connect teachers' professional growth to students' academic achievement for a more comprehensive assessment of the impact and effectiveness of online CoPs.

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APPENDIX A:

SUMMARY OF EMPIRICAL STUDIES ON ONLINE TEACHER PROFESSIONAL DEVELOPMENT BY PUBLICATION DATE

Study	Purpose	PD Program	Research Design and Participants	Findings
Elster (2010)	Evaluate the effectiveness of learning communities to enhance science teacher quality and learning. Data on teachers' attitudes, behavior, system level and process were collected as well.	10 learning communities around the German-wide program, *Biology in Context*.	Mixed methods. N=144 teachers N=1689 students	Teachers' use of Information and Communication Technology (ICT) tools increased over time and facilitated collaboration. Information literacy skills impact sustainability of learning communities.
Fisher et al. (2010)	Compare a computerized PD program without human facilitation to a face-to-face program based on Kirpatricks's four evaluation levels: teacher and students' learning, reaction, behavior, and results.	Mastery Routine (a concept mapping technique to support student learning)	Randomized controlled trial. N=50 certified teachers (study one). N=152 students and N=8 teachers (study two).	Teachers in both conditions gained similar knowledge but those in the face-to-face program expressed somewhat higher satisfaction rates. No significant differences in terms of students' learning and satisfaction with the instruction they received.
Marrero et al. (2010)	Evaluate the relevance of online interactive short-courses as a source of teacher professional development.		Case Study N=59 K-12 educators	Teachers valued the flexible design of the PD program and showed interest in engaging in communities of practice with other educators around the nation.

Study	Purpose	PD Program	Research Design and Participants	Findings
Masters et al. (2010)	Evaluate the effects of a learning-community model of PD on teachers' knowledge and instructional practices.	4th grade ELA instruction. The PD program lasted 7 weeks and required 4 to 6 hours of weekly participation.	Randomized controlled trial. N=255 ELA teachers were recruited but only N=110 completed the study (high level of attrition).	The PD program has a significant effect on teacher's knowledge and instruction of vocabulary, reading comprehension and writing, in comparison to the control group.
Powell et al. (2010)	Evaluate the effects of a literacy-focused PD and differences between online and on-site delivery of expert coaching.	A one-semester intervention to improve teachers' instruction.	Randomized controlled trial. N=88 teachers and N=759 children	No significant differences between online and on-site coaching. The intervention had positive effects on early literacy and language development.
Prestridge (2010)	Explore the role of online discussion and constructive dialogue to support teacher professional development.	Online discussions were used to enable teachers to reflect on their pedagogical practice.	Mixed methods N=16 teachers	Online discussion forums facilitated both collegial dialogue to maintain community and critical conversations to transform teachers' beliefs.
Schumaker et al. (2010)	Determine the effects of a virtual vs. a face-to-face PD program on teachers' classroom practices and the performance of students with and without learning disabilities.	Certified teachers (4th to 12th grades) participated in a graduate-level course on reading methods.	Randomized controlled trial. N= 60 teachers in study one N=21 teachers and N=292 students in study two.	The computerized program was as effective as the face-to-face PD relative to reaction, teacher learning, student learning and student satisfaction. The computerized PD program was more effective than face-to-face PD in terms of teacher behavior in the classroom.

Study	Purpose	PD Program	Research Design and Participants	Findings
Tsai et al. (2010)	Understand how teachers participate in an online community of practice (CoP) to enhance their teaching and examine teachers' perceptions of their social experience and professional growth.	The CoP focused on teaching methods for K-8 science.	Mixed methods: Dependent-samples t-tests and content analysis. N=92 pre-service and in-service science teachers	Significant changes in teachers' perceptions of social navigation, ease of use, usefulness and satisfactions with the CoP were found. Teachers reported the CoP was effective in supporting their teaching.
Holmes et al. (2011)	Describe teachers' perspectives on an online PD program, the value of online presence, and the factors that affect PD quality and satisfaction.	University professors offered various online PD courses for in-service teachers, who were eligible for two graduate credits.	Within-stage mixed-method. N=95 in-service teachers.	Social and teacher presence in the online program were the most important factors related to teacher's learning and satisfaction. Other factors include cognitive presence, social networking, and prior experience with online courses.
McAleer and Bangert (2011)	Explore the professional growth of mentor mathematics teachers after participating in an e-mentoring program, specifically the relationship between patterns of engagement and program design.	The Electronic Mentoring for Student Success (eMSS) model.	Mixed methods. N=43 mathematics mentor teachers	The eMSS program promoted individual and social knowledge construction in mathematics mentors teachers. Particularly, content forum discussion promoted reflective practices.
Reeves and Pedulla (2011)	Identify factors related to participant background, design and implementation that co-vary with	e-Learning for Educators (EfE) initiative sponsored by the US	Hierarchical ordinary least squares linear	The variables with the strongest relationship to teacher satisfaction of the OPD were the beneficence of discussion topics, quality of learner

Study	Purpose	PD Program	Research Design and Participants	Findings
	satisfaction of primary and secondary educators in OPD programs.	Department of Education.	multiple regression analysis. N = 3998 teachers from nine States.	interactions, ease of content transferability, adequacy of compensation, course organization, and the clarity of participation expectations.
Renninger et al. (2011)	Study teachers' motivation and learning in a non-moderated online workshop.	The program provided math teachers with opportunities for exploration on reflection about technology-enhanced rich challenge problems for algebraic reasoning.	Mixed methods N=164 teachers	Teachers' participation on the online workshop does not necessarily depend on their levels of motivation and self-efficacy but on the contents and structure of the workshop. Designers of oTPD should provide enough flexibility to accommodate teachers' disciplinary content, strengths, and needs.
Dash et al. (2012)	Evaluate the effects of OPD on mathematics achievement in 5th grade teachers and students.	e-Learning for Educators (EfE) initiative sponsored by the US Department of Education.	Randomized controlled trial. N=79 math teachers and N=1,438 students.	Teachers in the experimental group exhibited significant gains in pedagogical content knowledge and pedagogical practices. However, there were no differences between students' mathematics achievement.
Liu (2012)	Investigate the impact of online videocase discussion among pre-service and in-service teachers as a professional development tool for English teachers in Taiwan.	English as a foreign language teachers engaged in Web-based videocase discussions for over a year.	Mixed methods N= 21 pre-service teachers, 7 secondary teachers, and 4 university teachers.	Pre-service and in-service teachers adopted different roles during the online discussions. There is evidence that online videocase discussions were a valuable source for professional development.
Smith and Sivo (2012)	Examines how the Technology Acceptance	Certified K-12 teachers participated	Structural Equation modeling	Perceived ease of use, usefulness and social presence are significant

Study	Purpose	PD Program	Research Design and Participants	Findings
	Model (TAM) can predict teachers' desire to engage in online PD based on their perception of social presence and sociability.	in an online course on reading strategies and practices in the classroom.	N=517 teachers	predictors of teacher's intention to engage in online professional development.
Wang and Lu (2012)	Explore teachers' engagement and perceptions of an online community of practice and the impact on their teaching practices.	Secondary school teachers in China participated in the online community of practice to improve their pedagogical practice.	Mixed methods N= 283 teachers	Teachers exhibited positive attitudes towards the online community and reported transformational changes.
Donnelly and Boniface (2013)	Analyze science teachers' perceptions on the use of a wiki for professional development and sharing their knowledge of practice.	The wiki was used to support teachers' adoption of the New Zealand curriculum for science.	Qualitative case study N= 6 teachers	Teachers' use of the wiki as a tool for PD is affected by their technology competence, utility and resourcing.
Fishman et al. (2013)	Identify differences in teacher knowledge and beliefs, teacher classroom practice, and student learning outcomes as a result of online vs. face-to-face PD.	PD on a year-long environmental science curriculum for high school teachers.	Randomized controlled trial. N=49 teachers	No significant differences between PD modality. Teachers exhibited gains in both experimental conditions.
Francis and Jacobsen (2013)	Describe the intent and formation of a professional learning community to improve math teachers' pedagogical strategies.	Teachers discussed mathematical tasks and how to design learning experiences that promote	Hermeneutic phenomenology N=13 teachers	The online synchronous environment allowed teachers to learn about collaborative mathematical problem solving and improve their teaching practices. The selection of an

Study	Purpose	PD Program	Research Design and Participants	Findings
		creativity and imagination in their students.		appropriate discussion question or task was essential for optimal professional development.
Hunt et al. (2013)	Evaluate the effects of the participation of novice special education teachers in an e-mentoring program on their perceived teacher preparedness and knowledge of professional standards. A second research question analyzed teachers' perceptions of their professional growth over a year.	The Electronic Mentoring for Student Success (eMSS) model was initially developed for math and science teachers, but the system was expanded to mentor novice special education teachers.	Mixed methods N=22 teachers for the quantitative component N=10 teachers for qualitative analysis	There were statistically significant differences in teachers' levels of perceived preparedness and knowledge of standards and laws after their participation in the e-mentoring program. However, there were no effects on perceived teacher knowledge.
Matzat (2013)	Examine whether blended learning communities are more beneficial for teacher PD than fully online communities.	Secondary teachers in The Netherlands participated in 26 informal online learning communities.	Multiple linear and logistic regression N= 1492 teachers	A mix between online and face-to-face interaction showed additional benefits to fully online learning communities. However, a combination of online and real-life exchanges between *some* members may be enough to strengthen the community as a whole.
McConnell et al. (2013)	Determine the benefits and challenges of virtual professional learning communities (PLCs) in comparison to face-to-face PLC meetings.	The PD program was aimed to help K-12 science teachers implement inquiry-based learning. The program was delivered face-to-	Phenomenology and comparative case study N=54 teachers assigned to a total of 11 learning communities.	Teachers who engaged in the virtual PLCs experienced the same benefits as member of the face-to-face PLCs. Video-conferencing promotes collaboration from remote distances and helps PLCs be more sustainable over time.

Study	Purpose	PD Program	Research Design and Participants	Findings
		face but required teachers to meet (either online or face-to-face) with a professional learning community for over a year.		
McFadden et al. (2014)	Explore the use of a video annotation tool in the Teacher Induction Network (TIN), an online program for novice secondary science teachers.	TIN is a 15-month online post-baccalaureate program at the University of Minnesota. TIN offers initial licensure plus three credits towards a M.Ed. degree.	Convergent parallel design of mixed methods N= 16 secondary science teachers and 229 video annotations	The video annotation tool facilitated teachers' reflection on their classroom practices, however teachers had a tendency to focus on just description and explanation, rather than higher-level reflection such as evaluation and interpretation.
Al-Balushi and Al-Abdali (2015)	Design and evaluate the effectiveness of a Moodle course to train science teachers in Oman to teach for creativity.	The Moodle-based distance program was designed using the Community of Inquiry framework (cognitive, Teaching and social presence).	Pre–post one-group quasi-experimental design N=19 science teachers in grades 5-10	Science teachers showed statistically significant improvement in terms of their knowledge on how to teach for creativity. Teachers engaged cognitively in the online course but their social presence was limited. Teachers did create social bonds due to their lack of time, workload, or the intense nature of the Moodle course.
Pape et al. (2015)	Describe and evaluate the impact of an online professional development program to increase	*Prime Online* is a year-long program designed to help general education	Mixed Methods N= 17 elementary general education	*Prime Online* provided teachers with rigorous and high-quality learning opportunities to improve their content and pedagogical knowledge.

Study	Purpose	PD Program	Research Design and Participants	Findings
	teachers' pedagogical knowledge in Math and promote teacher inquiry.	and special education teachers to teach Math to all students, particularly those with disabilities.	teachers and 6 special education teachers. Grades 3-5.	Further research needs to be conducted on design features and implementation of online teacher professional development programs.
Stone-MacDonald and Douglass (2015)	Examine the perceptions of early child educators and teacher trainers on an online training program as well as determine the technological knowledge and processes required for teachers to engage in the program.	The online program was mandated by the state to fulfill training requirements of the Quality Rating and Improvement System (QRIS).	Survey Research Methods N= 231out of 801 educators completed the survey N= 28 out of 62 teacher trainers completed the survey	Although some early education teachers exhibited the necessary technological skills to complete a fully online training, most educators preferred having the guidance and support of a supervisor who could answer any questions related to the content or use of technology.
Moore et al. (2016)	Evaluate the impact (as opposed to effectiveness) of a hybrid professional development program designed to prepare science and math teachers to implement Geographic Information Systems (GIS) technology in their classrooms.	Teachers received 40 h of synchronous online instruction and 80 h of in-person instruction and support over an 8-month period. The study had three cohorts of teachers over a 3-year period as was funded by	One-group, pretest, posttest design (correlation, ordinary least squares, and ordered logit regression analyses) N= 59 of 139 teachers completed the program	The logic model for this study identified five necessary components for teachers to adopt and implement GIS: community, empowerment, relevance, comfort, and competence. After the intervention, teachers reported higher frequency of GIS use in the classroom, as well as enhanced feelings of preparation, competence, community, and comfort with GIS. Teachers' attitudes about empowerment and relevance did not change.

Study	Purpose	PD Program	Research Design and Participants	Findings
		the National Science Foundation.		
Polly et al. (2016)	Explore teachers' instructional decisions while participating in a hybrid professional development program on formative assessment for math teaching.	This was a year-long program consisting of 40h of face-to-face workshops and 40h of classroom-embedded activities that were facilitated online. The program follows guidelines for learner-center professional development (LCPD) (Polly & Hannafin, 2010).	Mixed Methods N= 138 teachers from grades K-2	Teachers gained expertise on how to use an assessment tool to collect student data and develop targeted instructional plans. However, there was a lot of variance between teachers and school districts, suggesting that the teachers' context and environment affect the outcomes of the professional development program.
Shaha et al. (2016)	Explore the impact of a hybrid professional development model on student performance.	Little information is provided on the program itself. The professional development was provided by "School Improvement Network", a private company.	Meta-analyses of impact using data from nine previous studies 52 schools in five states	Students improved their reading and math scores by 19% and 24% respectively. Title 1 schools also showed significant gains when contrasted with non-Title 1 schools. The researchers concluded that a program combining seminars with online and on-demand professional learning had higher impacts on student learning than each approach separately.
Zhang et al. (2016)	Examine the impact of teaching presence on the levels of engagement of	Three-module course for English teachers about	Regression and Principal	The researchers identified four levels of engagement: Passive, active, constructive, and interactive. Passive

Study	Purpose	PD Program	Research Design and Participants	Findings
	Chinese middle school teachers in an online professional development program	general pedagogy, domain-specific pedagogy, and case studies.	components factor analyses N=218 middle school English teachers in Shanghai	engagement involves activities such as reading or listening. Examples of active engagement include repeating a lecture or a video. Constructive engagement requires learners to go beyond learned materials and produce new explanations or artifacts. Interactive engagement implies collaborative discussions and negotiation of meaning. Online teacher presence only had statistical significant effects on the constructive and interactive engagement levels.

APPENDIX B:

SEMI-STRUCTURED INTERVIEW

Research Question

- How do teachers perceive the social network dynamics and the value of their participation in the online CoP?

Introduction

My name is Diego Boada. I am a doctoral candidate in Learning, Design, and Technology at the University of Georgia and a CLASE graduate research assistant. Thank you for taking the time to talk with me about your participation in the CLASE teacher platform. This research is part of my doctoral dissertation. I am interested in understanding the formation, development, and evolution of an online teacher community of practice and I want to know more about your experience and participation in the CLASE teacher platform. Before we start, please know that your participation in this study is voluntary and you can stop at any time or choose not to participate at all. This interview will be recorded in order to have a complete record of our discussion. Is that okay with you? Do you have any questions before we begin?

Questions

- What is your current role as an educator?
- Years of experience
- When did you first learn about instructional conversations?
- When did you join the CLASE teacher platform?
- Are you a member of OTHER online teacher communities of practice?
- What do you understand by an online teacher community? What do you expect to get out of it?

- What has been your level of engagement on the CLASE teacher platform? High, medium, low? How so?
- How often do you log in to check on the online community? Do you log in because you need to download something, because someone else replied to a comment you made or what determines whether you go online or not?
- Do you feel your school supports you enough to implement ICs?
- Do you feel CLASE supports you enough to implement ICs?
- How comfortable do you feel navigating on the CLASE platform? In general, would you say you are technologically savvy?
- From your experience on the website, what feature or functionality do you wish you had?
- Have you had a chance to meet in person other members of the online community?
- What's your main motivation to participate in the CLASE online community?
- What kind of rules or norms should guide teacher participation in the online community?
- In what ways, if any, have instructional conversations changed you as a teacher?
- Has your participation in the online community changed your understanding or implementation of the IC pedagogy in any way? How so?
- In which ways have you used the CLASE teacher platform?
- What do you find most helpful about this online community?
- What do you find least helpful about this online community?
- Based on our records, you have interacted with these teachers (name them). Can you further describe your relationship with them? Why did you choose to talk to them and not to other members? Do you personally know them?

- Do you ever talk in person with any other IC-trained teachers? Are those teachers also members of the online community?
- When you are planning your IC lessons or your lessons in general, do you ever need help or go to anyone for advice or resources?
- Why do you think some teachers do not engage in the CLASE platform as much? Is there anything we can do to encourage them?
- Is there anything we can to do to support you better as you try to implement instructional conversations?
- Based on your experience with teacher professional development, how can we best support teachers and provide sustainable and transformative learning? To what extend does the online CoP help to achieve that goal?
- Is there anything that we've not talked about that you think is important for me to know?

Probes:

- What do you mean?
- I'm not sure I'm following you
- Would you explain that?
- Give me an example.
- I'm hearing you say XYZ, what would you say to that?

APPENDIX C:

CODE FOR SOCIAL NETWORK ANALYSIS USING R

```
# Social Network Analysis for the STIN and Teacher Networks

# 6 network configurations:
# mynet = sociotechnical network, no isolated nodes
# mynet.s = sociotechnical network, no isolated nodes, simplified
# mynet.i = sociotechnical network with isolated nodes
# mynet.i.s = sociotechnical network with isolated nodes and simplified
# mynet.m = Teacher Network using coding procedures from Manca et al 2009, no
 isolated nodes
# mynet.m.s = Teacher Network simplified, NETWORK D3

#IMPORTING DATA

edgelist <- read.csv("/Users/dboada/Google Drive/UGA/2018 Dissertation/R Data
/MyData/EdgelistCSV.csv")
edgelist.m <- read.csv("/Users/dboada/Google Drive/UGA/2018 Dissertation/R Da
ta/MyData/EdgelistCSV-Manca.csv")

#subset of edgelist
edgelist <- edgelist[,1:4]
edgelist.m <- edgelist.m[,1:2]

nodes <- read.csv("/Users/dboada/Google Drive/UGA/2018 Dissertation/R Data/My
Data/NodesCSV.csv", header = TRUE)
isolates <- read.csv("/Users/dboada/Google Drive/UGA/2018 Dissertation/R Data
/MyData/IsolatesCSV.csv", header=FALSE)

library(igraph)

mynet <- graph.data.frame(edgelist, directed=TRUE)
mynet.m <- graph.data.frame(edgelist.m, directed=TRUE)

# Adding isolate nodes
i <- as.character(isolates$V1)
mynet.i <- add.vertices(mynet, 149, name= i)
length(V(mynet.i)$name)

mynet # IGRAPH DN-- 236 630". The first number means unique vertices and the
second number is the edges

mynet.i # IGRAPH DN-- 385 630

mynet.m # IGRAPH DN-- 166 518

# SIMPLIFYING NETWORKS
```

```
# We can simplify our graphs to remove loops & multiple edges between the sam
e nodes. Use edge.attr.comb to indicate how edge attributes are to be combine
d - possible options include sum, mean, prod (product), min, max, first/last
(selects the first/last edge's attribute).

E(mynet)$weight <- rep(1, length(E(mynet)))
E(mynet.i)$weight <- rep(1, length(E(mynet.i)))
E(mynet.m)$weight <- rep(1, length(E(mynet.m)))

mynet.s<- simplify( mynet, remove.multiple = T, remove.loops = F, edge.attr.c
omb=c(weight="sum", place="ignore", type="ignore") )

mynet.i.s<- simplify( mynet.i, remove.multiple = T, remove.loops = F, edge.at
tr.comb=c(weight="sum", place="ignore", type="ignore") )

mynet.m.s<- simplify( mynet.m, remove.multiple = T, remove.loops = F, edge.at
tr.comb=c(weight="sum") )


mynet.s # IGRAPH DNW- 236 539

mynet.i.s # IGRAPH DNW- 385 539

mynet.m.s # IGRAPH DNW- 166 469 --


#COLOR AND SHAPE FOR "mynet"

V(mynet)$role=as.character(nodes$role[match(V(mynet)$name,nodes$name)])
# This code says to create a vertex attribute called "role" by extracting the
 value of the column "role" in the data frame when the vertex name matches th
e edgelist name.

V(mynet)$gender=as.character(nodes$gender[match(V(mynet)$name,nodes$name)])

table(V(mynet)$role) #7 coaches, 3 platform, 226 teachers

table(is.na(V(mynet)$role)) #no missing roles

V(mynet)$color=V(mynet)$role #assign the "role" attribute as the vertex color
V(mynet)$color=gsub("T","blue",V(mynet)$color) #Teachers will be blue
V(mynet)$color=gsub("C","red",V(mynet)$color) #Coaches will be red
V(mynet)$color=gsub("P","gold",V(mynet)$color) #Platform will be gold

V(mynet)$shape=V(mynet)$gender #assign the "gender" attribute as the vertex s
hape
V(mynet)$shape=gsub("Female","circle",V(mynet)$shape) #F will be circle
V(mynet)$shape=gsub("Male","square",V(mynet)$shape) #M will be square
```

```
#COLOR AND SHAPE FOR "mynet.s"

V(mynet.s)$role=as.character(nodes$role[match(V(mynet.s)$name,nodes$name)])
V(mynet.s)$gender=as.character(nodes$gender[match(V(mynet.s)$name,nodes$nam
e)])

V(mynet.s)$color=V(mynet.s)$role #assign the "role" attribute as the vertex c
olor
V(mynet.s)$color=gsub("T","blue",V(mynet.s)$color) #T will be blue
V(mynet.s)$color=gsub("C","red",V(mynet.s)$color) #C will be red
V(mynet.s)$color=gsub("P","gold",V(mynet.s)$color) #P will be gold

V(mynet.s)$shape=V(mynet.s)$gender #assign the "gender" attribute as the vert
ex shape
V(mynet.s)$shape=gsub("Female","circle",V(mynet.s)$shape) #F will be circle
V(mynet.s)$shape=gsub("Male","square",V(mynet.s)$shape) #M will be square


#COLOR AND SHAPE FOR "mynet.i"

V(mynet.i)$role=as.character(nodes$role[match(V(mynet.i)$name,nodes$name)])
V(mynet.i)$gender=as.character(nodes$gender[match(V(mynet.i)$name,nodes$nam
e)])

V(mynet.i)$color=V(mynet.i)$role #assign the "role" attribute as the vertex c
olor
V(mynet.i)$color=gsub("T","blue",V(mynet.i)$color) #T will be blue
V(mynet.i)$color=gsub("C","red",V(mynet.i)$color) #C will be red
V(mynet.i)$color=gsub("P","gold",V(mynet.i)$color) #P will be gold

V(mynet.i)$shape=V(mynet.i)$gender #assign the "gender" attribute as the vert
ex shape
V(mynet.i)$shape=gsub("Female","circle",V(mynet.i)$shape) #F will be circle
V(mynet.i)$shape=gsub("Male","square",V(mynet.i)$shape) #M will be square

#COLOR AND SHAPE FOR "mynet.i.s"

V(mynet.i.s)$role=as.character(nodes$role[match(V(mynet.i.s)$name,nodes$nam
e)])
V(mynet.i.s)$gender=as.character(nodes$gender[match(V(mynet.i.s)$name,nodes$n
ame)])

V(mynet.i.s)$color=V(mynet.i.s)$role #assign the "role" attribute as the vert
ex color
V(mynet.i.s)$color=gsub("T","blue",V(mynet.i.s)$color) #T will be blue
V(mynet.i.s)$color=gsub("C","red",V(mynet.i.s)$color) #C will be red
V(mynet.i.s)$color=gsub("P","gold",V(mynet.i.s)$color) #P will be gold

V(mynet.i.s)$shape=V(mynet.i.s)$gender #assign the "gender" attribute as the
vertex shape
```

```
V(mynet.i.s)$shape=gsub("Female","circle",V(mynet.i.s)$shape) #F will be circ
le
V(mynet.i.s)$shape=gsub("Male","square",V(mynet.i.s)$shape) #M will be square



#COLOR AND SHAPE FOR "mynet.m"

V(mynet.m)$role=as.character(nodes$role[match(V(mynet.m)$name,nodes$name)])
V(mynet.m)$gender=as.character(nodes$gender[match(V(mynet.m)$name,nodes$nam
e)])

V(mynet.m)$color=V(mynet.m)$role #assign the "role" attribute as the vertex c
olor
V(mynet.m)$color=gsub("T","blue",V(mynet.m)$color) #T will be blue
V(mynet.m)$color=gsub("C","red",V(mynet.m)$color) #C will be red
V(mynet.m)$color=gsub("P","gold",V(mynet.m)$color) #P will be gold

V(mynet.m)$shape=V(mynet.m)$gender #assign the "gender" attribute as the vert
ex shape
V(mynet.m)$shape=gsub("Female","circle",V(mynet.m)$shape) #F will be circle
V(mynet.m)$shape=gsub("Male","square",V(mynet.m)$shape) #M will be square

#COLOR AND SHAPE FOR "mynet.m.s"

V(mynet.m.s)$role=as.character(nodes$role[match(V(mynet.m.s)$name,nodes$nam
e)])
V(mynet.m.s)$gender=as.character(nodes$gender[match(V(mynet.m.s)$name,nodes$n
ame)])

V(mynet.m.s)$color=V(mynet.m.s)$role #assign the "role" attribute as the vert
ex color
V(mynet.m.s)$color=gsub("T","blue",V(mynet.m.s)$color) #T will be blue
V(mynet.m.s)$color=gsub("C","red",V(mynet.m.s)$color) #C will be red
V(mynet.m.s)$color=gsub("P","gold",V(mynet.m.s)$color) #P will be gold

V(mynet.m.s)$shape=V(mynet.m.s)$gender #assign the "gender" attribute as the
vertex shape
V(mynet.m.s)$shape=gsub("Female","circle",V(mynet.m.s)$shape) #F will be circ
le
V(mynet.m.s)$shape=gsub("Male","square",V(mynet.m.s)$shape) #M will be square

# EDGE WIDTH FOR SIMPLIFIED GRAPHS

E(mynet.s)$width <- E(mynet.s)$weight
E(mynet.i.s)$width <- E(mynet.i.s)$weight
E(mynet.m.s)$width <- E(mynet.m.s)$weight

# Assigning other vertex attributes: school, district, level, grade, subject
```

```
# mynet
V(mynet)$school=as.character(nodes$school[match(V(mynet)$name,nodes$name)])
V(mynet)$district=as.character(nodes$district[match(V(mynet)$name,nodes$nam
e)])
V(mynet)$level=as.character(nodes$level[match(V(mynet)$name,nodes$name)])
V(mynet)$grade=as.character(nodes$grade[match(V(mynet)$name,nodes$name)])
V(mynet)$subject=as.character(nodes$subject[match(V(mynet)$name,nodes$name)])

# mynet.s
V(mynet.s)$school=as.character(nodes$school[match(V(mynet.s)$name,nodes$nam
e)])
V(mynet.s)$district=as.character(nodes$district[match(V(mynet.s)$name,nodes$n
ame)])
V(mynet.s)$level=as.character(nodes$level[match(V(mynet.s)$name,nodes$name)])
V(mynet.s)$grade=as.character(nodes$grade[match(V(mynet.s)$name,nodes$name)])
V(mynet.s)$subject=as.character(nodes$subject[match(V(mynet.s)$name,nodes$nam
e)])

# mynet.i
V(mynet.i)$school=as.character(nodes$school[match(V(mynet.i)$name,nodes$nam
e)])
V(mynet.i)$district=as.character(nodes$district[match(V(mynet.i)$name,nodes$n
ame)])
V(mynet.i)$level=as.character(nodes$level[match(V(mynet.i)$name,nodes$name)])
V(mynet.i)$grade=as.character(nodes$grade[match(V(mynet.i)$name,nodes$name)])
V(mynet.i)$subject=as.character(nodes$subject[match(V(mynet.i)$name,nodes$nam
e)])

# mynet.i.s
V(mynet.i.s)$school=as.character(nodes$school[match(V(mynet.i.s)$name,nodes$n
ame)])
V(mynet.i.s)$district=as.character(nodes$district[match(V(mynet.i.s)$name,nod
es$name)])
V(mynet.i.s)$level=as.character(nodes$level[match(V(mynet.i.s)$name,nodes$nam
e)])
V(mynet.i.s)$grade=as.character(nodes$grade[match(V(mynet.i.s)$name,nodes$nam
e)])
V(mynet.i.s)$subject=as.character(nodes$subject[match(V(mynet.i.s)$name,nodes
$name)])


# mynet.m
V(mynet.m)$school=as.character(nodes$school[match(V(mynet.m)$name,nodes$nam
e)])
V(mynet.m)$district=as.character(nodes$district[match(V(mynet.m)$name,nodes$n
ame)])
V(mynet.m)$level=as.character(nodes$level[match(V(mynet.m)$name,nodes$name)])
V(mynet.m)$grade=as.character(nodes$grade[match(V(mynet.m)$name,nodes$name)])
V(mynet.m)$subject=as.character(nodes$subject[match(V(mynet.m)$name,nodes$nam
e)])
```

```
# mynet.m.s
V(mynet.m.s)$school=as.character(nodes$school[match(V(mynet.m.s)$name,nodes$name)])
V(mynet.m.s)$district=as.character(nodes$district[match(V(mynet.m.s)$name,nodes$name)])
V(mynet.m.s)$level=as.character(nodes$level[match(V(mynet.m.s)$name,nodes$name)])
V(mynet.m.s)$grade=as.character(nodes$grade[match(V(mynet.m.s)$name,nodes$name)])
V(mynet.m.s)$subject=as.character(nodes$subject[match(V(mynet.m.s)$name,nodes$name)])


#### GRAPHS

#X11()
#pdf("name.pdf", width=10, height=10)
set.seed(60)

plot.igraph(mynet,vertex.label=NA,layout=layout.fruchterman.reingold, vertex.size=4)

plot.igraph(mynet.s,vertex.label=NA,layout=layout.fruchterman.reingold, vertex.size=4)

plot.igraph(mynet.i,vertex.label=NA,layout=layout.fruchterman.reingold, vertex.size=4, edge.arrow.size= 0.5)

plot.igraph(mynet.i.s,vertex.label=NA,layout=layout.fruchterman.reingold, vertex.size=4, edge.arrow.size= 0.5)

plot.igraph(mynet.m,vertex.label=NA,layout=layout.fruchterman.reingold, vertex.size=4, edge.arrow.size= 0.5)

plot.igraph(mynet.m.s,vertex.label=NA,layout=layout.fruchterman.reingold, vertex.size=4, edge.arrow.size= 0.5)


#title(main="CLASE Online Teacher CoP", sub="January 2016", col.main="black",
 col.sub="black", cex.sub=1.2,cex.main=2,font.sub=2)

#legend('bottomright', col=c("blue", "red", "gold"), fill=c("blue", "red", "gold"), bty = "n", legend=c("Teachers n=376", "Coaches, n=6", "Platform features=3"), title="Participants")
#col means color in the legend command. Fill and C need to be the same

#dev.off()
```

```
######## Interactive plotting with tkplot

tkid <- tkplot(mynet.m.s,vertex.label=NA,layout=layout.fruchterman.reingold,
vertex.size= 4, edge.arrow.size= 0.5) #tkid is the id of the tkplot that will
 open
l1 <- tkplot.getcoords(tkid) # grab the coordinates from tkplot
tk_close(tkid, window.close = T)
pdf("MyNet-M-S.pdf", width=10, height=10)
plot.igraph(mynet.m.s,layout=l1, vertex.label=NA, vertex.size=4, edge.arrow.s
ize= 0.5)
dev.off()

tkid <- tkplot(mynet.i.s,vertex.label=NA,layout=layout.fruchterman.reingold,
vertex.size= 4, edge.arrow.size= 0.5) #tkid is the id of the tkplot that will
 open
l2 <- tkplot.getcoords(tkid) # grab the coordinates from tkplot
tk_close(tkid, window.close = T)
pdf("MyNet-I-S.pdf", width=10, height=10)
plot.igraph(mynet.i.s, vertex.label=NA,layout=layout.fruchterman.reingold, ve
rtex.size=4, edge.arrow.size= 0.5)
dev.off()



# NODE SIZE


#deg <- data.frame(degree(mynet.i), V(mynet.i)$gender, V(mynet.i)$role)
#write.csv(deg, "degree_mynet_i.csv")

#deg <- data.frame(degree(mynet.m), V(mynet.m)$gender, V(mynet.m)$role)
#write.csv(deg, "degree_mynet_m.csv")

d_mynet <- read.csv("/Users/dboada/Google Drive/UGA/2018 Dissertation/R Data/
MyData/degree_mynet_i.csv", header=TRUE)
d_mynet_m <- read.csv("/Users/dboada/Google Drive/UGA/2018 Dissertation/R Dat
a/MyData/degree_mynet_m.csv", header=TRUE)


#Coaches and platform degree was divided by 6 for visualization purposes

V(mynet.i.s)$size=as.numeric(d_mynet$degree[match(V(mynet.i.s)$name,d_mynet$n
ame)])
V(mynet.m.s)$size=as.numeric(d_mynet_m$degree[match(V(mynet.m.s)$name,d_mynet
_m$name)])

#pdf("degreeSTIN.pdf", width=10, height=10)
plot.igraph(mynet.i.s,vertex.label=NA,layout=layout.fruchterman.reingold, edg
e.arrow.size= 0.5)
#dev.off()
```

```
#pdf("degreeTeacher.pdf", width=10, height=10)
plot.igraph(mynet.m.s,vertex.label=NA,layout=layout.fruchterman.reingold, edg
e.arrow.size= 0.5)
#dev.off()


# DISPLAY ONLY THE LABELS FOR VERTICES WITH SIZE GREATER THAN 20

plot.igraph(mynet.m.s, vertex.label = ifelse(V(mynet.m.s)$size > 20, V(mynet.
m.s)$name, NA), layout=layout.fruchterman.reingold, vertex.label.color = "bla
ck")

# OR

plot.igraph(mynet.m.s, vertex.label = ifelse(degree(mynet.m.s) > 20, V(mynet.
m.s)$name, NA), layout=layout.fruchterman.reingold, vertex.label.color = "bla
ck")


###### NETWORK D3 (Interactive Network)

#install.packages("networkD3")
library(networkD3)

#For more info: https://www.rdocumentation.org/packages/networkD3/versions/0.
4/topics/forceNetwork

# Network D3 for "mynet.m.s"

mynetD3.m <- mynet.m.s

V(mynetD3.m)$label<-V(mynetD3.m)$name #we're going to store the names as a la
bel at the vertex level. That way we don't lose that info.

length(V(mynetD3.m)) #166 unique nodes

V(mynetD3.m)$name<-1:length(V(mynetD3.m)) #modifying names from 1 to the leng
th of names

linksD3.m<-as.data.frame(get.edgelist(mynetD3.m)) #we're going to translate t
he edgelist into numeric values as the object "links"

str(linksD3.m) #the structure uses factor levels, so R thinks our data are ch
aracters


linksD3.m$V1<-as.numeric(as.character(linksD3.m$V1)) #Now, we transform value
s as numeric for V1 (first column)
```

```
linksD3.m$V2<-as.numeric(as.character(linksD3.m$V2)) #Transforming values as
numeric for V2 (second column)

str(linksD3.m) #now both columns are numeric and NOT character

colnames(linksD3.m)<-c("source","target") #the first column needs to be "sour
ce" and 2 column needs to be "target". This is a requirement of network D3.

linksD3.m<-(linksD3.m-1) #we're subtracting -1 from everything so we can star
t by 0. If we don't have a 0 value, we will have an error message when runnin
g network D3.

linksD3.m$value <- E(mynetD3.m)$weight

nodesD3.m <- data.frame (name= V(mynetD3.m)$label, group = c(rep(1)), size =
c(rep(1)))
#I'm creating a column "group" but leaving empty righ now. I'll fill it in wi
th gender

nodesD3.m$group <- as.numeric(nodes$role[match(V(mynetD3.m)$label,nodes$nam
e)])

d_mynet_m <- read.csv("/Users/dboada/Google Drive/UGA/2018 Dissertation/R Dat
a/MyData/degree_mynet_m.csv", header=TRUE)

nodesD3.m$size = as.numeric(d_mynet_m$degree[match(V(mynetD3.m)$label,d_mynet
_m$name)])


### NETWORK D3 GRAPHS

# mynet.m.s
forceNetwork(Links = linksD3.m, Nodes = nodesD3.m, Source = "source", Target
= "target", Value = "value", NodeID = "name", Group = "group", Nodesize = "si
ze", opacity = 0.8, zoom = FALSE, fontSize = 20, fontFamily = "serif", colour
Scale = JS("d3.scaleOrdinal(d3.schemeCategory10);"), arrows = FALSE, bounded
= TRUE)


#DESCRIPTIVES - NETWORK ATTRIBUTES


dataexport1 <- data.frame (V(mynet.m)$role, V(mynet.m)$gender, degree(mynet.
m), degree(mynet.m.s), degree(mynet.m, mode="in"), degree (mynet.m, mode="out
"), betweenness(mynet.m), closeness (mynet.m, mode="all", weights = NA), evce
nt(mynet.m)$vector, components(mynet.m)$membership, V(mynet.m)$district, V(my
net.m)$level, V(mynet.m)$grade, V(mynet.m)$subject, V(mynet.m)$school)
#write.csv(dataexport1, "vertexdataNetM.csv")
```

```
dataexport3 <- data.frame (V(mynet.i)$role, V(mynet.i)$gender, degree(mynet.
i), degree(mynet.i.s), degree(mynet.i, mode="in"), degree (mynet.i, mode="out
"), betweenness(mynet.i), closeness (mynet.i, mode="all", weights = NA), evce
nt(mynet.i)$vector, components(mynet.i)$membership, V(mynet.i)$district, V(my
net.i)$level, V(mynet.i)$grade, V(mynet.i)$subject, V(mynet.i)$school)
#write.csv(dataexport3, "vertexdataNetI.csv")


######### VERTEX DEGREE OR NODE DEGREE

sort(degree(mynet.m)) #connections of each vertix
sort(degree(mynet.m, mode="in")) #in degree, number of edges pointing in towa
rds a vertex
sort (degree(mynet.m, mode="out")) #out degree, number of edges pointing out
from a vertex


#Degree Distribution

hist(degree(mynet.m.s), col="lightblue", xlim=c(0,50), xlab="Vertex Degree",
ylab="Frequency", main="Node Degree Distribution", labels = FALSE)
#Histogram with vertex degree and frequency

#Degree distribution
deg.dist <- degree_distribution(mynet.m, cumulative=T, mode="all")
plot( x=0:max(degree(mynet.m)), y=1-deg.dist, pch=19, cex=1.2, col="orange",
      xlab="Degree", ylab="Cumulative Frequency")


#Vertex strength

#It's obtained simply by summing up the weights of edges incident to a given
vertex. The distribution of strength—sometimes called the weighted degree dis
tribution—is defined in analogy to the ordinary degree distribution.

hist(graph.strength(mynet.m), col="pink",
     xlab="Vertex Strength", ylab="Frequency", main="")

# Neighbors

neighbors(mynet.m, "Teacher name", mode=c("total"))

######### VERTEX CENTRALITY

sort(closeness (mynet.m, mode="all", weights = NA))

sort(betweenness(mynet.m)) #We can calculate betweenness to estimate an actor
 with a bridging role. Higher scores mean the actor has a bigger role as a br
idge
```

```
evcent(mynet.m) #eigenvector centrality

sort(evcent(mynet.m)$vector)


#An intuitively appealing way of displaying vertex centralities (for networks
 of small to moderate size) is to use a radial layout, with more central vert
ices located closer to the center. The function gplot.target, in the package
sna, can be used for this purpose.


#Target Plots for mynet.m
#x11()
setwd("/Users/dboada/Google Drive/UGA/2018 Dissertation/R Data/")
A <- get.adjacency(mynet.m, sparse=FALSE)
library(network)
g <- network::as.network.matrix(A)
library(sna)
g
pdf("NetM-Degree.pdf", width=10, height=10)
sna::degree(g)
sna::closeness(g)
sna::betweenness(g)
sna::evcent(g)
sna::gplot.target(g, degree(g), main="Degree", circ.lab = FALSE, usearrows =
FALSE, vertex.col=c("red", "red", "blue", "blue", "red", "blue", "blue", "red
", rep("blue", 12), "red", rep("blue", 55), "red", rep("blue", 89)),edge.col=
"darkgray", displaylabels = FALSE)
dev.off()
#I created the colors based on a CSV sorted by degree. RED is instructor and
BLUE teachers.

#Target Plots for mynet.i
A2 <- get.adjacency(mynet.i, sparse=FALSE)
library(network)
g2 <- network::as.network.matrix(A2)
library(sna)
g2
pdf("NetI-degree2.pdf", width=10, height=10)
sna::degree(g2)
sna::closeness(g2)
sna::betweenness(g2)
sna::evcent(g2)
sna::gplot.target(g2, degree(g2), main="Degree", circ.lab = FALSE, usearrows
= FALSE,edge.col="darkgray", displaylabels = FALSE, vertex.col=c("red", "red
", "red", "blue", "red", "blue", "blue", "red", "blue", "blue", "red", rep("b
lue", 12), "red", rep("blue", 209), "gold", "gold", "gold", rep("blue", 14
9)))
dev.off()
```

```
myvector <- evcent(mynet.i)$vector #evcent values from igrpah and sna package
s were different. I created a vector using igraph values to plot.

# NETWORK COHESION

#Cliques

table(sapply(cliques(mynet.m), length))

clique_num(mynet.m) #A clique is defined as a group of vertices where all pos
sible links are present. This vallue will represent the largest clique for th
is graph

cliques(mynet.m, min=3) #I want to to all the subgroups or vertices with a cl
ique of 3

table(sapply(cliques(mynet.i), length))
clique_num(mynet.i)
cliques(mynet.i, min=4)


#alternatively
#cliques(mynet.m)[sapply(cliques(mynet.m), length) == 3]

#Note that there is some redundancy in this analysis, in that the cliques of
larger sizes necessarily include cliques of smaller sizes. A maximal clique i
s a clique that is not a subset of a larger clique.

table(sapply(maximal.cliques(mynet.m), length))

#create graph
vcol <- rep("grey80", vcount(mynet.m))
vcol[unlist(largest_cliques(mynet.m))] <- "gold"
plot(as.undirected(mynet.m),vertex.color=vcol, vertex.label = NA, vertex.size
=4)
largest_cliques(mynet.m)

#Dyad and triads

dyad.census(mynet.m) # Mutual, asymmetric, and null node pairs
dyad.census(mynet.i)

triad.census(mynet.m)

# Density

#The density of a graph is the frequency of realized edges relative to potent
ial edges.
graph.density(mynet.m)
graph.density(mynet.i)
```

```r
d <- edge_density(mynet.m, loops = FALSE)
d #density is the number of connections divided by the number of possible con
nections. A complete linked network has a density of 1. A decimal value repre
sents the percent of possible links that are actually present
# The proportion of present edges from all possible edges in the network
d2 <- ecount(mynet.m)/(vcount(mynet.m)*(vcount(mynet.m)-1)) #calculating edge
 dendity for a directed network
d2

# Transitivity

#It is a measure of global clustering, summarizing the relative frequency wit
h which connected triples close to form triangles.

# global - ratio of triangles (direction disregarded) to connected triples.
# local - ratio of triangles to connected triples each vertex is part of.

transitivity(mynet.i) #Result is 0.03 which means than 3% of the connected tr
uples form triangles
transitivity(mynet.m, type="global") # net is treated as an undirected networ
k
transitivity(as.undirected(mynet.m, mode="collapse")) # same as above
transitivity(mynet.m, type="local")
triad_census(mynet.m) # for directed networks

#Reciprocity

reciprocity(mynet.m, mode="default")
reciprocity(mynet.i, mode="default")
reciprocity(mynet.m, mode="ratio")
2*dyad_census(mynet.m)$mut/ecount(mynet.m) # Calculating reciprocity defualt
mode

#Connectivity, Cuts, and Flows

is.connected(mynet.m)
#FALSE

is.connected(mynet.i, mode="weak")
is.connected(mynet.i, mode="strong")

components(mynet.m) #A group of connected network nodes is called a componen
t.
components(mynet.i)

comps <- decompose.graph(mynet.m) #Creates a separate graph for each componen
t of a graph.
table(sapply(comps, vcount)) #A census of all connected components within thi
s graph. This may provide evidence for a giant component.
```

```
#Small World

average.path.length(mynet.m)
diameter(mynet.m) #the longest of paths is not much bigger.
get_diameter(mynet.m)

average.path.length(mynet.i)
diameter(mynet.i)#the longest of paths is not much bigger.
get_diameter(mynet.i)

#In igraph, diameter() returns the distance, while get_diameter() returns the
 nodes along the first found path of that distance. Note that edge weights ar
e used by default, unless set to NA.

diameter(mynet.m, directed=T, weights=NA) #distance is 9 for mynet.m

diam <- get_diameter(mynet.m, directed=T)
diam

#Color nodes along the diameter

vcol <- rep("gray40", vcount(mynet.m))
vcol[diam] <- "gold"
ecol <- rep("gray80", ecount(mynet.m))
ecol[E(mynet.m, path=diam)] <- "orange"
# E(mynet.m, path=diam) finds edges along a path, here 'diam'
plot(mynet.m, vertex.color=vcol, edge.color=ecol, edge.arrow.mode=0, vertex.l
abel= NA, vertex.size=5)


vertex.connectivity (mynet.m)
edge.connectivity(mynet.m)

mynet.cut.vertices <- articulation.points(mynet.m)
length(mynet.cut.vertices) #number of cut vertices
articulation.points(mynet.m)


myneti.cut.vertices <- articulation.points(mynet.i)
length(myneti.cut.vertices) #number of cut vertices
articulation.points(mynet.i) # Useful to identify broker or bridges

shortest.paths (mynet.m)
graph.maxflow (mynet.m)
graph.mincut (mynet.m)

# GRAPH PARTITIONING OR COMMUNITY DETECTION

mynet.m.UD <- as.undirected(mynet.m.s, mode = "collapse")
```

```
#Collapse= One undirected edge will be created for each pair of vertices whic
h are connected with at least one directed edge, no multiple edges will be cr
eated.

kc <- fastgreedy.community(mynet.m.UD)
kc
length(kc)
sizes(kc)
membership(kc)
plot(kc, mynet.m.UD, vertex.label=NA, vertex.size=4)
#fast greedy community detection works for undirected graphs only

#ASSORTATIVITY AND MIXING

assortativity.nominal(mynet.m,types=factor(V(mynet.m)$role),directed=T)

assortativity.nominal(mynet.m,types=factor(V(mynet.m)$gender), directed=T)

assortativity.nominal(mynet.m,types=factor(V(mynet.m)$school),directed=T)

assortativity.nominal(mynet.m,types=factor(V(mynet.m)$district),directed=T)

assortativity.nominal(mynet.m,types=factor(V(mynet.m)$level, exclude=NA),dire
cted=T)

assortativity.nominal(mynet.m,types=factor(V(mynet.m)$grade, exclude=NA),dire
cted=T)

assortativity.nominal(mynet.m,types=factor(V(mynet.m)$subject, exclude=NA),di
rected=T)
```

APPENDIX D:

RESEARCHER'S JOURNAL

The purpose of this journal is to document my thoughts as well as any significant events and decisions as the research unfolds given my multiple roles in the CLASE CoP as a researcher, participant, and instructional designer.

Entry #1

Date: September 1st, 2017

Main role: Instructional designer

We sent out an email to all teachers announcing 4 Webinars this year. All platform members can participate in the webinars and not only this year's cohort. The purpose of the webinar is to support teachers' implementation of the IC pedagogy in addition to the other sessions offered (i.e. learning labs, fall and spring renewals). A second goal is to bring teachers back to the platform because some of them have not logged in for quite a while. We set up a sign-up form on Qualtrics and will email reminders as well as send them the Webinar recording and ask participants for feedback. The following message was sent out to all platform members.

Dear teachers,

We hope you have all had a great start to the school year. We've very excited to announce that we have set dates for 4 Webinars this year. We think they're going to be a great opportunity to reconnect with each other, share what we're doing in our classrooms, and support each other as we implement instructional conversations. Please save these dates:

Tuesday, September 12, 2017: Getting Started with ICs and Working in Centers (3:30-4:30pm)

Tuesday, October 10, 2017

Tuesday, January 9, 2018

Tuesday, February 13, 2018

Based on your feedback, we will set the times and topics for the upcoming Webinars. If you'd like to sign up, please fill out the survey below. We will send you an email with a link to the Webinar and instructions on how to join us on September 12.

Can't make it? Don't worry. All webinars will be recorded and can be watched later through our Ning teacher platform. If you'd like to receive a video recording via email, please fill out the form and let us know.

Here's the link to the sign-up form:

http://tinyurl.com/CLASEWebinars

Thank you and we hope to see you there,

The CLASE Team

Entry #2

Date: September 15th, 2017

Main role: Instructional designer

A total of 117 teachers filled out the interest form for the first Webinar. Out of those teachers, 30 of them indicated they would be joining the live session, 12 teachers said they would join later or might need to leave early, and 75 teachers said they could not join but asked to be sent the video recording. In the sign-up form, we also collected information about teachers' school districts, preferred time and day for future webinars, and topics they would like us to address in the future.

The Webinar meeting room was supported by Blackboard Collaborate Ultra Experience. The session and the activity chat were recorded for research purposes and to be shared with

teachers who could not join the Webinar. We had 28 participants attending the live session. Our agenda for the day consisted of the following activities:

- Welcome and Reconnect
- Establish Expectations and Norms for CLASE Webinars
- Getting Started with ICs (instructor-lead)
- Joint-Productive Activity in Online Meeting Rooms (small-group activities)
- Share out

First, participants introduced themselves in the chat window and tested their webcams and microphones. Then, the instructor started a poll to find out about grades participants taught, whether they had set norms with their students, and whether they had implemented any ICs so far. As a group, we set up expectations and norms for online interactions and CLASE webinars. Then, the instructor presented some ideas and advice on how to get started with ICs. In small groups, participants discussed the following questions and created a chart using the whiteboard tool:

- What's the best way to work in centers?
- What have you done to set up ICs that has been successful?
- What have you done that has been challenging, scary or ineffective initially?
- What strategies can you collectively come up with to address the challenges?

After 20 minutes, we all went back to the main room and one representative of each group shared their chart and ideas. As a follow-up, we created a discussion board for teachers to keep the conversation going, particularly for those who could not join the live Webinar.

Along with the Webinar recording, we also sent out an evaluation form to get feedback from teachers. We asked them what they enjoyed, what they would like to see changed or

discarded in future webinars, and what ideas, topics, or formats they wanted to suggest. The CLASE team also had a debrief meeting after the webinar. Based on our personal reflection and teachers' comments, we realized some participants felt frustrated about issues with the technology (e.g. audio not working), yet they appreciated the interactive format of the Webinar. The whiteboard tool did not work well either and we decided we will use google docs in the future.

Entry #3

Date: October 3rd, 2017

Main role: Instructional designer

We sent out an email to all teachers and invited them to read and participate in our latest blog by one of the teacher trainers. In her blog, Dr. M. reflects on the importance of slowing down and taking time to build a safe classroom environment. The instructor also shares what we learned from our first Webinar. Regular blog posts will be coming out from teacher trainers and instructional coaches to help teachers with the IC pedagogy and remind them to log in and check out any online CoP updates.

We also have a high school intern whose main role will be to help us cultivate the online teacher CoP and strengthen our online social presence. Our intern will work closely with me as the lead instructional designer. She will focus on the following tasks:

- Check out all member profiles and make sure that all teachers have a short bio and a picture. If anyone is missing any information, they will be messaged.
- Check out lesson plans for completeness, and correct use of tags and titles.
- Make video tutorials on a variety of topics, including how to upload and search for lesson plans, how to submit video lessons to the CLASE dropbox, how to post

in the teacher's corner, how to message a member, how to use the virtual classroom, how to create a group, etc. These videos will help teachers get more familiar with the different features of the platform.

- Send bi-monthly emails with updates, resources to share, tip of the day, or question of the week.
- Monitor and post to the CLASE Facebook page.

Entry #4

Date: October 26th, 2017

Main role: Instructional designer

Today, we had a meeting with the CLASE team to discuss how to increase our online presence and increase online interaction among teachers and between teachers and us. Another goal was to increase fidelity of implementation and support teachers as they move forward. We decided that three of our instructional coaches will devote 10 hours per week to interacting with teachers online and providing feedback on their posts and lesson plans. Instructional coaches will vet lesson plans and share them out with teachers. We need to make sure that lesson plans are well aligned with the IC pedagogy and ready to be used by other teachers. If the lesson plan is missing a task card or other elements, our instructional coaches will contact the teacher who originally posted the lesson plan and work with them to revisit their lesson plan. If teachers do not respond, instructional coaches will edit lesson plans by themselves and seek for the teacher's approval to share with the community.

Instructional coaches will also identify themes/concerns and create discussion board questions or blogs to prompt conversations among teachers and between teachers and us. Coaches will not only make work-related comments but they will also engage in social

interactions to strengthen personal relationships, for example, by replying to someone's personal introduction. Finally, coaches will be available for online meetings with individuals and grade-level teams. Instructional coaches will meet with Diego every two weeks to report on their progress and share any ideas or concerns.

Entry #5

Date: December 8th, 2017

Main role: Researcher

I contacted the Ning technical support team to ask whether it was possible to extract all discussion posts, blogs, and member activity to an Excel or CSV file for research purposes. At first, they responded that Ning social networks only allow administrators to extract member data such as names, emails, sign-up date, last login date, IP address, etc. To date, administrators are not able to extract any other type of data beyond that. I asked if their engineers/programmers could make an exception and work with us on an individual basis. They agreed. I asked for a CSV file with as much information as possible about all members' participation (384 members), specifically any posts, blogs, or comments they have made over time. The CSV file would need to have the date, member's name, type of post (comment, blog, discussion post, etc.), and content of the post. The Ning support team said they would try to get this done before the end of the year.

Entry #6

Date: December 12th, 2017

Main role: Instructional designer

Our three instructional coaches have identified three exemplary lesson plans that we will share with other teachers in January. The coaches have started to vet lesson plans. I created a

new section on the platform called “CLASE Lesson Plans”, which is reserved for lesson plans that have been reviewed and approved by our coaches. These lessons are ready to be shared and contain all necessary resources/materials to be implemented. By providing exemplary lessons and facilitating the sharing of resources, we hope to promote more peer interaction and prevent the isolation some teachers face - especially those who are the only ones doing ICs in their school. We need to build mechanisms to help them take the necessary steps to begin and sustain their activities.

Our new task card template has three sections: “Questions to consider”, “Debrief and reflection”, and “Follow-up activity.” One coach asked for clarification regarding how those sections were different. Although some questions can be included or embedded within “task activities”, “question to consider” are meant to be used during the IC to promote higher order thinking. “Debrief and reflection” questions are used after the IC and are linked to the instructional goal. “Follow-up activity” is an extension to the IC or extra activities for students who get done faster during an independent JPA. The teacher's lesson plan and students' task card can be the same thing for higher grades. However, they will look very different for lower-level grades.

Our coaches are writing blogs post to engage teachers and they are not only replying to lesson plans but also making social comments to build social ties and rapport.

Entry #7

Date: January 5th, 2018

Main role: Researcher

I had contact the Ning technical support team back in December to request a CSV file with information on member participation and engagement. Although they acknowledged my

email, they never got back to me. Because data analysis can't wait any longer, I'll start to manually extract the data from the online platform. I created two Excel spreadsheets: One for nodes, and one for the edge list. The nodes file includes information about all 382 CoP members (I had 384 members but two of them were repeated records). Some of these data can be exported from the platform, but I'll have to manually enter missing data and additional demographic information. The nodes file will have the following headings: Name, ID (random number), gender, role (teacher or coach), school, district, level (elementary, middle, high, administrative), grade, subject, email, location, country, zip code, date joined, date of last visit to the website, about me section (profile information each member had to complete). The nodes file will serve to add attributes in the network graphs, such as different colors or shapes depending on the gender or role of the teacher. Also, the nodes file will be used to conduct the homophily analysis and calculate assortativity coefficients to determine if teachers are more likely to interact with each other based on common characteristics such working at the same school or teaching the same grade/content areas.

The edge list will contain each of the online interactions occurring in the online CoP. The headings in the excel spreadsheet will be: Sender (person who starts the communication), receiver (person to whom the message is directed), place (where the post was posted, that is, blog, teacher's corner, or lesson plan), type (1 for resource sharing, 2 for help giving, 3 for help seeking, 4 for social sharing, 5 for thanking or replying, and 6 for posing a question or task), date, post title, and full content of the post. This edge list will be used to make the connections in the social network visualization. Collecting all these data will be time consuming and will involve copying and pasting comments from the online platform into the excel spreadsheet.

Entry #8

Date: January 9th, 2018

Main role: Instructional Designer

We sent out a welcome-back-to-school message to our teachers and announced a Webinar and opportunities for online coaching. See email below.

Dear teachers,

We hope the new year will bring you abundance of happiness and prosperity. We're excited to continue learning from/with you in 2018! We have two important announcements to make:

We have scheduled a Webinar on Tuesday, January 23rd, 2018 from 3:30-4:30pm. We'd love to "see you" there and reconnect with you. Please let us know if you can join us:

<link here>

In an effort to better support you through our online teacher platform, we're working with <names and contact info> as our online instructional coaches. Our coaches will be reading your lesson plans and offering ideas for more powerful ICs. We have created a new section in our platform to feature those lesson plans that have been reviewed and are complete and ready to be shared. We already have one science lesson for 5th grade, and two math lessons for 1st and 3rd grades. Please check them out:

<link here>

If you would like to have your lesson plan featured or get feedback on a video lesson, please contact <names>. Our coaches are also available for consultation through our virtual classroom. If you have not started with ICs yet, don't worry! January is a great time to set norms and get started. Please don't be shy and let us know how we can best support you.

Entry #9

Date: January 17th, 2018

Main role: Instructional Designer

Today I met with the instructional coaches who are working with teachers on the online platform. Here are my notes:

- We want to find task cards for lower grades that use kid-friendly language, pictures, colors, etc., to share with other teachers and show them what these task cards may look like.
- Coaches are welcome to join us for Webinars (and we appreciate their support) but there's no expectation that they have to be there.
- Weekly blogs and lesson plans posted by each coach.
- Diego will send a general message to all platform teachers about the new task card template and a reminder that coaches will be contacting them.
- Coaches will message teachers twice. First, they'll message them through the platform and then they'll email directly. If teachers don't reply, we'll go ahead and work on the lesson plan, post it and say it was adapted from <name of the teacher>.
- New trained teachers will have great resources and lesson plans ready to be implemented for next year. We could encourage them to use one of the CLASE-approved lesson plans and videotape it.
- Lesson plans need to be posted with all materials attached. No PDFs, hyperlinks, or external websites.

- Coaches will devote 10 hours per week to the platform work (including our online meeting) and any additional work will add extra hours (e.g. learning labs, classroom visits)
- Online Office hours- Coaches can be available in the online classroom every other Thursday from 3:30-4:30. We will advertise these sessions every month. We will also offer the option to set up individual appointments.

Entry #10

Date: January 31st, 2018

Main role: Instructional Designer

Today I met with the instructional coaches. Here's a summary of our discussion:

- We need to make sure teachers include the standard(s) in their task card/lesson plans when posting.
- Diego will check if the virtual classroom is mobile friendly. Some teachers don't have access to a cam or a mic so it might be easier if they can use their tablets. UPDATE: Yes! They released an app that can be installed on iOS, Android, and Windows mobile devices. The app is called "Blackboard." Teachers just need to install it and when they click on the virtual classroom link, they'll be asked if they want to join the session via the Blackboard App. If you open the Blackboard App, you can set up school name, user, password, etc. This is in case the school uses blackboard as their Learning Management System. We don't need to set up anything at all, just download the app to your phone or tablet.

- D heard from teachers they would like to spend more time learning about task cards during the Summer Institutes/Renewals. We could also simulate an IC/JPA lesson with teachers.
- Coaches will post blogs on a weekly basis. However, we don't want blogs to be an extra task but rather something helpful to teachers. For example, we could post about a problem a teacher had and how he or she solved it, an idea about a website or resource, etc. For example, AS posted a PDF with "100 Questions that Promote Mathematical Discourse" and a lot of teachers found it helpful.
- GS will share a blog about a teacher whose students were not engaging in conversation but a simple change in placement helped students to speak more.
- M asks if we can demonstrate how to create a QR code during our Technology Webinar. One thing is to mention this as an idea and another thing is to actually show teachers how to do it.
- M says we can create a counseling section in our teacher platform if there's enough interest (right now, school counselors can create a group within the platform if they wish to).
- Kindergarten teachers struggle with task cards. D will explore this and think of a blog post with ideas/hints. For example, a task card could be built only with pictures and the teacher can have a poster on the wall with icons and what they mean (like a Pictionary). For example, every time students see an emoticon of two people holding hands, it means "work in pairs." Students can practice these animated instructions the way they do with goal setting or norms.

Entry #11

Date: February 2nd, 2018

Main role: Researcher

The process of data collection for the social network analysis is finished. The nodes and edge list files are complete. Now these data will be entered into R statistical software and analyzed using *igraph, sna,* and *networkD3* packages. All the coding in R will be saved and included in the dissertation as an appendix. Two networks will be created: Sociotechnical interaction network (STIN) and Teacher network. The main difference between them will be the inclusion/exclusion of non-human actors, isolated nodes, and isolated posts. Non-human actors will include the places where teachers can post on the online platform: Blog, Teachers' Corner, and Lesson Plans. Isolated nodes are teachers who never posted anything or who posted a few times but are not connected to the main network. Isolated posts are online comments or discussion who didn't get any responses or activity from other members in the online CoP.

Both the STIN and Teacher networks will have the same nodes, because participants are the same. However, the edge list will have to be adapted and coded differently. For example, in the STIN network, a teacher can be the sender and "lesson plans" can be the receiver. However, in the Teacher network, only another teacher who responded or commented on the post can be the receiver. Coding the interactions for the Teacher network will involve making decisions regarding who the sender is, who the receiver is, and when to exclude a person or a post. I will follow the recommendations from Manca, Delfino, and Mazzoni (2009) regarding their structural/semantic coding procedures for SNA. Two separate edge lists will be created. One for the STIN network and one using Manca and colleagues' coding procedures. The analysis in the

R software won't be significantly different and many portions of code can be reused and applied to both networks.

Entry #12

Date: February 15th, 2018

Main role: Researcher

Two core contributors, two brokers, and two peripheral observers were identified for follow-up interviews. Today, I emailed some teachers and invited them to participate in interviews. This is the sample message that went out to one of the core contributors:

Dear (teacher's name),

I hope everything is going well. I'm working on my doctoral dissertation about teacher interaction and engagement in the online CLASE community of practice. I've looked at website statistics and you are a core contributor. I was wondering if I could interview you for like 30-45 minutes regarding your experience with the teacher platform.

Please let me know if this is something you could help me with. Your participation is voluntary and if you agree, I was thinking we could meet on the virtual classroom whenever is convenient for you.

Looking forward to hearing from you!

Entry #13

Date: February 28th, 2018

Main role: Researcher

I already conducted two interviews. Core contributors were really fast at getting back to me. Some other teachers have not responded to my initial request. In particular, I've found that peripheral observers have been hard to reach out to. I had to go back to the social network

analysis and identify more teachers based on their node centrality measures and send out more invitations for interviews. Today, I also sent a reminder to those teachers who haven't replied yet:

Dear (teacher's name),

I just wanted to know if you received my previous email. I sent you an invitation to participate in a 30-45 interview about your experience with the CLASE teacher platform. We would love to have your feedback!

Please let me know if you're not available for an interview at this time.

Diego.

Entry #14

Date: March 5th, 2018

Main role: Instructional Designer

I'm working with our high-school intern to create a newsletter on Adobe InDesign that will keep teachers informed about what's new on the online platform. The objective is to reduce the number of emails that we sent out and facilitate the dissemination of information in the CoP. The design has to be visually appealing and needs to follow the same template or sections each month. So far, I'm thinking the newsletter needs to discuss the following areas:

- New lesson plans
- New posts in the IC blog
- Question of the month
- Coaches' online office hours
- New posts on teachers' corner
- Upcoming webinars

- Learning Labs (dates and info)
- Renewals (dates and info)
- Registration info about Summer Institutes
- Twitter and Facebook logos so teachers can follow us
- Teacher of the month featuring a cool project or something they're doing

Entry #15

Date: March 23rd, 2018

Main role: Researcher

Some of the interviews had to be rescheduled, but all of them are complete at this time. In general, core contributors and brokers were fast at getting back to me. One core contributor was contacted twice but she never replied or acknowledged receiving my messages. Peripheral observers had a much lower return rate. One of them declined her participation because of lack of time and prior commitments. Four peripheral observers did not reply to my requests despite multiple attempts to contact them. Teachers who did not find value in the CLASE CoP may have been more reluctant to participate in the interviews.

I have already started the transcription process. I will have help from some other CLASE graduate assistants. On average, the interviews lasted about 45 minutes. Transcriptions will be done in InqScribe and we will use a foot pedal to expedite the process. Anyone involved in the transcriptions will have to meet with me to go over technical and formatting aspects, to make sure that all transcripts are reliable and consistent. Once finished, transcriptions will be imported into NVivo for Mac version 11.4.3 for coding and analysis purposes. The first level of coding will be deductive with pre-established codes based on the interview and research questions. I will do all the coding and analyses in NVivo with no help from other graduate assistants.

Entry #16

Date: April 20th, 2018

Main role: Researcher

Both the quantitative and qualitative analyses are finished. I'm currently writing the findings chapter. I will organize this chapter based on the study's research questions. The first section will discuss the social network analysis. The second section will discuss the within- and cross-case qualitative analysis. The third section will discuss meta-inferences that combine the social network analysis and interview data for a deeper understanding.

For the qualitative analysis, I did two levels of coding in NVivo. The first level was deductive. Based on the interview and research questions, I established some codes before-hand that helped me organize the data across cases. For example, one of the interview questions asked participants to define what they understood by a teacher community of practice. Based on this, I created a code named "personal definitions of CoP". Later on, I created inductive codes to identify patterns and themes that emerged from the data. These codes were not pre-established, and they were clustered, split, combined, or discarded as the analysis progressed. For example, after a closer look at teachers' personal definitions of CoP, I created codes such as collaboration, peer-feedback, and professional learning as defining characteristics of a CoP. At the end, eight themes were identified from the cross-case analysis and will be discussed in Chapter 4.

Entry #17

Date: May 2nd, 2018

Main role: Researcher

I'm currently writing Chapter 5. I went back to my literature review and read it through the lens of my study findings. I was trying to make connections with the literature and find out

how my study supported or challenged previous studies. Based on this, I'm going to use a similar organizational structure. In Chapter 2, I started talking about Cultural-Historical Activity Theory (CHAT) and how this framework has been used in the field of instructional design. Then, I discussed Social Network Analysis (SNA), Sociotechnical Interaction Networks (STIN), and again, I reviewed empirical studies where those perspectives have been applied in instructional design. Finally, I discussed research on teacher professional development, with a particular emphasis on teacher communities of practice.

In Chapter 5, I will use a similar approach. I will start with CHAT and how the CLASE CoP was designed and conceived as an activity system that interacts with other systems. I will use Engeström's model of activity theory to operationalize the theory and challenge why the notion of community should be understood differently in the context of a CoP. Then, I will talk about the differences between communities and social networks, drawing from the work of Wenger et al. (2011). Next, I will interpret the results of the qualitative analysis using the five cycles of the Value Creation Framework suggested by Wenger et al. (2011). The next section will discuss my study in light of prior research on teacher professional development. I will close the chapter with a discussion on implications of my study for theory, research, and practice, as well as limitations and suggestions for future research.