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SOUTH CAROLINA PUBLIC HIGH SCHOOLS: LEADERSHIP, NETWORK DYNAMICS AND INNOVATION

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Educational Leadership

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by
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August 2014

Accepted by:
Dr. Russ Marion, Committee Chair
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ABSTRACT

The purpose of this study was to identify and model the role of leaders in a complex organization. This paper analyzed the spread of innovations through use of Complexity Theory, Complexity Leadership Theory, and Social Network Theory. Complexity Leadership Theory suggests that certain “conditions”, “attractors”, or relationships must be present during the early stages of innovation, causing the emergence of innovation, long before an innovation reaches institutionalization. A Dynamic Network Analysis will be used to explore the inner workings and relationships that are present that influence the innovation as it moves through from emergence to possible institutionalization.

DEDICATION

I dedicate this work to my family, especially my wife, who offered unconditional and unwavering support throughout this endeavor, and to my son – this is for you buddy.

ACKNOWLEDGMENTS

I would like to thank my committee for their guidance throughout this journey. Specifically, I would like to thank Dr. Russ Marion for everything that I have learned through his remarkable patience, guidance and support; he went above and beyond and I will be forever grateful. To Dr. Jon Christiansen, thank you for all of your advice and assistance when I began to panic and for the reassurances that everything was going as planned. Dr. Dave Fleming and Dr. Mike Campbell, thank you for your willingness to guide me in this process and for the knowledge that you both have shared.

To my colleagues, thank you for your support and flexibility as I worked to achieve this goal.

To my parents, thank you for all of the sacrifices that you have made through the years and for giving me the opportunity to be in this position today. To my in-laws, you are much more than in-laws and I truly appreciate all of your support and encouragement.

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CHAPTER ONE

INTRODUCTION

Introduction to the Problem

Business is about relationships and successful CEOs seem to realize that fact. While public education is not a business and cannot be run like a business (Vollmer, 2010), lessons can be learned about the importance of relationships. Leadership need not always be top down and the successful leader is not always a dynamic or heroic figure that implements and drives change.

Our public education system has long passed the days of the one-room schoolhouses and the local autonomy that each school possessed to educate their children in the best way they deemed sufficient. Public schools are mature social networks and organizations are linked together in a way that resists major change, but also protects the organization from major damage (Marion, 2002). Mature social networks or organizations can be referred to as complex systems. Public schools are just one piece to a larger puzzle that is our nation's public education system. Decisions are carefully made but are rarely made locally. This is not to say that teachers do not make decisions in their classroom or that building level administration does not make decisions at their school, but neither makes major decisions or implements a major change without influence from district, state, and national rules and regulations.

Such influence, however, may overwhelm innovation and creativity in education. Since the passing of the former legislation of No Child Left Behind (NCLB), the public

school system is a complex organization with a great deal of bureaucratic hierarchy that both enables and hinders change within the organization. The NCLB legislation mandated that more attention be directed to test scores and the bureaucratic regulations built around this goal hinder flexibility and creativity. These mandates hold teachers and principals accountable for strictly defined sets of educational competencies and impose significant penalties for failure to achieve outcome goals (Marion & Uhl-Bien, 2007). The actions of school personnel are limited by the rules imposed by these mandates.

Due to federal and state legislation and the bureaucratic hierarchy that exists within every facet of P-12 education, change often disrupts the status quo to which most members of the organization are accustomed. But change and adaptability are crucial for innovation to occur. Innovation occurs when the collective whole interacts together on common problems to produce the knowledge necessary for the whole to improve. This premise is the subject of two recent theories of organization and leadership. The first of these is complexity theory, which argues that innovative organizational behaviors are impelled more by interaction dynamics across an organization than by leadership coordination (Cilliers, 1998). The idea is that leadership is a dynamic organizational process that creates or cultivates leadership within all facets of the organization notwithstanding position or potential individuals within the system.

This is in direct contradiction to previous ideas of directive leadership as displayed by Fiedler (1967). Such traditional leadership perspectives suggest that only individual authority roles express leadership or that leaders are controlling and act with authority. Complexity theory views organizing as an informal dynamic that is generated

through interactive bonding among interdependent, need seeking individuals, each of whom are driven by their local assessment or social and organizational events. (Marion & Uhl-Bien, 2001) Complexity theory is a paradigm shift because it speaks to informal dynamics that are produced through the complex interactions of individuals and that determines innovative behaviors.

Complexity theory proposes that effective network dynamics are driven by interactive, interdependent information flows, and that networks are the structures by which information is converted into such things as creativity, innovation, learning, and adaptability (Uhl-Bien, Marion, & McKelvey, 2007). Complexity dynamics are vibrant information exchanges controlled by the nature of the network itself (e.g., its level of interactive coupling, the nature of actions by individuals within the network, the amount of information in the system, and the amount of systemic pressure to adapt). Importantly, complex systems tend to break into clusters, called cliques, in order to efficiently handle the large amounts of information typically flowing through complex organizations (Clune, Mouret, & Lipson, 2013).

Complexity Leadership Theory (CLT) is a framework for studying emergent leadership dynamics in relation to bureaucratic superstructures (Marion & Uhl-Bien, 2001). Together, the idea of Complexity Theory and Complexity Leadership Theory describes an innovative and emergent leadership model where there is a healthy balance among all of the components of a complex organization such as P-12 Education. CLT describes the role of leadership in complex dynamics, and proposes three leadership functions; enabling leadership, adaptive leadership, and administrative leadership. A key

role of enabling leadership is to effectively manage the entanglement between administrative and adaptive structures and behaviors in a manner that enhances the overall flexibility and effectiveness of the organization (Marion & Uhl-Bien, 2007). It is undeniable that the administrative component of the organization does exist and will inevitably influence the organization. Adaptive leadership refers to unstructured, bottom-up initiative by actors in informal roles.

In post-NCLB P-12 Education, a leadership model is going to have to emerge that recognizes and supports the notion that the bureaucratic hierarchy work in unison with the members of the organization in a way that enable creativity and innovation. Complexity leadership can be very productive toward this end. If an organization is given the proper amount of time to implement the model and if traditional leaders will learn to relinquish power, the organization could experience innovation and positive change to the point that the leader/follower relationship blurs and a partnership emerges. Through the emergence of a partnership P-12 Education could experience a change in the organization that would encourage new creative strategies and initiatives that could foster positive long-term changes which would align with the goals and requirements set forth by the former NCLB legislation. This is important, if for no other reason, the fact that a 2010 study by the Center of Educational Policy indicated that over one-third of United States public schools failed to meet Annual Yearly Progress (AYP) in the 2008-2009 academic year (Daly, Moolenaar, & Carrier, 2010). Obviously changes and innovations must come, and leaders need to find a way to foster creativity among the teachers in the complex organization and work with them rather than attempt to go at it alone.

Background of the Study

This study challenges the traditional role of the principal or the administrative team in the change and innovation processes. Must the principal be a "heroic" or directive leader? Is the top-down approach the best way to lead and foster change? Group dynamics and network dynamics may have more influence in accomplishing organizational goals than the type of leadership style that the typical "boss" believes to be the best.

Traditional leadership is a positional, top-down approach where the leader is an authoritative manager rather than a leader. However, when an organization is understood to be a complex system, leadership must be approached as a process not as an event and the leader must be adaptive and enabling.

Statement and Significance of the Problem

The lack of understanding of the group dynamics may cause the organization to "spin its wheels" or become stagnant. Equally importantly, there is relatively little in the literature that examines the effects of networked dynamics on leadership in schools, although that literature is beginning to grow (Marion, Klar, H. W., Brewer, C. A., Griffin, S., Reese, K. L., Schreiber, C., et al. , 2013). Consequently, there is a need to explore the group dynamics within an organization with such staunch bureaucracy as the public school system.

Purpose of the Study

Given the widespread and somewhat cyclical implementation of budding innovation in South Carolina public high schools, the purpose of this study is to explore

the network dynamics of a public high school to determine if there are consistent and identifiable factors that contribute to successful implementation of change and innovation within the network(s). More specifically, this study asks the following:

1. How does the level of adaptive leadership impact innovation?

2. How do cliques and leaders of cliques influence innovation?

3. Does the nature of the network structure in a school contribute to successful change and innovation?

Theoretical Premises

Schools as Complex Systems

Public schools are mature social networks and organizations are linked together in ways that resist major change, but which also protects the organization from major damage (Marion, 2002). However, decisions are rarely made locally, meaning that schools do not have the autonomy to make decisions or implement change without district or State approval. Creativity can be stifled in this environment and it is important to understand that schools are made up of social networks and can be referred to as complex systems. It is also important to understand that building interpersonal relationships between leader and follower is important but perhaps subordinate to the importance of effective colleague to colleague and group-to-group interactive dynamics.

Complexity Theory and Complexity Leadership Theory

It is common to look at any successful organization and assume that the organization must have a very dynamic and charismatic leader. However, when dealing with complex organizations, it is not that simple. Marion (2013) states, “Complexity will

require you to practice leadership from a dramatically different worldview than you are used to, and this change of worldview is the biggest hurdle practitioners will face in capitalizing on complexity"(p. 3). The idea of top-down leadership, where a leader gives his/her subordinates directives and they carry out the leaders bidding, are gone – or at least they are in highly dynamic organizations where true innovation and positive change are taking place. Complexity and innovation are about the interaction of information, and people (agents) are the information carriers; this paper examines this claim.

This paper assumes that innovation is explained by the structure of networks in a system, by the strength of adaptive leadership, by the viability of cliques in the system, and by ones influence within such cliques.

Social Network Theory

Moolenaar (2012), points out that "… a pattern of social relationships among teachers may significantly enhance our understanding of the ways in which teachers collaboration takes place and contributes to student learning, teachers' instructional practice, and the implementation of reform…" (p. 7). Social network theory provides an analytical framework and a method to evaluate the specific nature of teacher/staff relationships within organizations such as schools (Moolenaar, 2012). Social network analysis is a methodology that examines the dynamics of such relationships, thus is ideal for studying complex organizational processes. It permits researchers to describe the vibrancy and viability of network dynamics, to identify adaptive leaders and adaptive processes, and to explore the effects of network and adaptive leadership measures on organizational outcomes. It is used in this paper to examine the effects of adaptive

leadership, clustering processes, clique dynamics, and network structures on creativity and innovation.

Methods

This study examines school effectiveness through the exploration of the social networks and the level of adaptive leadership within the school. The research is exploratory in nature and makes assumptions that all organizations are, in fact, complex. This is a sequential mixed methods study that will incorporate a survey, which will be examined and then subjected to a dynamic network analysis (DNA) to identify the network level characteristics and clusters (cliques) in order to understand their role in school effectiveness.

Data Sources

The participants in this study were the faculty of a medium-sized, high school in the Upstate of South Carolina. A representative sample of 16 faculty members were asked to complete a preliminary survey, then all 75 faculty members individually completed an online survey that collected information for a network analysis.

Analysis

Survey questions were analyzed with complexity leadership theory serving as a theoretical lens. Individual surveys were conducted from all faculty members at the target school. Questions provided data on work, social, and trust relationships, on work, task and knowledge relationships, and on beliefs about innovation in the school. Information on the attributes gender and level of education were also collected.

A Dynamic Network Analysis (DNA) was performed using the Organizational Risk Analysis (ORA) software created by Kathleen Carley at Carnegie Mellon.

Significance of the Study

This study contributes to the body of literature that attempts to understand network dynamics and determine a relationship between network dynamics and how educational leaders and organizations adopt innovation, as well as to what extent these innovations are effective based on the network dynamics.

Limitations

The two limitations to this study are listed below.

1. Since the interviews will be conducted with the all faculty members, there may be a limitation on the objectivity of the data being collected and may depend on the staff member's involvement with the innovations or the meta-network.
2. This study includes one public high school in South Carolina and caution must be used when generalizing the results and applying them outside the state or individual school.

CHAPTER TWO

LITERATURE REVIEW

Introduction

There is an ever-growing body of literature that has described educational change and the implementation of new initiatives and programs intended to improve student achievement. This chapter includes a review of that literature regarding educational change, complexity theory, complexity leadership theory, network theory, and complex adaptive systems. First, a history of educational change is explored as well as the reasons for implementing change. Secondly, a literature review of innovation is presented. Lastly, a literature review of Network Theory, Complexity Theory and Complexity Leadership Theory is presented and focuses on what drives a dynamic network and how the network fosters change. The review specifically focuses on how network dynamics influence an organizations response to change and innovation.

Brief History of Education Change 1960-Present

Many outsiders view educational leaders as unable to create and sustain effective educational change (Hanson, 2001). Schools are continuously influenced by waves of reform that define historical periods and the directions of schools and districts (Hargreaves & Goodson, 2006). In the past five decades, many educational changes and initiatives have been implemented each raising questions of lasting effects on education and the degree to which changes are sustained.

The first major post World War II change was implemented after the introduction of James Bryant Conant's report, *The American High School Today,* in 1959. The issue explored by Conant was school size. Conant did not believe that small high schools were equipped to produce high academic standards or that their enrollments were large enough to incorporate a diverse curriculum with a large selection of learning opportunities (Rury, 2002). Conant believed that large high schools of one thousand or more provided the diversity necessary for academic specialization (Conant, 1959). It is interesting that Conant's argument of why small schools were not adequate to accomplish academic progress may be the very reason why they were adequate. Many of the problems 9th grade students encounter are a result of the large size of the school and the fact that school size can be overwhelming (Chmelynski, 2004).

Hargreaves and Goodson (2006) argue that educational change between the 1960s to the 21st century falls into three historical periods. The first period was from the 1960s through the mid-1970s; it was a time in which the major focus was on diversity and social reform. The second period was from the mid-1970s through the mid-1990s, when the major focus was on common learning standards and test-based accountability. The third period, as stated by Skerrett and Hargreaves (2008), was a "culminating period of standardization and marketization, permeated by a standardized and monocultural curriculum along with high stakes testing, [which] continues to influence much of educational policy and practice" (p. 915). The standardization and marketization in the current period of educational change has influenced schools and districts to adopt changes in curriculum and school structure in order to maintain and/or gain legitimacy.

The educational change literature transitioned in recent years from a contingency theory perspective (the environment influences change) to a collectivist or group-focused perspective. We currently live in the "digital era" where the organizational goals are perpetuated by the demands of the knowledge-based economy characterized by volatile, changing environments. This shift has been accompanied by a shift from post-positivist, objectivist (individual based) epistemologies to a constructionist epistemology where reality is socially constructed and individuals and individual leaders are not as important as the group. Crotty (1998) defines constructionism as "the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context" (p. 42). As epistemologies have changed, revised perspectives about leadership and beliefs about change and innovation have likewise been under pressure to change. School leaders need to understand that successful change and innovation is a product of group interaction and group dynamics, not individuals.

This shift in epistemology frames the following review of literature on innovation and leadership and helps explain what complexity theory is about.

Innovation

Most innovations (the core subject of this research) occur as a reaction to pressure (McKelvey, 2003), such as a perceived problem. Damanpour and Schneider (2006) argue, "In both academic and practitioner communities, it is commonly perceived that organizations should innovate to be effective, or even survive, and that research can

guide the management of innovation in organizations ” (p. 215). In accordance with institutional theory, innovation is one the quickest and most widely accepted ways for an organization to become, or at least *appear*, to be successful (DiMaggio and Powell, 1983).

An innovation is a technology or a practice that is used for the first time within a given organization, or even a previously used technology or practice that is being used for the first time by this set of organizational members (Klein & Sorra, 1996). Innovation does not have to be a new concept; in fact, it can be a largely adopted concept that happens to be new to the organization. In academic and practitioner communities, it is common for organizations to be evaluated based their level of innovation or lack thereof, and research can guide the management of innovation in organizations (Damanpour and Schneider, 2006).

Innovation, as with creativity, has traditionally been studied from the perspective of individuals and not as a collective, team-based approach (Marion, 2012), but in the knowledge based economy in which we now reside, it is necessary to look at innovation as conglomeration of interactions between multiple people within an organization and not just the traditional leader-follower exchange. In complex organizations innovation is less about the leader and more about the group dynamics and how the innovative ideas travel within the organization – or the innovation diffusion.

Trust and Innovation

Teamwork, innovation, an organization’s capability for innovation depends heavily on relationships and trust (Andrews and Delahaye, 2000; Brower, Schoorman and

Tan, 2000; Chell and Tracey, 2005; Dodgson, 1993; Moolenaar and Sleegers, 2010; Phelps, 2010). Moolenaar and Sleegers (2010) argue, "…social interactions between educators that lie at the heart of every collective effort to improve schools are largely overlooked as a valuable resource to support the implementation of reforms" (p. 113). Dovey (2009) adds, "…innovation in organizations, can be said to depend on a level of interpersonal trust between stakeholders" (p. 315). Such interpersonal relationships assume additional importance as we move past the top-down, authoritative leader/follower paradigm to one that emphasizes collective behavior. Leaders of collective behaviors create conditions that enable informal dynamics and informal leaders, thus enabling creativity and innovation. As Moolenaar and Sleegers (2010) state,

> "Through building and fostering relationships that nurture trust and shape innovative-supportive climates, practitioners and policy makers can tap into the vast potential of collective action and collaborative invention that is often locked inside a single creative teacher or shared among only a handful of resourceful teachers. It is through these links with trust and innovation that the creation of new educational innovations flow…"(p.113).

Social networks and interaction are key to innovation and the diffusion of innovation. If organizations are going to be innovative, formal leaders will have to foster and sustain trust networks where innovation can thrive.

Innovation Motivators

Many researchers have argued that intrinsic motivations lead to innovation (George, 2007; Osterloh, Frost, & Frey, 2002; Zhang & Bartol, 2010). For example, Zhang and Bartol (2010) link the intrinsic motivation of workers with empowered leadership to explain innovation. George (2007) argues, however**,** that "**…**perhaps rather than focusing on singular processes such as intrinsic motivation, conscious thought, and positive affect as presumed facilitators of creativity, research should consider how seemingly opposing processes interact to bring about creativity" (p. 467). This is a valid point because, while such things as the intrinsic motivations of individuals are important, many current researchers argue that such person-centric processes are perhaps secondary to processing of information via leader and group interaction. As Shalley, Zhou and Oldham (2007) state,

> "…non-controlling supervisory behavior is expected to boost employees' intrinsic motivation and creativity, analogous behaviors on the part of employees' coworkers are expected to have similar effects. That is, employees are expected to exhibit high levels of creativity when their coworkers are nurturing and supportive, since such behavior enhances intrinsic motivation. Conversely, non-supportive, competitive coworkers should undermine intrinsic motivation and lower creativity" (p. 939).

Group dynamics and interaction will either motivate members to be innovative, or will stifle their creativity in a way that hinder adequate innovation diffusion. George (2007) argues that

> … intrinsic motivation is a good thing and one would be hard pressed to make a convincing argument that it is not a good thing when it comes to creativity in organizations. Yet, at the same time, extrinsic motivation is a powerful force (problems need to be identified and solved, novel ideas need to be "useful," work serves important economic functions in most people's multidimensional lives). Appreciating and understanding how both intrinsic and extrinsic motivation can contribute to creativity and how it is through their complex interplay that creativity emerges might bear more fruit than positing that a singular motivational process facilitates creativity (e.g., intrinsic motivation) and another singular, seemingly opposing process (e.g., extrinsic motivation) detracts from it. (p. 453)

This underscores the argument in the current paper that intrinsic, individual motivations exist and are useful to the organization, but should be coupled with strong and supportive group dynamics in order for a organization to innovate at the level in which it is truly capable, rather than group dynamics that hinder innovation.

Individual versus Group Innovation

Processing and dissemination of information is centrally important in the innovation process and arguments can be made for the importance of both individual and group dynamics in this process. As Janssen, Van de Vliert, & West (2004) argue,

> "With respect to individual innovation, such moderating factors might be found in the characteristics of the innovative idea, the innovator, coworkers, supervisors, the broader organizational context, and in national

> culture. Examples of factors that are likely to shape the beneficial and detrimental outcomes of group innovation include knowledge, skills and ability of group members, group tenure, diversity among group members, group processes (clarifying group objectives, participation, constructive management of competing perspectives), and external demands on groups" (p.129).

The argument of Janssen et al. (2004) suggests that there is a place for both individual processing and group dynamics when approaching the concept of organizational innovation.

However, even if an individual innovates without the group or without consideration to the group dynamic, the individual will have to gain support from the group in order for the innovation to be a success. As Van der Vegt and Janssen (2003) argue, "the next task of the innovation process consists of idea promotion to the potential allies" (p. 731). Therefore, I would argue that perhaps, individual innovation does have a place in a complex organization, but only when coupled with positive group dynamics will is have a strong likelihood of success. In fact, Welch (2014), in a genetic simulation of the innovative process, found that a balance of both individual and collective idea processing is optimal, thus it may be important for leaders to enable both approaches to creativity and innovation.

Leadership and Innovation

Leadership is key to innovation capabilities of an organization and the leader has the ability to either encourage or stifle that innovation. Friedrich, Mumford, Vessey,

Beeler, & Eubanks (2010) state,

> "Leaders have the unique opportunity to influence innovation at every level and across all stages of innovations. Thus, a leader that is knowledgeable of the appropriate steps to take with regard to the desired outcomes (e.g., a product innovation or a process innovation) will do his or her organization a great service" (p. 22).

Shalley and Gilson (2004) argue, "In order for creativity to occur, leadership needs to play an active role in fostering, encouraging, and supporting creativity" (p.35). Leaders in complex organizations must be active participants in innovation, but need to be careful not to micro-manage the efforts. Leaders need to create an environment where the members of the organization are striving to be innovative and not afraid to speak up or work with their colleagues on collaborative efforts of innovation. Leaders need to be careful not to withhold opportunities or tasks, but engage the members of the organization in problem solving tasks. As Basadur (2004) states,

> "Leaders must learn to hand off challenges to others, not make them wait for their own solutions. In addition, far from being the only content expert, they must engage other content experts. They must also learn to be process leaders, facilitating those content experts toward implementing novel solutions" (p. 108-109).

In other words, a leader must possess the characteristics of an enabling leader where he/she allows the members of the group to act as informal leaders and disseminate information and innovation across the organization.

Innovation Diffusion

The diffusion of innovation is important to the success or failure of an innovation. As Hartley (2005) states, "there is a lot to be learned about how diffusion takes place, and how and why innovations are adapted to different contexts and cultures" (p. 33). The reason for this is that innovative ideas can come in many forms and the perceived value of an idea, or innovation, can hinge on the diffusion, or how, why, and to what degree, innovation spreads within the organization. Innovative ideas can be more about how and when they were delivered or who delivered them than about the actual validity of the ideas. Rogers (2003) states,

> "…inter-personal channels are more effective in forming and changing attitudes toward a new idea, and thus in influencing the decision to adopt or reject a new idea. Most individuals evaluate an innovation not on the basis of scientific research by experts but through the subjective evaluations of near peers who have adopted the innovation. These near peers thus serve as role model, whose innovation behavior tends to be imitated by others in their system." (p. 38)

An innovative idea delivered by a colleague who is well respected in an organization will most likely gain support faster than an innovative idea that comes from a colleague who is not well liked or respected. This is an important factor when studying innovation in a complex organization such as a public high school as it may be more about how informal and formal leaders motivate, support, and direct innovation.

In P-12 education, innovation comes in many forms. Ninth grade academies, single gender academies, literacy initiatives, Common Core standards, etc., are all innovations that are being considered or initiated in a number of schools across the state. However, while innovation may start with one person or even a group of people, it will not succeed unless adopted by the whole organization or network. Innovation does not have to be initiated by the formal leader but it is more likely to be accepted across the system if the informal leaders in the organization accept it – informal leaders influence other members of the organization and gain support for innovation. Understanding the social networks within an organization can help the formal leaders in their attempts to innovate as well as understanding when and how to allow others to be the catalysts of innovation.

As discussed, it is important to understand that creativity and successful innovation are dependent upon the group dynamics within the organization. The following sections will provide insight into social network theory, complexity theory, and complexity leadership theory as they relate to innovation and an organization's capability to innovate. Social Network Theory is the basis of the methodology for this study while Complexity Theory provides the theoretical influence to guide the research. Complexity Leadership Theory evolved from Complexity Theory and provides a roadmap for leadership in a complex organization.

Social Network Theory

Social Network Theory is a growing and robust methodology to describe and examine the structure of relational network and their relationship to outcomes (Daly,

2010). In education, social network research can be used to shed light on concepts such as distributed leadership, professional learning communities, teacher collaboration, reform implementation, and teacher induction (Moolenaar, 2012). It is important for a leader to be able to identify relevant relationships and perhaps provide a little strategic grouping in order to foster creativity. Also, and maybe more importantly, sophisticated network models allow for patterns to be identified and compared in a way that leads to predictions of outcomes (Daly, 2010).

Teachers are a key component of these networks and of any innovation or reform that occurs within a school, and it is important for school leaders to recognize their significance. Research over the past several decades has observed that teachers need to be active agents in educational reform in order to realize improvements in the processes of teaching and learning (Datnow, 2012). Furthermore, the social networks within a school may be more important and more influential than the formal leaders (i.e. principals and assistant principals) in its ability to spur innovations and educational reforms. By studying the social networks and their inner workings, it may be possible for researchers to identify necessary components of the social networks that foreshadow effective change and innovation, and school leaders may even be able shape future outcomes by being able to influence the social networks.

Moolenaar (2012), points out that "… a pattern of social relationships among teachers may significantly enhance our understanding of the ways in which teachers collaboration takes place and contributes to student learning, teachers' instructional practice, and the implementation of reform…" (p. 7). Social network theory provides an

analytical framework and a method to evaluate the specific nature of teacher/staff relationships within school (Moolenaar, 2012). Social networks can facilitate or hinder education reform, and the key to successful innovation and change lies within relationships and interactions. Social networks are decentralized structures in which leadership emerges bottom-up to foster "real" innovation and change (Uhl-Bien et al., 2007).

Moolenaar (2012), in reflecting on the work of Degenne and Forsé (1999), points out that social network research can be divided into three assumptions about the "embeddedness of individuals in social structure" (p.10). The first perspective is that resources such as information and knowledge are transferred in relationships among networked members. In other words, each individual or teacher within a school is a change agent and a catalyst for information exchange. Second, social network theorists conclude that people are interdependent rather than independent, meaning that teachers rely on each other for information and resources. This can be found in the form of simple teacher friendships, grade level teams, departmental groups, and school-wide and district-wide networks. This premise is important to understand and appreciate because changes at any level of the network can alter the outcome at other levels (i.e. knowledge transfer at the departmental level can affect the network at the district level and vice versa) (Burt, 2000).

The third perspective suggests that social networks both propel and hinder the actions of organizational members and, by extension, the organization or network itself. Teachers or members of a network benefit from sharing and transferring knowledge and

resources, but only if they are adequately connected to the network, or to the "proper" network. For example, if cliques exist – and they are inevitably present within a large organization – then some members of the organization may be "left out" of interactive networks and do not benefit from a full exposure and access to all of the resources in a system. Not only can this failure to connect limit the potential of the individual, it will inevitably stifle the potential growth and prosperity of the organizational or school.

However, the existence of cliques within a network is not necessarily a negative phenomenon and can actually be very beneficial – even necessary. Marion et al. (2014) argued that a moderate level of organizational cliques enhances the capacity of an organization to successfully perform its tasks; they observe that cliques allow vast amounts of information to be divided into smaller, manageable chunks and processed by cliques rather than everything being processed by the entire organization. Further, Marion et al. (2014) stated, "cliques are generally more interactive with one another than commonly assumed (hence not likely to be self-contained information pits, or silos)" (p. 14).

The smallest unit of a clique is the Simmelian tie, or a set of three, reciprocally related agents in a network. Simmelian ties have been found to be stable across time (agents involved in such ties are less likely to drop out of the organization, for example; Krackhardt, 1998). Importantly, Tortoriello and Krackhardt (2010) have found that Simmelian ties, particularly ties that are interactive across other ties, are important for the creation of innovation. The existence and influence of cliques and Simmelian ties within a social network such as a high school will be explored in this study.

Complex Adaptive Systems

Lichtenstein et. al. (2006) said of complex adaptive systems within organizations:

> A CAS is comprised of agents, individuals as well as groups of individuals, who resonate through sharing common interests, knowledge and/or goals due to their history of interaction and sharing of worldviews. Agents respond to both external pressures (from environment or from other CAS or agents, e.g., leaders) and internal pressures that are generated as the agents struggle with interdependency and resulting conflicting constraints (e.g., when the needs of one agent conflict with those of another). These tensions, when spread across a network of interactive and interdependent agents, generate system-wide emergent learning, capabilities, innovations, and adaptability. Importantly, such elaborations are products of interactions among agents, rather than being caused by the specific acts of individuals described as leaders. (p. 3)

Schools, and more particularly, cliques within schools, are complex adaptive systems. Boal and Shultz (2007) stated, "The behavior and structure of an organization emerges out of the interaction of a collection of agents" (p. 411). Marion and Gonzales (2014) also suggest that Complex Adaptive Systems (CAS) are "networked clusters of inter-synchronous agents … [within broader networks,]… people who gather around a metaphorical water cooler" (p. 237).

Agents, or teachers for the purpose of this study, in complex systems are moderately coupled rather than tightly or loosely coupled. Loose coupling produces too

few conflicting constraints to pressure a system to change, and tight coupling produces too many conflicting constraints to allow the resolution of the challenges they pose (Kauffman, 1995). Agents can be part of the same team, but they need not—should not—agree on all things, for disagreements introduce new ideas and pressure into a complex system (Marion, 2013). However, agents in a network shape each other's thoughts and actions; they are interdependent and interactive whether the relationship is perceived as positive, negative, or indifferent.

Complexity theorists argue that innovative behaviors emerge from the interaction of agents (teachers) without the influence of centralized control (leader/principal) (Boal & Schlultz, 2007). The notion of CAS (or cliques, from the perspective of network analysis) helps to explain the importance of social networks and social network theory when researchers or school leaders attempt to understand and predict the direction and emergence of change and innovation within a public school or school district.

However, the concept of CAS also provides lessons to be learned by the leaders of these organizations. As stated earlier, there is not a need for a "heroic" or directive leader but leaders do need to be involved. Uhl-Bien, Marion, and McKelvey (2007) suggest,

> In sum, complexity describes the interdependent interactions of agents within CAS, agents with CAS, and CAS with CAS. The primary unit of analysis in these interactive dynamics is, however, the CAS itself, and the behaviors of agents are always understood within the context of CAS. CAS are unique and desirable in that their heterogeneous, interactive, and

> interdependent structures allow them to quickly explore and consolidate solutions to environmental pressures. They require new models of leadership because problem solving is performed by appropriately structured social networks rather than by groups coordinated by centralized authorities. (p. 304)

District and school-level positional leadership does play an important role in the process of innovation, but it does so by managing contexts to drive the organization towards complex states in order to spark creativity and drive innovation. We will discuss this in the section on complex leadership theory below.

Complexity Theory

Complexity Theory suggests that innovative organizational behaviors are impelled more by interaction dynamics across an organization than by leadership action (Cilliers, 1998). Complexity theory proposes that positional leadership is an organizational process that should serve to cultivate leadership across all facets of the organization. This is in direct contradiction to previous ideas of leadership as a more prescribing function, as proposed by Fiedler (1967) and others. Traditional leadership theory suggests that individual authority roles express leadership and that anyone who expresses leadership is a leader with authority. Complexity theory argues that leadership is a process in which formal leaders contribute to, but don't necessarily control, the interactive dynamic and are not the only leaders in the system (Marion & Uhl-Bien, 2001).

Marion and Uhl-Bien (2003) argue in regards to complexity theory, "complexity agents view organizing as a bottom-up dynamic that is generated through interactive bonding among interdependent, need-seeking individuals, each of whom is driven by local (bounded) assessments of social and organizational events." (p. 56). It is important that leaders in complex organizations understand this argument. Leaders must nurture this "bottom-up dynamic" to allow creativity ideas and innovation to emerge from members of the organization.

Marion and Gonzales (2013) commenting on Cilliers (1998), state, "Cilliers said that complexity is an interactive dynamic in which the parts of a system constantly change because of their interactions with one another. That is, interacting agents adapt to each other (change); each adaptation forces other network agents to adapt, and these adaptations in turn forces further change, and so on"(p.233). Coveney (2003) explains complexity as, "The study of the behaviour of large collections of … simple, inter-acting units, endowed with the potential to evolve with time" (p. 1058). Snowden (2010) observes that interactive systems that are moderately constrained by some restraining force. Snowden's (2010) point about "moderately constrained" systems is important because leaders are often hesitant to relinquish the power and allow some of the interaction that is necessary for a complex organization to thrive, but Snowden argues that there still needs to be some constraints or pressures to encourage group interaction and therefore, the leader is relinquishing power in it's entirety.

Complexity theory is a paradigm shift in the way scholars think about leadership because it speaks to informal dynamics in a system that are produced by the complex,

interdependent interactions of individuals. From the perspective of complexity theory, leaders do not find quick, prescriptive fixes; rather, they find methods for creating and fostering an environment for knowledge growth, information flow, and change. Administrators exploit the system's informal group dynamic by raising follower's levels of consciousness about the importance and value of general, relatively open-ended (as opposed to specific) goals, and getting followers to transcend their own self-interest for the sake of the team organization, (Bass, 1985).

Marion (2013) has identified a number of contexts within which complexity can thrive. These contexts are leverage points that are available to the leader of a complex organization and, when properly levered, can foster innovation. Table 2.1 from (Marion, 2013, p. 36) provides a summary of those tools.

Table 2.1. Complexity contexts and tools of Enabling Leadership; from Marion, 2013.

Interaction	Organizes and structures in ways that put people into proximal relationships that foster interaction.
Interdependency	Organizes such that people have common tasks that require them to depend on one another.
Heterogeneity	Promotes diversity of skills, worldviews, preferences, etc.
Adaptive Pressure	Challenges that pushes people to explore creative solutions.
Conflicting Constraints	Incompatible needs or preferences.
Process-Related Conflict	Differences over how tasks are to be completed.
Adaptive Rules	Rules that pressure people to interact, to be interdependent, to challenge each other, to seek creative solutions to challenges, etc.
Psychological Safety	Trust, support, free from threat.
Vision	Non-restrictive, general perspectives of the future, framed to foster creative

Interaction refers to the positioning of agents into situations where they are forced to interact with one another thus enabling creative tensions that could foster innovation. Interdependency refers to organizing agents into groups based on shared interdependent goals or tasks to enable pressures necessary to increase innovative capabilities. Heterogeneity refers to grouping of individuals whose interests or attributes don't necessarily correspond with those of their colleagues. A heterogeneous group will be able to bounce diverse ideas off of one another and compare views from different perspectives. Adaptive pressures are situations created by the formal leader that pressure the members of the organization to be creative and innovative. Adaptive pressures create the conditions, and set the stage, for problem solving to emerge. Conflicting constraints

refer to situations in which actors are pulling in opposite directions and causing mutual pressure on one another. Such constraints require creativity or innovation to solve mutual (interdependent) problems. Process-related conflict refers to disagreements or differences of opinion on how to achieve goals, thus fostering problem solving and creating pressure to find creative solutions. Adaptive rules are rules enacted by the formal leader that cause people in interact and be interdependent, which can cause positive results as long as those involved are capable of interacting in an uncomfortable environment where disagreements are almost a certainty. Psychological safety refers to conditions in which people are free to voice their ideas and opinions in an atmosphere of trust without fear of reprimand or confrontation from administration. Psychological safety is a critical component in any complex organization and a necessity for any leader trying to enable the members of the organization to be adaptive leaders.

All of this can be done at various levels within the complexity dynamic. Complexity theory and social network theory offer leaders a logistical guide for facilitating a knowledge-producing group dynamic.

Information Flow

Complex systems are structured ultimately to optimize the flow and processing of information in an organization (Marion & Gonzales, 2014). Complexity theory envisions information flow as the core reason for structuring groups to function dynamically.

In public high schools, as in most organizations, information is not always accurately transmitted and may or may not be delivered in a positive manner. The children's game called "Telephone" is an example of how information can be

miscommunicated, exaggerated, diluted, or be completely inaccurate as the information flows across individuals – or in the case of public education, from district level administration to teachers within their networks (Daly, 2010). When information is transmitted from the district level administration to the school level administration, the school level administration must interpret that information and then deliver it to the next level of leadership; which is commonly the heads of different departments (i.e. social studies, science, math, etc.). There are abundant opportunities for miscommunication in this scenario. However, miscommunication within an organization is not as severe as in the children's game because social networks clarify messaging by providing feedback on what is received (Marion, 2002).

Information flow is more central to innovation than are the carriers of information (agents) alone. In a complex organization, the key change-producing dynamic is related to how information interacts, how it competes, combines, diverges, elaborates, and, occasionally, turns into something uniquely new (Marion, 2013). For example, a new standardized testing initiative created by administration will be more effective or pertinent if there is an open discussion among teachers about a district wide initiative because it engages dynamic information flow among agents with diverse information about curriculum. Information flow is critical to the success of a complex system and it is imperative that leaders foster conditions that enable members of the organization to be interdependent and to work together to innovate (Osborn & Marion, 2009).

Complexity Leadership Theory

Complexity leadership theory (CLT) is derived from complexity theory, and both are related perspectives of social networks. The ideas of CLT can be readily applied by practitioners. However, some leaders are cautious and sometimes resistant to accept the premises behind CLT because it means that the leader must relinquish some control or admit that perceived levels of control were already lost. Complexity theory is about distributed forms of leadership, network dynamics, social capital and collaborative efforts, informal and formal leadership (Marion, 2013). It is about how different parts of the organization interact and work together to produce creativity, innovation, and knowledge. Complexity Leadership Theory (CLT) provides a re-conceptualized definition of leadership, one that is distributed and that acts *within*, more than *on*, the organization's social and task dynamic (Marion, 2013).

Organizations change over time, they evolve. It is because organizations are complex systems that they inevitably change; whether the change is positive or negative, it will occur. Change can, and does, occur without a "heroic" or directive leader; instead, complexity leaders recognize that their roles are about "(1) managing conditions in which learning, creativity, and adaptability can emerge from a dynamic where ideas compete, grow, elaborate, and combine with other ideas, and (2) the act of actively participating in an interactive, network dynamic" (Marion, Klar, H. W., Brewer, C. A., Griffin, S., Reese, K. L., Schreiber, C., et al. , 2013, p. 7).

Complexity theorists Uhl-Bien, Marion, and McKelvey (2007) have identified three roles of complexity leadership: administrative leadership, adaptive leadership, and

enabling leadership. *Administrative leadership* refers to top-down bureaucracy, where successes and failures are measured by profits and losses (i.e. test scores and schools' Annual Yearly Progress data). *Adaptive leadership* is embedded in the complexity dynamic and is a bottom-up process where group dynamics and the various agents in the network-driven system lead change. *Enabling leadership* is designed to control (enhance or reduce, depending on environmental pressures; Boisot & McKelvey, 2010) the relative levels of adaptive an administrative leadership. Enabling leadership is also a form of management because it enhances or suppresses adaptive behaviors by using supervisory authority to manipulate a variety of enabling conditions (or contexts; see Table 2.1) (Osborn & Marion, 2009). Figure 1.1 (from Uhl-Bien et al., 2007) provides a clear visualization of the interaction of leadership, CAS and complexity, and bureaucracy in a system.

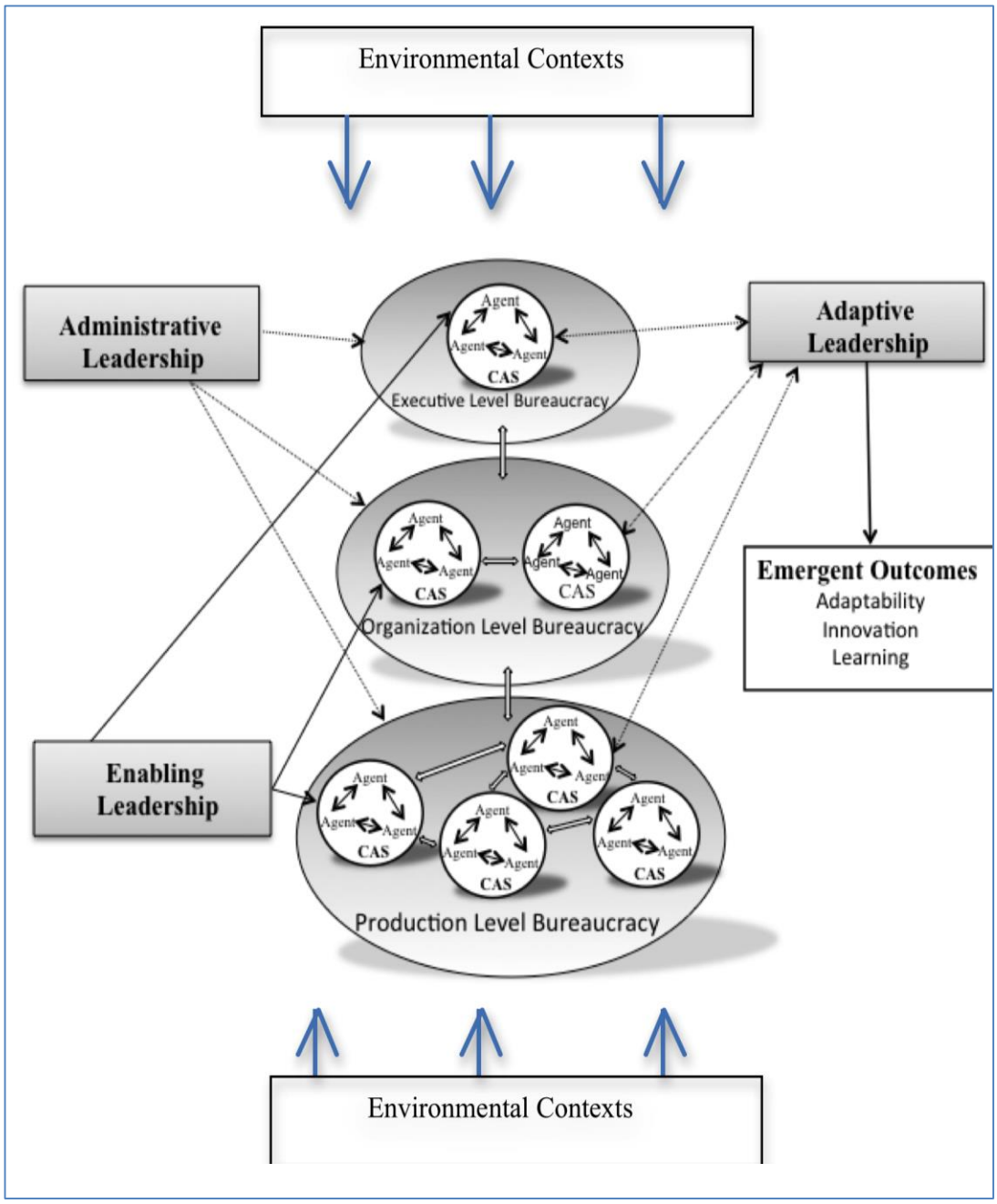


Figure 1.1. Model of complexity leadership theory in bureaucratic structures. From Uhl-Bien et al., 2007.

Propositions

Based on these discussions, the following propositions are offered:

Proposition 1: Engagement of agents in innovations is affected by the level of adaptive leadership within the organization.

Proposition 2: Engagement of agents in innovations is enhanced when leaders of cliques are also coupled with members of other cliques.

Proposition 3: Engagement of agents in innovations is influenced by their degree of Simmelian ties.

Proposition 4: Engagement of agents in innovation is affected by patterns of interactions in a network (i.e., the patterns of relationships in the respective networks).

Summary

This chapter included a review of literature regarding educational change, complexity theory, complexity leadership theory, network theory, complex adaptive systems, and information flow. First, a history of educational change was explored as well as the reasons for implementing change. Secondly, a literature review of innovation was presented. Lastly, a literature review of Network Theory, Complexity Theory, and Complexity Leadership Theory is presented and focuses on what drives a dynamic network and how the network fosters change, while tying in the reasons why information flow is so important to network dynamics and vice versa. The review specifically focused on how network dynamics influence an organizations response to change and innovation.

CHAPTER THREE

METHODOLOGY

Leadership theory and organizational change often focus on the existence of a directive leader that leads in a top-down manner. However, Lichtenstein and Plowman (2009) suggested that "the vast number of total interactions occur between peers rather than formal leaders and their 'followers' and therefore, much of the raw influence in the system likely accrues beyond the traditional manager-follower dyadic roles." (p. 618) Rarely is any attention given to the members of the organization and the network(s) that develop within the organization and it has been even more rare to identify those networks as catalyst for innovation within the organization.

Purpose of the Study

The purpose of the study was to explore network dynamics within a South Carolina public high school to identify network dynamics and informal leaders, and to determine their effects on innovation. We asked if dynamic networks are more open to innovation than are stable system? Do informal leaders influence innovation? How is innovation influenced by the presence of cliques? These questions are contextualized by complexity theory and explored with network analysis methodologies.

Research Propositions

The research study is an exploration of innovation within a public high school, looking specifically at the influence of adaptive leadership, cliques, clique leadership, and

network structure. More specifically, the following propositions were proposed at the end of Chapter 2:

Proposition 1: Engagement of agents in innovations is affected by the level of adaptive leadership within the organization.

Proposition 2: Engagement of agents in innovations is enhanced when leaders of cliques are also coupled with members of other cliques.

Proposition 3: Engagement of agents in innovations is influenced by their degree of Simmelian ties.

Proposition 4: Engagement of agents in innovation is affected by patterns of interactions in a network (i.e., the patterns of relationships in the respective networks).

All of the questions were framed with complexity theory, complexity leadership theory, and social network theory.

Research Design

This study is designed as a three-stage sequential exploratory mixed methods analysis (Plano Clark & Creswell, 2011). Since this was a sequential mixed methods study, the analysis proceeded in three steps, with each step informing the next. In the first step, information was gather to identify tasks, resources, and knowledge in the system; the findings at this stage were used as response scales in the second stage of the analysis. This preliminary data was collected with an open-ended survey of the tasks, knowledge, and resources that characterized work in the school. In the second step, a network analysis of data collected at the research site was performed to identify network dynamics used to measure the constructs identified in the propositions. The information collected in

the survey was entered in the Organizational Risk Analysis (ORA) program produced by Kathleen Carley at Carnegie Mellon University to perform a Dynamic Network Analysis. The analyses revealed patterns in the network structure. In the 3rd step of the analysis, quadratic assignment processes, a regression procedure that regresses matrices rather than variables, was used to ascertain the effects or the independent matrices on the dependent matrix, as identified in the propositions.

Step 1: Qualitative Analysis

A preliminary survey was created to gain knowledge regarding teachers' perceptions of tasks, knowledge, and resources. The preliminary survey asked open ended questions about the respondent's roles in the school, the tasks they complete within those roles, specialized knowledge needed to perform effectively in those roles, and resources needed to perform those roles (see Appendix A).

During this initial phase of the study, the survey was given to a representative sample of sixteen faculty and staff. The sample subjects were selected as representatives of all academic departments, administration, and office staff. The open-ended survey was given to gain perspective on their perceptions of tasks, knowledge, and resources that are needed for them to perform and innovate.

Data were analyzed using procedures similar to those described by Corbin and Strauss (2008). I first sorted all roles, knowledge, resources, and tasks into respective categories (open coding) then grouped similar concepts within categories into higher order groups. These higher order groups were used in the response scale for step 2. Examples of roles that were identified include math teacher or school administrator.

Knowledge groups included content knowledge and basic technology skills; sample tasks include classroom management and communicating with staff; finally, resource groups include basic computer software and textbooks. See Appendix B for a full list of concepts that were identified in this step of the analysis.

Step 2: Network Analysis

In the second step of the design, a survey was created in Qualtrics and emailed to all 75 faculty members (including administrators and office staff) at the target high school. The survey asked about teachers' perception of their relationships with one another; with resources, tasks, and knowledge; and with beliefs about innovation (see Appendices C and D). The questions in the agent, task, knowledge, and resources scales were adapted from a similar network dynamics study by Marion, et al., (2013); the innovation belief questions came from a previous study of innovation capability in a professional service firm by (Hogan, Soutar, McColl-Kennedy, & Sweeney, 2011).

Using this data, a Dynamic Network Analysis (DNA) was performed to explore and interpret different connections and relationships among faculty members. A DNA is different from traditional social network analysis because the method allows the researcher to approach the network analysis from different perspectives. DNA allows researchers to explore links between the different agents, nodes, and even multiple networks within the larger meta-network (Carley, Reminga, Storrick, & Columbus 2010), while also allowing researchers to study network evolution. Studying network evolution and the progression of relationships and their influence on the diffusion of innovation

(Carley et al. 2010), researchers can predict and perhaps even shape future outcomes and innovations.

For this study, agent-by-agent matrices were created for the Social, Trust, and Work networks, respectively. For example, each respondent (or agent) was asked whom he or she considered to be a friend; I then created a matrix with agent names (coded) in the left-most column and the top row of a spreadsheet; dyadic friendships were then represented as 1's in the respective cells. Agent-by-task, agent-by-knowledge, and agent-by-resources matrices were created in the same manner. The agent-by-agent social network, then, represents the patterns of friendship relationships at the school. Likewise the agent-by-agent trust matrix represents patterns of trust and the agent-by-agent work matrix represents patterns of agents who share work-related information. For instance, two agents may share negative views regarding administration, as revealed in the agent-by-belief matrix, and the trust network may reveal that these agents trust each other, thus they can safely interact with one another about these beliefs.

A number of agent-level and network-level measures can be calculated from such networks. For this analysis I used closeness centrality, eigenvector centrality, and Simmelian ties, all of which are agent-level statistics. Closeness centrality is defined as how close each node (agent) is to all other nodes (agents). Agents with high closeness centrality possess information; in other words, closeness centrality refers to people who are "in the know" (Carley et al., 2010). This statistic represents adaptive leadership in this study. Eigenvector centrality identifies nodes (agents) who are most connected to other highly connected nodes (agents). In other words, eigenvector centrality refers to the

leaders of cliques who are at least moderately coupled with leaders of other cliques. Simmelian ties can be defined as three nodes (agents) having a close, relationship with one another; that is, Simmelian ties identify the degree to which agents are linked into reciprocally-related triads; such triads are foundational to clique formation.

Respective agent-by-agent matrices were created from measures of adaptive leadership (closeness centrality), clique leadership (eigenvector centrality), and Simmelian ties cliquing by using repeated columns procedures (Carley et al., 2010). Thus the information produced matrices for agent-by-agent closeness centrality, agent-by-agent eigenvectors, and agent-by-agent Simmelian ties. The three existing agent-by-agent matrices for work, trust, and friendships, were used as the last of the predictors in this analysis (proposition 4).

The outcome matrices, innovation beliefs, were likewise created using repeated measures procedure. The innovation belief matrices emerged from the agents' responses on the various belief questions. The scores that were converted to matrices were all calculated using a Principal Component Analysis and this procedure is discussed in the next section.

Step 3: Regression Procedures

The dependent matrices used in the analysis were created from the belief data on attitudes about issues of innovation. The conversion of scores into matrices began with a Principal Component Analysis (PCA) of the belief items (attitudes about innovation). A PCA reduces a large set of items into smaller subsets or groups, and allows researchers to

understand themes and data structures. The 35 belief statements that were included in the survey were analyzed using the PCA routine in SPSS.

Factor scores were then calculated for the resulting factors and each set of factor scores was converted to agent-by-agent (A x A) matrices using repeated columns procedures (Carley et al., 2010). This is done by copying a set of factor scores into the first column of an empty A x A matrix, then repeating that column for each of the remaining columns. These matrices were used as dependent matrices in the subsequent QAP analysis.

Quadratic Assignment Process (QAP). A Multiple Regression Quadratic Assignment Process (MRQAP) was then calculated with the ORA software to regress the dependent matrix on the independent matrices. Traditional regression procedures are used when analyzing variables and cannot be used when analyzing matrices because network data is frequently digital rather than continuous and because agents within a network are interdependent while standard regression assumes independence of cases. QAP allows analysis of digital and interdependent data.

Significance for the MRQAP analysis was determined using Dekker permutations (Dekker, Krackhardt, & Snijders, 2007), which are more stable than other permutation procedures against network collinearity, skewness, and kurtosis (Dekker, 2007). A Dekker permutation $p < 0.10$ was accepted. We accept this higher p level because it is calculated using Monte Carlo procedures, and outcomes of Monte Carlo will vary over a probability range each time it is performed.

The dependent, multi-vector agent-by-beliefs matrices were regressed individually onto the agent-by-agent matrices for closeness centrality, eigenvector, Simmelian ties, work, trust, and social to determine which dynamics account for attitudes about innovation. Closeness centrality, or people "in the know" (Carley et al., 2010), is used to evaluate proposition 1 on adaptive leadership. Eigenvector centrality, which identifies the degree to which one is a leader of cliques, is used to measure proposition 2 on clique leadership. Simmelian ties, defined as three reciprocally related agents, is used to measure proposition 3 on cliques. The three agent-by-agent matrices, or nodes (agents) that are related by work, socially, or by trust, evaluate proposition 4 on patterns of relationships.

The six input matrices were analyzed simultaneously in QAP with the ORA software. Significance was tested using permutation procedures developed by Dekker (Dekker et al., 2007).

Specifically, the propositions listed at the end of Chapter 2 were analyzed as indicated in the equation:

$$\mathbf{Y} = \mathbf{X_1}b_1 + \mathbf{X_2}b_2 + \mathbf{X_3}b_3 + \mathbf{X_4}b_4 + \mathbf{E}$$

Where:

Y is one of the four agent-by-agent innovation matrices (the analysis is repeated for each innovation matrix).

$\mathbf{X_1}$ is an agent-by-agent matrix of levels of adaptive leadership as measured by closeness centrality.

$\mathbf{X_2}$ is an agent-by-agent matrix of eigenvector centrality, a measure of clique

leadership.

$\mathbf{X_3}$ is an agent-by-agent matrix of Simmelian ties, which are reciprocal relationships involving at least three agents; such ties are foundational to cliques and thus are media by which information is shared.

$\mathbf{X_4}$ is actually three agent-by-agent relationship matrices (work, trust, and social).

Summary

This study is a dynamic network analysis. Data collection relied on a preliminary survey sent to a representative sample that was then used to create the larger survey instrument. This survey, which identified relationship information for the network analyses, was distributed, and data from that survey was analyzed with ORA to identify network characteristics. These characteristics were then analyzed using ORA's MRQAP routine. In the first research question, an investigation of the effects of adaptive leadership within the organization on the engagement of agents in innovation adaptive leadership was measured with the network statistic, closeness centrality. The second research question on clique leadership used the network statistic, eigenvector centrality. The third research question looked at the effects of cliques on engagements of agents using Simmelian ties. The fourth proposition, the effects of patterns of relationships on innovation, was evaluated by regressing innovation on the three agent-by-agent matrices. All independent matrices were evaluated together to control for overlapping variances.

Ethical Considerations

When designing this study, I did not foresee any ethical problems but perhaps some unwillingness to participate because the teachers did not see the value in the study.

However, as I worked on my presentation to the teachers I realized that the participants may actually feel as if they were being singled out on unfairly grouped when I began to run the data and analyze aspects such as friendship or cliquing. So I designed the instrument and then a proxy researcher (a member of my doctoral committee) submitted it; I only received access to the information after it was coded so that everyone's anonymity was protected.

CHAPTER 4

FINDINGS

The purpose of this study was to explore network dynamics in a public high school in South Carolina to describe relationships and identify leaders within the networks. The study allowed exploration of the network dynamics and levels of adaptive leadership of a public high school to determine if they influenced attitudes about change and innovation in the network(s).

There were three phases to this study: a qualitative preliminary survey, a dynamic network analysis, and a quantitative phase. As mentioned in earlier chapters, the initial phase of the study was the preliminary survey that was given to a representative sample of 16 faculty and staff members to gain their perspective on the tasks, knowledge, and resources needed to adequately fulfill their job responsibilities. The responses were summarized for categories using procedures based on Corbin and Strauss' (2008) axial coding procedures. The second phase of the study was a dynamic network analysis that was conducted by use of a 35-question survey created in Qualtrics and sent to 75 faculty and staff members. The third phase of the study was the regression procedures, specifically; a PCA and a MRQAP were performed. The PCA was ran to produce factors to be used in the study while the MRQAP was conducted to regress the dependent matrix onto the independent matrices in order to identify the networks, clusters, and relationships that influence innovation in the network.

Data

Surveys were constructed in Qualtrics for the qualitative and the network analysis data collections. The qualitative survey data were collected and coded, and the results used as response scales for the network survey. The network data was distributed to all administration, faculty and clerical staff; resultant data were entered into the ORA software for analysis. Dynamic network analysis and MRQAP were used to analyze the data.

This study sought to address the following propositions:

Proposition 1: Engagement of agents in innovations is affected by the level of adaptive leadership within the organization.

Proposition 2: Engagement of agents in innovations is enhanced when leaders of cliques are also coupled with members of other cliques.

Proposition 3: Engagement of agents in innovations is influenced by their degree of Simmelian ties.

Proposition 4: Engagement of agents in innovation is affected by patterns of interactions in a network (i.e., the patterns of relationships in the respective networks).

Table 4.1 defines key terms used in the remainder of this study, as defined by Carley et al. (from McFarland, 2012).

Table 4.1. Dynamic Network Analysis Terminology

Terminology	Definition
Node	Individual data points within a network
Matrix	Relationship between nodes
Network	Relationship between nodes, links between nodes
Meta-network	Collection of networks within a system

There were 75 participants in the study; they evaluated 36 belief questions, and identified whether they were conversant with each of 7 knowledge categories, whether they needed each of 12 resources, and told whether they performed each of 11 tasks. The knowledge, resources, and tasks they chose from came from the stage 1 qualitative analysis. Table 4.2 reviews the number of nodes per pre-determined categories; the surveys are in the appendix.

Table 4.2. Meta-Network Node Counts

Node sets	Size
Agents	75
Beliefs	36
Knowledge	7
Resource	12
Task	11

The network survey was distributed to 75 teachers, staff, administrators, and teachers who were part time at the school (e.g., speech), but excluding custodial, lunchroom, and substitute staff. In total, 63 faculty and staff members completed the survey. That is a response rate of approximately 84% of the total faculty and staff

population with only 12 potential respondents electing not to participate. The 12 non-respondents, however, were potential candidates for selection in the agent-by-agent matrices (for example, teacher A could select Teacher B as a friend even though Teacher B did not answer the survey). Except in the trust network, all teachers either selected or were selected into the network; in the trust network, only two teachers neither selected nor were selected (isolates). Therefore, the actual networks included all or nearly all, potential respondents. The networks were not limited by non-response rates per se but by the outgoing links from non-respondents.

The survey participants for the network study were asked whom they trusted, whom they worked with on a daily basis, and whom they socialized with on a daily basis. They wee asked about tasks, resources, and knowledge. Their belief statements addressed perceptions of adaptive teamwork, technology use, innovation inhibitors, and innovative behaviors. Cronbach's alpha for the belief questions was 0.989.

Step 1: Qualitative Analysis

The goal of step 1 was to identify recurring themes among faculty members and their perception of what tasks, resources, and knowledge were pertinent and necessary for them to adequately perform their daily duties. A representative sample of 16 faculty and staff were selected to complete the preliminary survey. The respondents were chosen as representative of the academic departments and the office staff. The tasks, resources, and knowledge information was summarized into categories using procedures based on Corbin and Strauss' (2008) open and axial coding procedures. The information was used

to develop categories for the response scale in the subsequent organizational innovation survey.

The preliminary survey results provided a wide array of tasks, knowledge, and resources that the faculty members perceived as necessary to their daily duties within the organization. Each category was narrowed down to a few themes based on the recurrence and similarity of the answers to the survey. Tasks were defined as tasks that were necessary to properly performed job duties (i.e., lesson plans and preparations, data analysis and assessing student learning, and communicating with parents). Knowledge was determined by the knowledge sets that faculty members believe necessary to successful complete their daily responsibilities (i.e., instructional strategies and methods, content knowledge, and basic technology skills). Resources were defined as the items that faculty members believe necessary to successfully complete their daily responsibilities (i.e., textbooks, reliable internet connection, and basic computer software). The complete set of categories for tasks, knowledge and resources are listed in Appendix B.

Step 2: Network Analysis

A Dynamic Network Analysis (DNA) was performed to explore and interpret different connections and relationships among faculty members. The network analysis was used to create networks for each of the agent-by-agent belief statements in the survey and for the knowledge, resources, and the tasks networks. For example, an agent-by-agent network was created for work that represents patterns of work relationships (for an example, see Figure 4.1). A DNA is different from traditional social network analysis because the method allows the researcher to approach the network analysis from different

perspectives. DNA allows researchers to explore links between the different agents, nodes, and even multiple networks within the larger meta-network (Carley 2003), while also allowing researchers to study network evolution.

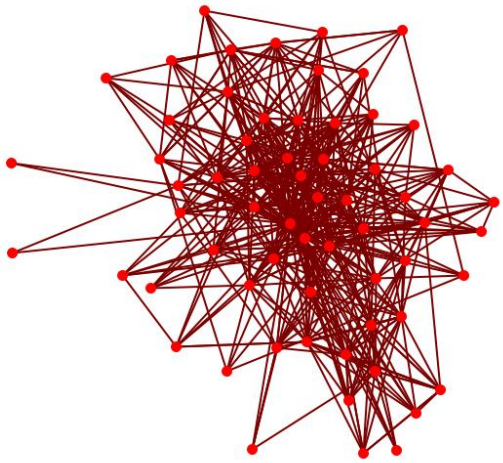


Figure 4.1. Circles represent nodes and lines represent links between nodes.

For this study, agent-by-agent matrices were created for the Social, Trust, and Work networks, respectively. For example, each respondent (or agent) was asked whom he or she trusted; I then created a matrix with agent names (coded) in the left-most column and along the top row of a spreadsheet; dyadic trust relationships were then represented as 1's in the respective cells. Agent-by-task, agent-by-knowledge, and agent-by-resources matrices were created in the same manner. The agent-by-agent trust network, then, represents the patterns of trust relationships at the school. Likewise the agent-by-agent work matrix represents patterns of work relationships and the agent-by-agent social matrix represents patterns of agents who share a level of friendship. For instance, two agents may share negative views regarding Innovation Inhibitors, as

revealed in the agent-by-belief matrix, and the trust network may reveal that these agents trust each other, thus they can safely interact with one another about these beliefs.

A number of agent-level and network-level measures can be calculated from such networks. For this analysis I calculated closeness centrality, eigenvector centrality, and Simmelian ties, all of which are agent-level statistics. Closeness centrality is defined as how close each node (agent) is to all other nodes (agents). Agents with high closeness centrality possess information; in other words, closeness centrality refers to people who are "in the know" (Carley et al., 2010). This statistic represents adaptive leadership in this study. Eigenvector centrality identifies nodes (agents) who are most connected to other highly connected nodes (agents). In other words, eigenvector centrality refers to the leaders of cliques who are at least moderately coupled with leaders of other cliques. Simmelian ties can be defined as three nodes (agents) having a close, relationship with one another; that is, Simmelian ties identify the degree to which agents are linked into reciprocally related triads; such triads are foundational to clique formation.

Respective agent-by-agent matrices were created from measures of adaptive leadership (closeness centrality), clique leadership (eigenvector centrality), and Simmelian ties cliquing by using repeated columns procedures (Carley et al., 2010). Thus matrices for agent-by-agent closeness centrality, agent-by-agent eigenvectors, and agent-by-agent Simmelian ties were generated. The three existing agent-by-agent matrices for work, trust, and friendships, were used as the last of the predictors in this analysis (proposition 4). The meta-network is a conglomeration of all networks, and that it represents the complex interactions across these networks.

ORA analyzed the work network to calculate eigenvector centrality, closeness centrality, and Simmelian tie coefficients for each of the participants. We chose to calculate the coefficients for the work network because it represents the core function of the school, but the results for the trust and social networks were similar. For Closeness centrality, the average was 0.455 with a standard deviation (SD) of 0.240; the average for eigenvector centrality was 0.147 with SD = 0.070; for Simmelian ties, the average = 0.050, SD = 0.069. The coefficients for the Simmelian ties were, overall, rather low, indicating low robustness for the variable in the work network. Coefficients could range from 0 to 1; the minimum value for Simmelian ties was 0.00 and the maximum value was 0.311.

Agent x Agent x Belief Newman Grouping

The survey results were analyzed with a procedure called Newman grouping (Carley et al., 2010), in which the main clusters are identified that agents. We ran the procedure using the agent-by-agent work network plus the agent by work network; this produces an agent-by-agent-by-belief network. The results exhibit clusters of agents and beliefs. The Newman's algorithm was performed by "removing low influence links in a network to create two, then three, then N separate groups until the end result was only the closely tied clusters of those who shared common beliefs and agent attributes" (Russ Marion, 2014).

Four major themes or clusters emerged from the measure and Figure 4.2 portrays the results of the Agent by Agent by Belief Newman grouping. Belief items within each cluster are shown as purple nodes. The themes that emerged were adaptive teamwork,

technology, innovation inhibitors, and innovative behaviors. Further, the analysis calculated a Newman modularity coefficient for the network of 0.15, which indicates a great deal of interaction between cliques. Newman modularity is measured on a scale of 0 to 1; coefficients close to 0 indicate more interaction across cliques and close to 1 indicates little interaction.

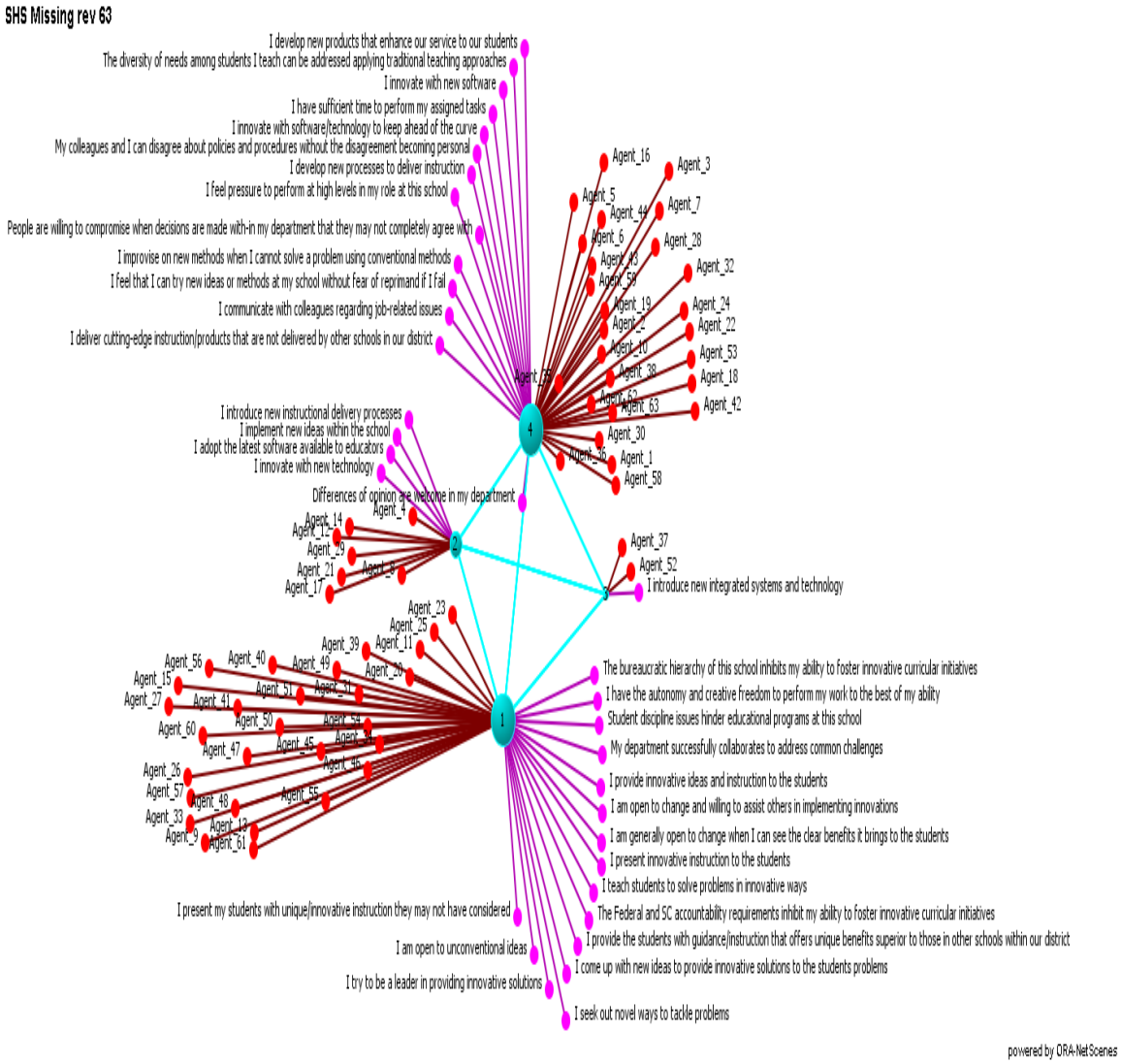


Figure 4.2. Agent by Agent by Belief Newman Grouping

Step 3: Statistical Analyses

The statistical analysis phase included a PCA of belief data and a multiple regression quadratic assignment procedure (MRQAP) to test the propositions.

Principal Component Analysis

A Principal Component Analysis (PCA) is another way (other than Newman's grouping) to identify important themes or clusters in a network. PCA offers the added advantage of providing scores (called factor scores) for each participant on each cluster that can be used in subsequent analyses. The PCA results for the belief questions are presented in Appendix E. I performed a list wise deletion, which means that any row (case) that was missing a response was excluded from the analysis. The determinant indicates no collinearity, meaning that the independent variables are truly independent of one another (Fields, 2009). The commonalities are almost all above 0.800, indicating that a sample smaller than 100 is sufficient for this study (Fields, 2009). The measure of sampling adequacy (MSA) is 0.893. The MSA's are measures of each question's reliability and should be at least 0.50, thus the MSAs for this study are highly reliable measures of innovative attitudes.

The PCA identified four factors that had eigenvalues of greater than 1; they explained 0.85 of the variance in the questions. This four-factor solution was supported by a root curve analysis. The factors were Adaptive Teamwork, Technology, Innovation Inhibitors, and Innovative Behavior, as defined below. It should be noted that the factors produced through the PCA were identical to the clusters produced through the Newman's grouping, further validating the results.

Factor 1 was Adaptive Teamwork; it describes contexts, particularly contexts related to teamwork, which are conducive to innovation. Factor 1 statements are as follows:

- I feel that I can try new ideas or methods at my school without fear of reprimand if I fail.
- I communicate with colleagues regarding job-related issues.
- My department successfully collaborates to address common challenges.
- My colleagues and I can disagree about policies and procedures without the disagreement becoming personal.

Factor 2, Technology, identified items that describe innovative use of technology; they are as follows:

- I adopt the latest software available to educators
- I innovate with software/technology to keep ahead of the curve
- I introduce new integrated systems and technology

Factors 3, Innovation Inhibitors, are items that identify organizational factors that suppress innovation; these statements are as follows:

- The bureaucratic hierarchy of this school inhibits my ability to foster innovative curricular initiatives
- The Federal and SC accountability requirements inhibit my ability to foster innovative curricular initiatives
- Student discipline issues hinder educational programs at this school

Factor 4, Innovative Behavior, expresses the respondent's commitment to innovative activities; these statements are as follows:

- I present innovative instruction to the students
- I teach students to solve problems in innovative ways
- I come up with new ideas to provide innovative solutions to the students problems
- I am open to unconventional ideas

Each respondent was assigned a weighted score based on factor loadings for each factor. The resultant factor scores were converted to agent-by-agent matrices using repeated columns procedures and entered into ORA for further analysis. It should be noted that factor 4, Innovative Behavior, had a negative factor loading; meaning that the respondents do not perceive themselves as being innovative (i.e., the scale's meaning should be reversed when compared to other factors). It should also be noted that the scale for Factor 3, Innovation Inhibitors, was reverse coded. These characteristics for factors 3 and 4 made interpretation something of a challenge.

Although PCA is calculated based on listwise deletion of cases, it nonetheless calculates factor scores for cases with missing data. Leaving these scores in the dataset would have biased the results of the QAP, thus the scores for cases that did not respond to the survey were deleted before conducting the QAP. Consequently, the agent-by-agent matrices used in the QAP were 63 nodes by 63 nodes instead of 75 by 75, as used in other analyses in the study (remember that the other analyses still included data for non-respondents because these non-respondents were subject to selection by others).

Quadratic Assignment Process

Data from the surveys were converted into matrices, with agents (respondents) in the rows and other nodes (agents, tasks, resources, knowledge, beliefs) in columns. The information thus produced matrices for agent-by-agent, agent-by-belief, agent-by-agent closeness centrality, agent-by--agent eigenvector centrality, and agent-by--agent Simmelian ties. The repeating scores method (Carley et al., 2010) was used to create the agent-by-agent matrices for eigenvector centrality, closeness centrality, Simmelian ties, and the four belief matrices. These matrices were analyzed with multiple regression quadratic analysis procedures (MRQAP) (Dekker et al., 2007), which is available in ORA. Significance was determined using Dekker permutations (Dekker et al., 2007), which are more stable against network collinearity, skewness, and kurtosis than more traditional Y-permutations. A Dekker permutation probability of 0.05 is significant and 0.10 is near significance (Dekker et al., 2007). We accept this higher p level because it is calculated using Monte Carlo procedures, and outcomes of Monte Carlo will vary over a probability range each time it is performed. MRQAP was used to regress each of the four multi-vector belief matrices onto the three agent-by-agent matrices (social, work, and trust) and the adaptive leadership (closeness and eigenvector) and cliquing (Simmelian ties) matrices. The results of the work, trust, and social networks are reproduced in Table 4.3.

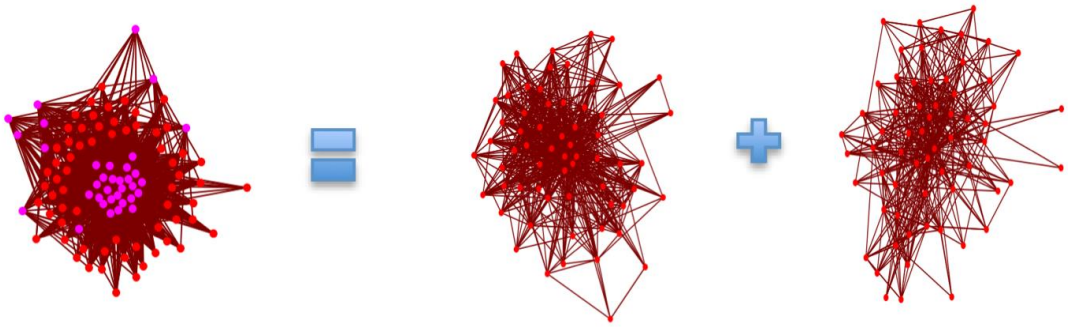
Table 4.3. Dekker Significance for Work, Trust and Social Networks.

Dependent Matrices	Independent Matrices	Coefficient	Dekker Significance
Adaptive Teamwork	Closeness Centrality	1.008	0.040**
	Eigenvector Centrality	-0.409	0.310
	Simmelian Ties	0.246	0.380
	Trust	0.069	0.070*
	Social	-0.047	0.360
	Work	-0.001	0.470
Technology	Closeness Centrality	0.027	0.420
	Eigenvector Centrality	1.225	0.280
	Simmelian Ties	-1.116	0.260
	Trust	-0.168	0.040**
	Social	0.219	0.030**
	Work	-0.016	0.430
Innovation Inhibitors	Closeness Centrality	-1.989	0.120
	Eigenvector Centrality	-2.198	0.190
	Simmelian Ties	4.628	0.010**
	Trust	-0.266	0.010*
	Social	0.243	0.090*
	Work	0.013	0.430
Innovative Behaviors	Closeness Centrality	0.967	0.130
	Eigenvector Centrality	0.178	0.390
	Simmelian Ties	0.322	0.330
	Trust	-0.135	0.010**
	Social	0.086	0.150
	Work	-0.015	0.400

Effects of Independent Variables on Dependent Variable for Trust, Social and Work Networks
**p<0.05
*p>0.10

The dependent matrices were the 4 clusters that were identified through Newman's grouping and a PCA (adaptive teamwork, technology, innovation inhibitors, and innovative behaviors) while the independent matrices were closeness centrality,

eigenvalue, and Simmelian ties as correlated with one of the three networks (i.e. work, trust, or social). MRQAP regression is representationally explained by Figure 4.3 to emphasize the fact that QAP regresses networks onto networks rather than variables onto variables.



Pred. Inhibitors Belief Network = β_1 Trust network + β_2 Social network

Figure 4.3. Visual representation of QAP matrix regression; the error term is omitted for simplicity.

The directionality of the coefficient produced by QAP is relevant to the relationship among matrices. If an independent matrix shows a statistically significant impact on the work matrix, a positive beta tells us that groups merge in the dependent matrix for the given characteristic evaluated by the independent matrix, while a negative coefficient reveals inverse relationships among groups in the dependent matrices that are attributable to the differences in the independent matrices (Marion, 2014).

The QAP was run four times, once for each of the dependent variable (adaptive teamwork, technology, innovation inhibitors, innovative behaviors) with 6 independent variables (closeness centrality, eigenvector centrality, Simmelian ties, trust, social, work).

Adaptive Teamwork

There was a positive coefficient of 1.008 and a Dekker significance of 0.040 for the regression of the agent-by-agent dependent matrix, adaptive teamwork, on the agent-by-belief independent matrix, closeness centrality. Also, there is a slightly positive relationship between adaptive teamwork and the trust network with a coefficient of 0.069 and a near significance of 0.070. The results of the QAP could indicate that members of the organization trust others that are perceived as team players and "in the know". The people are trusted, perhaps, because they are viewed as valuable assets and informal leaders.

Technology

The significant effects on Technology were from the independent matrices, except trust and social, which are likely grouped together because most people who interact socially or consider someone a friend also trust that individual. However, the coefficient for trust was a negative -0.168 with a Dekker significance of 0.040, meaning there was a significant negative relationship between technology and trust, while there was a positive significant relationship between technology and social with a coefficient of 0.219 and a Dekker of 0.030. One explanation for the differing results between the independent variables of social and trust could be that agents are friends with other agents who are technologically proficient and innovative, but do not want to share ideas or information with those agents due to their own aspirations, otherwise known as "intraorganizational secrecy" (Hansen, 1999; Tortoriello & Krackhardt, 2010).

Innovation Inhibitors

The results indicated a significantly positive relationship between Innovation Inhibitors and Simmilean ties with a coefficient of 4.628 (indicating a very strong relationship) and a Dekker significance of 0.010. The results also indicated a significantly negative relationship between Innovation Inhibitors and trust with a coefficient of -0.266 and a Dekker significance of 0.010. However, there is a near significant positive relationship between Innovation Inhibitors and social with a coefficient of 0.243 and a Dekker of 0.090. These particular results could mean that agents who are distrustful of others are also likely to focus on organizational characteristics that they feel prevent them from being innovative.

Innovative Behaviors

The results indicated just one significant relationship for Innovative Behaviors. The coefficient for trust and innovative behaviors was -0.135 while the Dekker significance was 0.010. The results can be interpreted as a near significant negative relationship between innovative behaviors and trust network. It should be noted that innovative behaviors had a negative factor loading in the PCA and therefore, these results can be interpreted as agents who do not value innovative technology and do not trust others in the organization with this information as it would most likely be detrimental to their job security.

Summary

This chapter presented the results gathered from the data collected using the methodology of Dynamic Network Analysis, described in Chapter 3. Data collection

began with an open ended preliminary survey to create themes to be used for a response scale in a subsequent and larger survey. This preliminary data was analyzed and used to create a questionnaire that became the survey submitted to all faculty and staff. Survey results were analyzed using ORA. Specifically, MRQAP analysis was used to interpret relationships, themes, and networks that enable or inhibit the potential for organizational innovation.

Closeness centrality and trust had a significant effect on the adaptive teamwork matrix. Neither closeness centrality, eigenvector centrality, nor Simmelian ties had a significant impact on the technology matrix, however, there was a significant relationship between technology and social, as well as technology and trust. Trust, Social and Simmelian ties had a significant effect on the innovation inhibitors matrix. Finally, trust was the only variable that had a significant impact on the innovative behaviors matrix. The interpretation and impact of these results are discussed in greater detail in Chapter 5.

CHAPTER 5

DISCUSSION

This chapter addresses the research questions and propositions through a detailed analysis of the findings and results of the study. This discussion is based on an exploration of innovation within a public high school, looking specifically at the influence of network structure, adaptive leadership, cliquing, and information flow on innovation. More specifically, this study asked the following:

1. How does the level of adaptive leadership impact innovation?

2. How do cliques and leaders of cliques influence innovation?

3. Does the nature of the network structure in a school contribute to successful change and innovation?

All of the questions were answered based on the principles of complexity theory, complexity leadership theory, and social network theory, using dynamic network analysis (DNA) methodology.

The first part of this chapter is structured to explore the four propositions for this study and to propose implications for practice. The propositions are:

Proposition 1: Engagement of agents in innovations is affected by the level of adaptive leadership within the organization.

Proposition 2: Engagement of agents in innovations is enhanced when leaders of cliques are also coupled with members of other cliques.

Proposition 3. Engagement of agents in innovations is influenced by their degree of Simmelian ties.

Proposition 4: Engagement of agents in innovation is affected by patterns of interactions in a network (i.e., the patterns of relationships in the respective networks).

The last section of the paper explores implications of the results for future research.

Explanation of the Findings

Proposition 1

According to the findings, there is supporting evidence to suggest that the engagement of agents in innovation is directly correlated to the level of adaptive leadership (as measured by closeness centrality). Specifically, the QAP analysis revealed that closeness centrality is relevant to factor 1 (adaptive teamwork), but is not significant in factors 2, 3 or 4. Adaptive leaders, then, are particularly influential to respondents who believe they are allowed the creative freedom to be innovative but are not influential among those who use technology, are concerned about innovation inhibitors, or who express commitment to innovative behaviors.

Uhl-Bien and Marion (2009) describe adaptive leadership (both individual and collective) as a "dynamic process in which agentic adaptive leaders interact with—and engage the potential of—emergent complexity dynamics to produce adaptive change for an organization" (p.638). It is imperative that adaptive leadership exists in a complex organization in order for innovative ideas to be suggested, attempted and properly carried out. So, given the partial support in this study for adaptive leadership's affect on

innovation, are Uhl-Bien and Marion only partially correct, or are there other explanations?

A likely relationship between closeness centrality and two of the relationship networks, social and trust, may help explain. In all four analyses of the dependent, innovation networks, either the social or the trust networks, or both, significantly affect the respective innovation outcome. It is logical to assume that closeness centrality and social relationship, all of which evaluate relational ties, overlap, thus the effect of one (e.g., closeness) explains much of the variance that might be explained by the other (e.g., trust). That is, once the effect of trust is determined, there is little left for closeness to explain. Agents who trust one another are in close communication (closeness centrality) with each other, and these have higher innovation factor scores than do agents who don't have trusting relationships and who aren't close.

The innovation belief statements that respondents felt particularly strong about were, "I feel that I can try new ideas or methods at my school without fear of reprimand if I fail," "Differences of opinion are welcome in my department", "My department successfully collaborates to address common challenges", and "People are willing to compromise when decisions are made within my department that they may not completely agree with." The centrality of these beliefs indicate that the agents feel they are respected by their colleagues and their ideas are welcomed. The idea that those faculty members feel comfortable sharing information, disagreeing when needed, and trying to reach solutions together is a indication of positive information flow and also

conditions where innovative ideas can thrive. It is easy to understand why such feelings would be enabled by feelings of trust and by high levels of closeness centrality.

Proposition 2

There is no evidence to support the proposition that engagement of agents in innovation are enhanced when leaders of cliques are also moderately coupled with leaders of other cliques (indicating strong interaction across cliques plus strong adaptive leadership within cliques), as the eigenvector centrality was not significant in any of the analyses of the four dependent innovation variables. Eigenvector centrality typically identifies those who mobilize others (Carley et al., 2010) or those that are capable of getting others on board with new or innovative initiatives. The absence of an effect for eigenvector centrality suggests that interaction among and across clique members does not affect innovation within this organization. It would be inaccurate to conclude, however, that the absence of an eigenvector centrality effect means that there is no interaction among cliques or that this measure does not influence innovation for two reasons. First, the 0.15 Newman modularity that was reported in Chapter 4 reveals the existence of significant interaction between cliques (a modularity coefficient of 0.00 would indicate that agents communicate between cliques to the same degree that they communicate within cliques). Secondly, due to the use of closeness centrality to measure adaptive leadership and the positive impact it had on the adaptive teamwork matrix, it is possible that closeness centrality is overshadowing eigenvector centrality as they are both a measure of degree of interaction.

Proposition 3

There is evidence that the engagement of agents in innovation is influenced by their degree of Simmelian ties for factor 3 (innovation inhibitors), implying that those who see the organization, district, and government inhibiting their creativity also have a close knit group of colleagues that they socialize with and/or trust. These people are typically difficult to engage in innovative ideas and initiatives because they have strong relational ties that support their negative opinions.

However, when looked at more closely, I observed an interesting variation in factor scores. Agents' scores on the innovation inhibitors factor ranged from -1.21 to 2.41; negative scores identify agents who do **not** believe that the innovation inhibitors are a problem within the organization (reverse interpretation). Simmelian ties are powerful bonds. If such ties characterize those with negative attitudes, then the concern for practitioners should be that, given the potency of Simmelian groups, the negative respondents may have an advantage in influencing others regarding their perspective. It would be to the advantage of leaders to offset this advantage by enabling stronger ties among innovative individuals.

However, examination of the Newman's grouping analysis of the agent-by-agent-by belief network (Figure 4.2) revealed a different perspective: respondents whose attitudes about inhibitors ranged from positive to negative were grouped in that particular clique. That is, Simmelian ties may characterize respondents with both negative and positive attitudes, and the QAP, then, may be revealing differences between respondents who cluster in this clique versus those who don't. If so, the question becomes, whose

attitude will be most influential, those who feel inhibitors are a problem or those who don't? Either way, the recommendation that administration enable strong relationships among creative personnel stands.

Proposition 4

There is no evidence to suggest that the engagement of agents in innovation is influenced by the structure of the work network (who works with whom) in relation to any of the 4 factors. There is evidence indicating that the engagement of agents in innovation is influenced by the structure of the social network for factors 2 (use of technology), 3 (innovation inhibitors), and 4 (innovative behaviors). Engagement is influenced by the structure of the trust network for all 4 factors.

The work network, then, has no impact on the organization's ability to innovate and it appears that both the social and the trust network are critical to innovation and the organization's capability to innovate. Trust and social networks are "affective" networks, meaning that the relationships between agents are about how they feel about one another and about commonalities they share outside of the work environment. On the other hand, it is possible, and likely fairly common, for people to work together without sharing common social bonds. I argue, then, that strong social and trust networks are valuable assets to any organization; people may work with most anyone, but they work together better and more innovatively when they like and/or trust their colleagues.

The results of this proposition are surprising given my observations within the organization. I originally believed and would have argued that agents were innovative based the department in which they worked, and I even wanted to know what factors

guided this outcome. However, it is now evident that agents' capability and willingness to innovate is directly related to their trust and social relationships and that the innovation we may see by department is attributable to affective relationships. This finding would be of particular interest to the administrative team as the importance of these relationships is evident and could be nurtured in order to increase the innovative capability of the organization.

Implications

The purpose of this study was to explore network dynamics within a public high school to identify network dynamics and informal leaders, and to determine the effects of these network characteristics on innovation. The results yielded interesting results, some surprising and some confirmation of predicted outcomes. I have determined five particular findings that could have future implications for the organization.

First, the impact of adaptive leadership (closeness centrality) is evident, which indicates that the principal at the research site has created conditions where such informal leaders can emerge. These adaptive leaders are only influential in fostering adaptive teamwork, and in combination with trust, but this is an important effect. As Uhl-Bien and Marion (2009) argue, the collective (team) is foundational to innovative behavior. There are departments and other groups where innovation is not evident, thus more needs to be done to strengthen such teamwork across the school, and the research suggests that teamwork is enabled by fostering adaptive leadership and trust. Perhaps the principal could organize team-building opportunities throughout the school year. For example, small team building activities inserted into bi-weekly faculty meetings that take no more

than 10 minutes, but could go a long way in building relationships of trust and could see the emergence of adaptive leaders. Also, off-campus opportunities such as ropes courses or leadership retreats have become a bit cliché, but they are enjoyable ways to engage your staff in activities that can foster relationships of trust and nurture, if not create, adaptive leadership and trust.

Second, we found that affective relationships, social and trust, were generally important across all measures innovation. Perhaps the formal leadership should create more opportunities for faculty and staff to interact socially (i.e., periodic luncheons, fun team building activities, family nights at sporting events). One obstacle to creating opportunities that fosters social relationships, of course, is the lack of discretionary funds in an organization such as a public high school, but since affective relationships are so important, the school might consider diverting some non-educational money, such as revenues from snack and soft drink vending, to such efforts. Professional development opportunities that encourage faculty members to step outside of their department or clique could perhaps foster new friendships or levels of trust with colleagues that otherwise would never exist.

A third recommendation is to strengthen work (e.g., departmental) networks by way of the social and trust networks. One way to strengthen the social and trust networks of departments is off-campus activities such as a ropes course as was mentioned above in regards to building trust and adaptive leadership. Another example is for the principal to create team building activities or break-out sessions that encourage the departments to work together to solve a problem or achieve a particular goal within the school. Also, it

would be a good idea to take entire departments to professional development opportunities such as summer conferences and then ask them to present on interesting or useful techniques and methods that they discovered at the conference. These presentations could be delivered at faculty meetings throughout the year. Such activities could help create new friendships or build levels of trust. The possible outcome of such an activity could strengthen the organization as a whole.

The fourth recommendation is possibly the toughest to achieve. It is evident that there is a group of faculty members that dwell on innovative inhibitors as reason for not being innovative. Particularly, they believe that "the bureaucratic hierarchy of the school inhibits my ability to foster innovative curricular initiatives". Obviously it would be easier to address this concern if we could identify the respondents, but their anonymity is protected within this study. With that in mind, perhaps the formal leadership could create opportunities that would allow all faculty members to participate in policy creation and encourage them to get involved in other district committees that create policy. It should be noted that this organization already has a committee that creates, discusses, and amends policy in which faculty members are voted into, but it is typically made of the departmental leadership and I can see how it would be difficult for someone that is disgruntled about the bureaucratic hierarchy to obtain enough votes to secure a position on this committee.

The fifth recommendation is to strengthen Simmelian ties within the organization. It was discussed in proposition 3 above that Simmelian ties did exist among respondents with negative attitudes about innovation inhibitors, but I would argue that the

Simmelian ties need to be stronger throughout the organization. Tortoriello and Krackhardt (2010) argue,

"When individuals share common third-part ties they are more likely to generate innovations than when they lack common third-party ties and bridging relationships embedded in a dense social structure facilitate the formation of common knowledge and shared meanings, reduce frictions due to differences in understanding, and promote the cooperation and coordinated actions that are necessary to integrate and take advantage of diverse sources of knowledge" (p.168).

The organization should make efforts to increase Simmelian ties and therefore the innovation capabilities within the organization by creating scenarios that cause faculty members to create bridges based on shared goals and initiatives. Ideas such as cross-curricular initiatives, professional learning communities, inter-departmental professional development opportunities, etc. could be used to create these bridges and strengthen Simmelian ties. It should be noted that one inter-departmental initiative has occurred recently as members of each department worked together on a accreditation process which caused everyone to work with faculty members that may not otherwise communicate with, all with a common goal in mind. This particular initiative was of particular importance to all involved as the school's accreditation can be directly related to work environment.

Implications for Future Research

This study provides a broad overview of the organization and indicates that adaptive leadership, Simmelian ties, and affective relationships can provide useful means

by which information and creativity can flow throughout the organization. However, closer attention could be given to each network (trust, social, work) to further understand what makes the relationships in the trust and social networks so much more impactful than those in the work network. Also, a closer look into the innovation inhibitors and the Simmelian ties could provide formal leadership with perspectives that could lead to stronger conditions for innovation and greater capability for growth, which should be the goal of every organization.

Also, adaptive leadership was measured through closeness centrality or who is "in the know" and perhaps different measures of adaptive leadership would have yielded different results. For example, betweeness centrality is a way to identify gatekeepers between groups (Carley et al., 2010) or "go-between". It is possible that betweeness centrality would have indicated a different level of adaptive leadership, or perhaps no adaptive leadership at all. However, if betweeness centrality were used instead of closeness centrality to measure adaptive leadership, there could be a stronger relationship between eigenvector centrality and the networks because eigenvector and betweenness centralities are less likely to overlap and dilute each other's impact.

In addition, this study measured agents' beliefs or perceptions about innovation rather than actual innovation. It might be interesting and beneficial to the organization to compare agents' perceptions of innovation as compared to measures of actual innovation. Is the organization more or less innovative than thought? If more innovative, then why do the agents' not believe the organization to be innovative? The answers to these questions

could prove to be helpful to the leaders of the organization and the organization's innovative capabilities for future successes.

APPENDICES

Appendix A

Preliminary Survey Used to Identify Tasks, Resources, and Knowledge

1. What is your role in relation to Upstate High School? (For example, 9th grade Math Teacher)
2. What tasks do you complete in your role? (For example, assess student learning)
3. What specialized knowledge is needed by anyone who performs the types of tasks you perform (For example, how to use data to assess student learning)?
4. What resources are needed by anyone who performs the types of tasks you perform? List all major resources that apply. (For example, lab equipment and textbooks)

Appendix B

Preliminary Survey Results and Categories

Tasks

Lesson Plans and Preparations - prepare lessons and learning opportunities, develop lesson plans, plan lessons, design curriculum, implement curriculum, provide instruction in a variety of ways to meet the needs of a diverse group of students, offer real world application of materials, incorporate hands-on learning opportunities, implement literacy, promote cooperative/collaborative learning, Student instruction, Day to Day Instruction, compose rubrics

Data Analysis and Assessing Student Learning - data analysis, evaluate assessments in terms of student achievement, assess student learning, assess student comprehension, assess present levels of performance, assess learning and the effectiveness of the curriculum, compose assessments, using formative and summative assessments, keep accurate records of attendance and grades, monitor student learning through informal assessment, assess student understanding of content through formal assessments, Benchmark Tests, assess student learning by using data, complete a grade distribution form each quarter to see how the letter grades are distributed, using data to organize lessons, Benchmark Testing and Data Evaluation, Assess Student Learning and Progression

Communicating with Parents, Students, and Staff - communicate with students, parents, staff and faculty, establish communication with parents, establish professional

relationships with all of my students, provide feedback, coordinate teachers within department

Classroom Observation - observations (formal and informal), mentoring teachers, working with new teachers

Professional Development - implement school goals, serve on committees as assigned, attend meetings, continue to learn through staff development opportunities, attend extracurricular functions, keep an updated website

Classroom Management - handle discipline referrals, discipline students within the classroom, manage a comfortable learning environment, supervise and manage the classroom

Provide Remediation or Extra Help - facilitate work completion, facilitate learning, re-teach, small group instruction, remediate students when misconceptions in learning have occurred, provide opportunities for retests and remediation

Standardized Testing - testing, assist with standardized testing such as PLAN, HSAP and EOC's

Advising, Mentoring, or Counseling Students - academic counseling, personal-social counseling, career counseling, advisement, post-secondary planning, interpreting test scores, liaison between faculty-parents-students, advisor, Coach, role model, mentor, disciplinarian, Motivational Encourager

Knowledge

Instructional Strategies and Methods - understanding of instructional methods, how to engage youth in collaborative learning, instructional strategies, understanding in

student psychology to maintain a successful learning environment, knowledge of student cognitive development, how to introduce strategies for students to be successful in the general education curriculum

Content Knowledge - solid background of calculus skills, Content knowledge is a key aspect, science content knowledge, content knowledge for my subject area, scientific process understanding, laboratory methods and design, One needs to know more than his/her content

Data Analysis and Interpretation - knowledge of skills necessary to interpret data in an unbiased manner, basic understanding of statistics for assessing learning, Reflection about your school and its culture is needed – be able to reflect on the data and make informed/instructional decisions, know how to collect the data, analyze it, develop goals, design a strategy and then evaluate your methods, how to use student data for future instruction, using data to improve teaching and to assess student learning, data analysis, how to use the assessment tools, analyze assessments to improve students and teacher performance

Basic Technology Skills - basic technology skills, Training in the formatting and multiple uses of Excel, Microsoft office (Word, Excel), basic computer software knowledge, must be able to read and publish data on Excel sheets, use PowerSchool to record grades, run reports and give progress reports

Designing and/or Creating Assessments - test/assessment design, how to assess students: informally/formally

Awareness of Student Background - interpersonal skills, good communication skills, team building skills, how to relate with students and show them that you truly care, understand that there are many factors that influence student learning other than effort and intelligence, respond to student feedback appropriately (use it to become a better teacher), how to engage all students

Current Events Related to Education **-** understanding education-related movements--Common Core, for example

Resources

Textbooks

Workbooks, Practice Books, Ancillaries, Literary Resources

Reliable Internet Connection

iPads/laptops/tablets

Smartboard, Projector, Desktop Computer

Basic Computer Software (Excel, Word, Publisher, etc.)

Specialized Computer Software (Kurzweil, TI-Inspire, Reading Plus, etc.)

Copier, Scanner, Printer

Consumables (paper, art supplies, lab materials, etc.)

Calculators

Significant Financial Support

Appendix C

Informed Consent Letter

South Carolina Public High Schools: Leadership, Network Dynamics, and Innovation

Description of the Study and Your Part in It

Dr. Russell Marion and Brandon Blackwell are inviting you to take part in a research study. Dr. Marion is a professor at Clemson University. Brandon Blackwell is a student at Clemson University and is running this study with the help of Dr. Marion. The purpose of this research is explore the network dynamics of the networks within larger organizations (Research Site) and identify relationships, cliques, and informal leaders within the networks. Specifically, the study will allow exploration of the network dynamics and levels of adaptive leadership of the high school to determine if they contribute to successful implementation of change and innovation in the network(s).

Your part in the study will be to complete an online survey.

It will take you about 20 minutes to be in this study.

Risks and Discomforts

We do not know of any risks or discomforts to you in this research study.

Possible Benefits

We do not know of any way you would benefit directly from taking part in this study. However, this research may help us to understand the network dynamics of Seneca High School and help us understand the innovation capability of this institution.

Protection of Privacy and Confidentiality

We will do everything we can to protect your privacy and confidentiality. We will not tell anybody outside of the research team what information we collected about you in particular and your names (required for setup) will be coded prior to analysis to protect everyone's anonymity.

Choosing to Be in the Study

You do not have to be in this study. You may choose not to take part and you may choose to stop taking part at any time. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study.

Contact Information

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Marion at Clemson University at 864-656-5105. If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-6460 or irb@clemson.edu. If you are outside of the Upstate South Carolina area, please use the ORC's toll-free number, 866-297-3071.

Clicking on the "agree" button indicates that:

- You have read the above information
- You voluntarily agree to participate
- You are at least 18 years of age

You may print a copy of this informational letter for your files.

❍ I AGREE (1)

Appendix D

Survey for the network Analysis Data

Q2 Please select your name from the list below. We must have this information to prepare the data for analysis. The names will be anonymized before the data is analyzed.

Q3 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q4 Do you have a Master's degree or higher?

- ❍ Yes (1)
- ❍ No (2)

Q5 If you do not have a masters degree, do you have aspirations or plans to obtain an advanced degree?

- ❍ Yes (1)
- ❍ No (2)

Q6 In the following list, please check the names of all faculty members that you interact with regarding work related issues on a daily basis.

Q7 In the following list, please check the names of all of the faculty members that you interact with socially on a daily basis.

Q8 In the following list, please check the names of the faculty members with whom you would most likely discuss confidential information.

Q9 In the following list, please check the resources that you most depend on to help complete your assigned duties.

Q10 With which of the following knowledge sets are you most proficient?

Q11 Which of the following tasks do you regularly perform in your role?

Q12 Please rate your level of agreement with each of the following statements as related to your primary role in the school:

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
Student discipline issues hinder educational programs at this school (1)	❍	❍	❍	❍	❍	❍	❍
I am generally open to change when I can see the clear benefits it brings to the students (2)	❍	❍	❍	❍	❍	❍	❍
I am open to change and willing to assist others in implementing innovations (3)	❍	❍	❍	❍	❍	❍	❍
I feel that I can try new	❍	❍	❍	❍	❍	❍	❍

ideas or methods at my school without fear of reprimand if I fail (4)							
I have sufficient time to perform my assigned tasks (5)	❍	❍	❍	❍	❍	❍	❍
I communicate with colleagues regarding job-related issues (6)	❍	❍	❍	❍	❍	❍	❍
Differences of opinion are welcome in my department (7)	❍	❍	❍	❍	❍	❍	❍
My department successfully collaborates to	❍	❍	❍	❍	❍	❍	❍

address common challenges (8)							
People are willing to compromise when decisions are made with-in my department that they may not completely agree with (9)	❍	❍	❍	❍	❍	❍	❍
My colleagues and I can disagree about policies and procedures without the disagreement becoming personal (10)	❍	❍	❍	❍	❍	❍	❍
The diversity of needs among students I	❍	❍	❍	❍	❍	❍	❍

teach can be addressed applying traditional teaching approaches (11)							
I feel pressure to perform at high levels in my role at this school (12)	❍	❍	❍	❍	❍	❍	❍
I have the autonomy and creative freedom to perform my work to the best of my ability (13)	❍	❍	❍	❍	❍	❍	❍
The Federal and SC accountability requirements inhibit my ability to foster	❍	❍	❍	❍	❍	❍	❍

innovative curricular initiatives (14)							
The bureaucratic hierarchy of this school inhibits my ability to foster innovative curricular initiatives (15)	❍	❍	❍	❍	❍	❍	❍
I present my students with unique/innovative instruction they may not have considered (16)	❍	❍	❍	❍	❍	❍	❍
I present innovative instruction to the students (17)	❍	❍	❍	❍	❍	❍	❍
For validation	❍	❍	❍	❍	❍	❍	❍

purposes, please select "Neither Agree nor Disagree" for this question. (18)							
I teach students to solve problems in innovative ways (19)	❍	❍	❍	❍	❍	❍	❍
I provide innovative ideas and instruction to the students (20)	❍	❍	❍	❍	❍	❍	❍
I come up with new ideas to provide innovative solutions to the students problems (21)	❍	❍	❍	❍	❍	❍	❍

I am open to unconventional ideas (22)	❍	❍	❍	❍	❍	❍	❍
I provide the students with guidance/instruction that offers unique benefits superior to those in other schools within our district (23)	❍	❍	❍	❍	❍	❍	❍
I seek out novel ways to tackle problems (24)	❍	❍	❍	❍	❍	❍	❍
I improvise on new methods when I cannot solve a problem using conventional methods (25)	❍	❍	❍	❍	❍	❍	❍

I implement new ideas within the school (26)	❍	❍	❍	❍	❍	❍	❍
I try to be a leader in providing innovative solutions (27)	❍	❍	❍	❍	❍	❍	❍
I introduce new instructional delivery processes (28)	❍	❍	❍	❍	❍	❍	❍
I develop new processes to deliver instruction (29)	❍	❍	❍	❍	❍	❍	❍
I develop new products that enhance our service to our students (30)	❍	❍	❍	❍	❍	❍	❍

I deliver cutting-edge instruction/products that are not delivered by other schools in our district (31)	❍	❍	❍	❍	❍	❍	❍
I innovate with new software (32)	❍	❍	❍	❍	❍	❍	❍
I adopt the latest software available to educators (33)	❍	❍	❍	❍	❍	❍	❍
I innovate with new technology (34)	❍	❍	❍	❍	❍	❍	❍
I introduce new integrated systems and technology (35)	❍	❍	❍	❍	❍	❍	❍

I innovate with software/technology to keep ahead of the curve (36)	❍	❍	❍	❍	❍	❍	❍

Appendix E

PCA Pattern Matrix

Component

	1	2	3	4
B1			.639	
B2	.420			-.416
B3	.639			
B4	.848			
B5	.563			
B6	.814			
B7	.908			
B8	.851			
B9	.835			
B10	.991			
B11	.606			
B12	.764			
B13	.552			-.456
B14			.588	
B15			.830	
B16				-.784
B17				-.876
B18				-.849
B19				-.902
B20				-.862
B21				-.826
B22				-.788
B23				-.804
B24	.675			
B25	.574			
B26		.502		
B27		.447		
B28				-.458

B29				
B30		.440		-.470
B31		.748		
B32		.881		
B33		.884		
B34		.943		
B35		.916		

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

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