7-1-2018

Exploring the Nature of Resources and Relationships in a Multi-Stakeholder Collaborative Network

Tracie Evans Reding
University of Nebraska at Omaha

EXPLORING THE NATURE OF RESOURCES AND RELATIONSHIPS IN A MULTI-STAKEHOLDER COLLABORATIVE NETWORK

By

Tracie Evans Reding

A DISSERTATION

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Education

Major: Educational Administration

Under the Supervision of Dr. Elliott Ostler

Omaha, Nebraska

July, 2018

Supervisory Committee:

Dr. Elliott Ostler

Dr. Kay Kaiser

Dr. Neal Grandgenett

Dr. Tamara Williams

Abstract

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Tracie Evans Reding, Ed.D.

University of Nebraska, 2018

Advisor: Dr. Elliott Ostler

Multi-stakeholder collaborative networks (MSCNs) centered around innovative problem solving have become increasingly popular. These collaborations seek to pool the resources of the various stakeholders in order to address their common issue. The importance of the collaboration members' awareness of one another's resources is the basis for this study. This study developed a new analytical method in which to quantify the resource awareness of members of an MSCN and how that relates to features of the network. The MSCN that was the focal organization for this study was as STEM Ecosystem. A perceptual framework was built upon literature from diverse areas including community asset mapping, collaborative innovation management, knowledge transfer, and social capital. The following variables were explored: the resource awareness of the members of a STEM ecosystem; the relationship between the resource awareness and the relational social capital of the ecosystem members; and the relationship between the resource awareness and the structural social capital of the ecosystem network. Quantitative data were collected using an electronic survey that was completed by 86 members of the STEM ecosystem. Data from the survey was analyzed

using both traditional statistical methods as well as social network analysis methods. Analysis of the data demonstrated some significant findings and directions for further research are included.

Keywords: Multi-stakeholder Collaborative Networks; Resource Awareness; Knowledge Transfer Networks; Social Capital; Social Network Analysis; STEM Ecosystem

Acknowledgements

While at times a dissertation can feel like such a lonely endeavor, so many people have contributed to this dissertation in various ways. I would first like to acknowledge my dissertation chair, Dr. Elliott Ostler, who showed great patience and guidance through this entire process. I also want to thank my committee members: Dr. Kay Keiser for instilling in me the importance of relationships; Dr. Tamara Williams for introducing me to the notion of complex problems; and Dr. Neal Grandgenett for his unwavering support and belief. I also want to thank my parents for showing me the value of hard work and persistence. Last, but certainly not least I want to thank my husband for being so great and making sure I had the time I needed to write.

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Chapter 1: Introduction

As problems facing society such as the management of environmental resources and social inequities become more and more complex and affect more stakeholders, people are looking to collaborate and pool their resources and expertise to find solutions (Becker & and Smith, 2018). One example of a complex problem facing the U.S. today is the workforce shortage in the areas of Science, Technology, Engineering, and Math (STEM). There have been numerous policies and programs to address the STEM workforce shortage through educational experiences including national initiatives such as President Obama's STEM for All aimed at increasing the access and quality of STEM education opportunities to all students (Handelsman & Smith, 2016).

Champions of increasing STEM educational opportunities for all students have begun to address this issue from a large-scale collaborative perspective. There is a nation-wide movement for localized cross-sector collaborations to address the STEM workforce shortage (STEM ecosystems.2018). These collaborations operate under the notion that these city-wide networks are the most effective way to implement and sustain STEM educational pathways for all students (Traphagen & Traill, 2014). Currently, cross-sector partnerships to address STEM education pathways are developing and becoming formalized. These partnerships are known as STEM Learning Ecosystems and they "feature dynamic collaborations among school, out-of-school time programs, STEM expert institutions (such as museums, science centers, institutions of higher education, and STEM professional associations), the private sector, community-based organizations, youth and families" (STEM ecosystems.2018). The purpose of these STEM Learning Ecosystems is to "provide the architecture for cross-sector learning, offering all young

people access to STEM-rich learning environments so they can develop important skills and engagement in science, technology, engineering, and math throughout preK-16" (STEM ecosystems.2018).

Collaborations such as STEM Ecosystems rely on the networks of the STEM partners to facilitate the combining of resources. The importance of awareness within the collaboration of what one another brings to the collaborative enterprise underlies the success of the collaboration during both the planning and implementing phases. The dynamic nature of STEM entities presents many opportunities where resources and goals can be aligned across organizations and stakeholders in a mutually beneficial way; but if there is little awareness of the resources within the collaboration, these mutually beneficial opportunities will be missed. This resource awareness will not only facilitate the alignment of resources to attain the current goal, but will enable and prompt future collaborations because of the awareness of resources within the collaboration. Due to the necessity of resource awareness, it is required to include it in the management of these collaborations, such as the STEM Ecosystems.

Perceptual Framework

This study was born out of a blending of the progression of previous research using social network analysis and personal observations by the author so it is based in a perceptual framework. While it is a perceptual framework, there are four major areas of literature from which it is based: community asset mapping; collaborative innovation management; knowledge transfer; and social capital. This section will first operationalize the definition of multi-stakeholder collaborative network then summarize the four major areas of literature to provide clarification of the framework.

Multi-stakeholder Collaborative Networks

The term stakeholder was initially coined and defined as "those groups without whose support the organizations would cease to exist" (Stanford Research Institute, 1963). The term stakeholder is now largely represented in many different fields of literature including business, natural resource governance, and education and the definition tends to be contextually dependent. When applied in a business ethics context, one definition identifies stakeholders as individuals "to whom the organization has a moral obligation" (Phillips, 2003, p.30). The term stakeholder in an environmental governance context is any naturally occurring entity with the environment itself considered a stakeholder (Starik, 1995). In education, stakeholders have been identified as those individuals that "have personal, professional, civic, or financial interest or concern" relating to the school and its students (Great Schools Partnership, 2014). Stakeholders in all areas are affected by the decisions and actions of the focal organization in some way and as problems facing society and institutions become more complex, stakeholders are encouraged to be more engaged (Dentoni, Bitzer, & Schouten, 2018).

When these stakeholders work together on a certain issue, they are collaborating. In general, collaboration includes cooperation of some sort such as working together on a research study; willingly complying and helping an enemy of the state; or sharing services with another agency (Collaborate, n.d.). Due to the expansive nature of the definition of collaboration, it is necessary to focus the term specific to multi-stakeholder collaboration. It has been suggested that a proper definition of organization collaboration identify the actors, environment, structure, dynamics, and circumstances involved

(Johnson, 2003). These collaborations form a social network. Recently, the term social network has become synonymous with online, media tools designed to increase interactions including Facebook, Twitter, Snapchat, etc., but the term social network existed long before the internet and refers to the network of individuals (such as friends, acquaintances, and coworkers) connected by interpersonal relationships. The term network was purposefully added in this study to the term multi-stakeholder collaborative network (MSCN) to highlight the importance of the interpersonal relationships of the collaboration. Keeping all of these factors in mind, this study operates under the modified definition of multi-stakeholder collaborative networks as the alliance of stakeholders that strategically aggregate the resources and competencies of each to resolve a shared social problem, issue, challenge or opportunity through their interpersonal relationships (Foundation for Development Cooperation, 2003; Johnson, 2003).

Community Asset Mapping

Many community improvement initiatives are MSCNs centered around economic development, such as the STEM Ecosystems. A common practice in community improvement initiatives involves the mapping of the community's assets. Community assets are defined as "the skills and talents of local residents, as well as the capabilities available or possible through local organizations and institutions. Collectively, these resources offer the wherewithal to address the host of important issues impacting the community" (Beaulieu, 2002, p. 2). There are five steps in the asset mapping process summarized by Beaulieu, based on the research of McKnight and Kretzmann (1996). The first step of asset mapping involves identifying the various forms of capital that exist

within the community. The second step involves encouraging the formation of relationships amongst the community members. The third step is the mobilization of the assets that have been pooled through the relationships that were previously formed. The fourth step is developing a shared vision for the future. The fifth and final step is the identification and procurement of any outside resources that may be needed in order to fill any gaps in the necessary resources that do not exist within the community (Beaulieu, 2002). This study draws on community asset mapping as the basic process involved in determining what resources are present and where in a STEM Ecosystem. It also highlights involving the community members in the process and performing a needs assessment to determine which external resources are needed.

Collaborative Innovation Management

Community improvement initiatives are not the only ones that seek to combine the resources of multiple stakeholders. Recently, collaborations with the purpose of innovating have become very prevalent. These innovation collaborations rely on the open sharing and combining of resources, known as open innovation, to produce innovations such as products, processes, or services (Almirall & Casadesus-Masanell, 2010). Organizations, whether single firms or MSCNs that successfully innovate view successful management of open innovation as creating conditions that enable innovation (Poutanen, Soliman, & Ståhle, 2016). These conditions that enable innovation include open innovation strategies, interconnectedness, self-organization of the system parts, and adaptiveness (Poutanen et al., 2016). Open innovation strategies include the encouragement of seeking out and integrating external resources; interconnectedness means forming and maintaining external and internal relationships; self-organization of

the system parts allows for the members within the network to "organize and reorganize to swiftly changing conditions" (Poutanen et al., 2016, p. 207); and adaptiveness means being able to balance between focusing on developing current capabilities while seeking new sources of capabilities and opportunities.

The three conditions that this study is concerned with are the open innovation, interconnectedness, and self-organization. Open innovation is important in this study because it emphasizes seeking external sources of knowledge, such as resources. Interconnectedness are the relationships that are formed which are the basis of collaboration. Finally, self-organization implies that network members are aware of one another's resources, so they are able to self-select whom to partner with.

The Knowledge Transfer Process

Regardless of whether the goal of a collaboration is a broad-based community improvement initiative or an innovative collaboration, knowledge must be shared amongst the collaboration members. Knowledge is the "familiarity, awareness, or understanding of some information" (Zhang et al., 2017, p. 2). Knowledge transfer includes identifying external sources of knowledge, accessing the desired knowledge, analyzing the knowledge obtained, and combining the new knowledge with existing knowledge (Filieri & Alguezaui, 2014). This combination of knowledge results in the form of new products, processes, skills or capabilities (Filieri & Alguezaui, 2014).

The pathways through which knowledge transfer occur are known as formal and informal. The formal knowledge transfer pathways occur through the organization's hierarchy through official documents, emails, and formal training. This knowledge transfer occurs through the formal relationships mandated through the organization. The

informal knowledge transfer pathways lie in the social relations of the members of the network that self-select their relationships and do not typically follow the formal, hierarchical pathway (Reagans & McEvily, 2003; Spillane, Healey, & Kim, 2010). It has been found that most knowledge is transferred through the informal knowledge transfer pathway which is dependent upon the informal social relations of the members rather than the formal knowledge transfer pathway where the relationships are mandated (Inkpen & Tsang, 2005).

Social Network Analysis and Social Capital

Many collaborations are turning to a social network perspective when managing their groups. The social network perspective includes the theories, models, and applications used to examine relational concepts or processes. These relational concepts or processes occur between participants in a social system that can consist of stakeholder collaborations, families, neighborhoods, schools, and entire organizations, just to name a few. These participants, combined with their interactions and relationships, make up a social network (Borgatti & Ofem, 2010; Kenis & Oerlemans, 2007; Wasserman & Faust, 1994). It is through the social networks where the transfer of knowledge, which in this study is resource awareness, occurs.

The concept and method used as the basis to measure these interactions and relationships of a social network is known as Social Network Analysis (SNA) which interprets the social environment as occurring in patterns or regularities among the social network. In SNA, the presence of these patterns in relationships are known as structures and SNA is an empirically based process that studies social network structures, such as collaborations. SNA uses social network structures to study how the types of relations

one has with others in the network influence both the individual's behavior/attitudes and those of the group (Wasserman & Faust, 1994). Recently, SNA studies have revolved heavily around studies of social media, such as Twitter. This study is not using social media as the data source, a survey is the data source used in this study.

One widely used theory within SNA that is used to explain how collaboration members transfer knowledge is known as Social Capital (SC). The foundation of SC is the relationships within the network and these relationships are the channels through which knowledge is transferred. SC can be defined as:

> "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit. Social capital thus comprises both the network and the assets that may be mobilized through that network" (Nahapiet & Ghoshal, 1998, p. 243).

There are two dimensions of SC used in this study that are distinctive but interrelated: relational and structural. Both dimensions are based on relationships amongst the network members but focus on different aspects that impact the overall SC. Relational SC contributes to the SC present due to the strength and type of relationships built over time which leads to trust, obligations, respect and friendship (Villena, Revilla, & Choi, 2011). Structural SC refers to how the overall patterns of the network based on the presence or absence of relationships influences the SC available, for example, network members that are connected to a relatively high number of other network members allows for easier knowledge transfer (Nahapiet & Ghoshal, 1998).

Combining Social Network Analysis and Community Asset Mapping

Recently, SNA was combined with community asset mapping to analyze a community health improvement plan (Mac McCullough, Eisen-Cohen, & Salas, 2016). The purpose of Mac McCullough's study was to identify network characteristics of a large urban community health improvement plan (CHIP). The CHIP study combined community asset mapping and social network analysis by mapping the frequency of collaborations, types of collaborations, and resources possessed by the coalition members. The network features that were studied were based on structural SC. The CHIP study provided the initial combination of community asset mapping and SNA and this study is similar to the CHIP study in that it seeks to examine the network features of a collaborative community-based network using SNA and community asset mapping. The difference in this study is that it seeks to explore the relationship between the network features and the resource awareness of its members.

Description of the Synthesis of Factors

This perceptual framework rests on the importance of resource awareness and the network features of an MSCN. This section will describe how the previously discussed factors of community asset mapping, collaborative innovation management, and the knowledge transfer process align with the variables of resource awareness and network features in the context of an MSCN.

Resource Awareness

While the term resource awareness is not explicitly stated in any of the factors that have been discussed so far, its importance is definitely eluded to. In the community asset mapping model, identifying existing forms of capital and procuring necessary

resources are two of the five steps (McKnight & Kretzmann, 1996). This identification of existing resources and procuring external resources requires an awareness of both the resources that are present in the community as well as an awareness of resources that are absent in the community but necessary. The innovation collaboration management condition of open innovation is concerned with seeking external resources with the explicit intent of combining them with current resources to produce innovations (Chesbrough, 2003). This implies an awareness that the current resource available are insufficient to produce competitive products and/or services and external resources are needed. The knowledge transfer process begins with the identification of external sources of knowledge (Filieri & Alguezaui, 2014). In the context of MSCNs, resources are considered a type of knowledge which must be shared and the identification of external resources is necessary in order to become aware of what knowledge is available.

Network Features

The network features present in any social network are dependent upon the relationships amongst the individuals in the network (Wasserman & Faust, 1994). In the community asset mapping model, the importance of relationships is explicitly stated in the second step of encouraging relationships because this enables the discussion around which resources are present within a community (Beaulieu, 2002). The third step in the community asset mapping model is mobilizing the assets that exist within the community and is dependent upon the established relationships (Beaulieu, 2002). The second and third collaborative innovation management conditions of interconnectedness and self-organization are reliant upon the relationships of the collaboration (Poutanen et al., 2016). Interconnectedness occurs through the relationships amongst the collaboration members

and self-organization only happens if the individuals are connected somehow (Poutanen et al., 2016). The last three steps of the knowledge transfer process are accessing desired knowledge, analyzing the knowledge obtained, and combining old and new knowledge (Filieri & Alguezaui, 2014). In an MSCN, these steps are facilitated through the relationships in a collaborative manner.

When looking at these three factors and considering the implications for collaboration management, one of the pieces of knowledge that must be diffused among the members are the resources available to them both within and outside of the collaboration. This transfer of knowledge is dependent upon the relationships of the collaborators which forms the network and shapes the network features. These two variables, resource awareness and network features, are the basis of this study.

Omaha STEM Ecosystem

As previously mentioned, there are localized, regional collaborations being implemented throughout the U.S. with the intent of improving STEM educational pathways. The purpose of these STEM Learning Ecosystems is to "provide the architecture for cross-sector learning, offering all young people access to STEM-rich learning environments so they can develop important skills and engagement in science, technology, engineering, and math throughout preK-16" (stemecosystems.org). According to stemecosystem.org there are four strategies for cultivating STEM Learning Ecosystems:

1. Cultivating Cross-sector Partnerships
2. Creating and Connecting STEM-Rich Learning Environments
3. Equipping Educators

4. Supporting Youth Pathways.

The STEM Ecosystem used in this study is the Omaha STEM Ecosystem, OSE. The OSE envisions a "community where all young people, especially those underrepresented in STEM careers, will have the opportunities needed to be successful in learning, scientific thinking, examining potential career paths and exploring opportunities to extend their educational achievements" (OSE Steering Committee, 2017, p. 1). The member organizations of the OSE include multinational companies such as Gallup and Union Pacific, charitable foundations such as Pacific Life Foundation and the Peter Kiewit Foundation, education institutions such as Omaha Public Schools, the University of Nebraska Omaha, and the University of Nebraska Medical Center, non-profits such as United Way of the Midlands, the AIM institute, and the Omaha Chamber of Commerce, and science centers and museums such as Fontanelle Forest and the Omaha Henry Doorly Zoo and Aquarium.

These organizations have come together in the OSE to collaboratively address the STEM workforce shortage in the Omaha, NE metro area. The OSE began the community asset mapping process in 2016 although not necessarily following the steps that were previously described. The steering committee of the OSE sent out a survey that had been developed through the STEM Funder's Network with the explicit purpose of mapping the assets in the Omaha metro area. This was at the very beginning of the collaborative efforts. The OSE has moved onto the next steps of community asset mapping while continuing to take stock of the assets in the Omaha area. Since this initial asset mapping was conducted, the steering committee has developed a strategic plan, vision, and guiding design principles.

The guiding principles of the OSE are as follows (OSE Steering Committee, 2017):

1. Fosters a culture where the values, beliefs, interests, and strengths of the diverse cultures we serve are reflected. The cornerstone of the OSE is to ensure youth and adult learners, of all socio-economic backgrounds, have access and opportunities for STEM related programs.
2. Sustain an overarching structure to bring community partners together to advance STEM learning as a priority in Omaha. We welcome diverse partners and experiment with innovative ways for engagement. By creating a network of community organizations, we provide a venue for collaboration around solutions to STEM issues and leveraging of resources.
3. Create pathways through experiential learning, high quality STEM programs, and job-connected mentoring/internships, that create lasting career opportunities. Formulate workforce development opportunities for individuals of all ages.
4. Support a research-informed culture of reflection and improvement. The measurable impact data include increased opportunities in high quality STEM programs, student participation in STEM courses, and a decrease in STEM career vacancies in the Omaha community.
5. Foster a STEM culture where awareness of community needs is identified, a common language around STEM is clearly defined for all stakeholders, and will be guided by best practices for youth. With increased collaborative

STEM efforts, we will celebrate success and apply lessons learned and provide an increase in STEM achievement celebrations in the Omaha area.

6. Create and maintain a system that informs and educates community members about STEM related issues, events, and resources as well as highlighting activities and celebrating STEM achievements.
7. Develop a system that provides continual professional development opportunities for educators, parents and business partners in STEM. Cultivate STEM professional development for educators with opportunities for mentoring, internships, and externships.

These guiding design principles, along with the variety of member organizations, demonstrate the multi-stakeholder collaborative nature through which it operates.

Research Questions

The overarching research question in this study is:

What is the relationship between the features of a multi-stakeholder collaborative network and the resource awareness of its members?

Research sub-questions are as follows:

1. What is the extent of resource awareness in the Omaha STEM Ecosystem?
    a. What is the resource status percent agreement for members within a stakeholder category of the Omaha STEM Ecosystem?
    b. What is the resource status percent agreement between the stakeholder categories of the Omaha STEM Ecosystem?
    c. What is the relationship between the resource status percent agreement between the stakeholder categories of the Omaha STEM Ecosystem?

2. What is the relationship between the relational social capital of the Omaha STEM Ecosystem members and the resource awareness of its members?
3. What is the relationship between the structural social capital of the Omaha STEM Ecosystem organization types and the resource awareness of its members?

Operational Definitions

Multi-stakeholder Collaborative Network (MCN): the alliance of stakeholders that strategically aggregate the resources and competencies of each to resolve a shared social problem, issue, challenge or opportunity through their interpersonal relationships (Foundation for Development Cooperation, 2003; Johnson, 2003).

Resource Awareness: The knowledge an individual has regarding the resources available

from the various organization types in the OSE

Social Capital: "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit" (Nahapiet & Ghoshal, 1998, p. 244)

Relational Social Capital: the dimension of Social Capital present due to the strength and type of relationships built over time (Villena et al., 2011)

Structural Social Capital: the contribution of the overall patterns of the network based on the presence or absence of relationships on the Social Capital of a network (Nahapiet & Ghoshal, 1998)

Significance of the Study

This study is exploratory in nature because of the dearth of literature associated with resource awareness in multi-stakeholder collaborative networks that are focused on improving educational pathways. It will provide empirical evidence through which future studies can use as reference. It will also provide a perceptual framework and analytical model on which other studies could be based. The social significance of this study lies in the contribution to the OSE and other multi-stakeholder collaborations of a method to analyze the resource awareness amongst its members in order to strategically address any gaps in resource awareness.

Purpose of the Study

The prevalence of multi-stakeholder collaborations being used to address issues that single organizations cannot solve is increasing (Edmondson, 2012; Senge, 2008). The purpose of these collaborations is to use the resources of its members to address the focal issues. The importance of the resource awareness necessitates its inclusion in the management of the collaboration. One useful method of collaboration management is by examining it through a network perspective. This study seeks to identify any relationships that may be present between the features of a multi-stakeholder collaborative network and the resource awareness of its members.

Delimitation

This study used only one MSCN, the Omaha STEM Ecosystem and the novel methodology and analytical framework used in this study has not been applied to other MSCNs.

Chapter 2: Literature Review

The purpose of this chapter is to provide a synthesis of the literature pertaining to this study and includes Social Network Analysis (SNA) studies centered around Social Capital (SC) and knowledge transfer. It also provides additional background information regarding community asset mapping and collaborative innovation management.

Social Network Analysis

Traditionally within social sciences, individual attributes are the focus of measurement for political, economic, or social outcomes. Considering a multi-stakeholder collaborative network (MSCN) is an alliance of stakeholders that strategically aggregate the resources and competencies of each to resolve a shared social problem, issue, challenge or opportunity through their interpersonal relationships (Foundation for Development Cooperation, 2003; Johnson, 2003), rather than using individual characteristics as the basis of socio-political outcomes, a focus on the relationships among interacting units of the network is a more effective approach and is the basis of the social networks perspective. The social network perspective includes the theories, models, and applications used to examine relational concepts or processes. These relational concepts or processes occur between participants in a social system. These participants, combined with their interactions and relationships, make up a social network (Borgatti & Ofem, 2010; Kenis & Oerlemans, 2007; Wasserman & Faust, 1994).

The concept and method used as the basis to measure these interactions and relationships of a social network is known as SNA which interprets the social environment as occurring in patterns or regularities among the social network. The presence of these patterns in relationships are known as structures and SNA is an

empirically based process that studies social network structures, such as the OSE. SNA uses social network structures to study how the types of relations one has with others in the network influence both the individual's behavior/attitudes and those of the group (Wasserman & Faust, 1994).

To demonstrate the empirical basis of SNA, it is necessary to review the history of its development. The mathematical foundations that form the basis of Social Network Analysis are graph theory and algebraic matrices. Graph theory origins can be traced back to the 1700's in Prussia where the mathematician Euler published the first paper referencing physical positions as a proof of a problem where he coined the term "geometria situs" or the geometry of position. Euler's proof later contributed to the basic theorems of Graph Theory which is the branch of mathematics concerned with networks of points connected by lines which is applied in a wide variety of contexts including natural sciences, information sciences, and social sciences. As graph theory evolved over time, the terms vertices and edges were adopted. Vertices are the dots present on a graph, which can represent individual people, animals, bacteria, etc., and edges are the lines that connect the vertices which can represent the flow of energy, the spread of infectious diseases, or the presence of relationships. It is necessary to note that Graph Theory does not pertain to line graphs or bar graphs, but pertains to a set of vertices connected by edges (Carlson, 2008).

Since the advent of Graph Theory in the 1700's, many advances have been made and applied to social networks by social scientists. The application of Graph Theory by social scientists began in the 1930's by the sociological pioneer Jacob Moreno. Moreno is credited with the first use of graphical mapping in the social sciences that dealt with

individuals' feelings about one another. Moreno's findings demonstrated that an increase in runaways at the Hudson School for Girls could be attributed to the social relations among the girls. The social relations among the girls served as a path for the flow of ideas and an individual's position within the network contributed to the presence or absence of reception of the idea to runaway (Moreno, 1934). Moreno coined the term "Sociometry" as the "psychological properties of populations, the experimental technique of, and the results obtained by application of quantitative methods" to describe this type of study (Moreno, 1934).

Moreno's Sociometry was rooted in Graph Theory by representing individuals as vertices (the girls in his study) on a graph and the edges representing the flow of information between them (the idea to runaway). This initial study, along with subsequent work conducted by Moreno and his colleagues, helped form the basis of the social network perspective in three important ways: providing empirical methods to studying the interactions of individuals in a group; highlighting the importance of structural network positions in identifying patterns embedded within a group; and emphasizing the use of mathematical models and graphical imagery to analyze the results (L. Freeman, 2004).

Throughout the 1940's, 50's, 60's and 70's mathematical models of social networks were strengthened by applying algebraic operations, beginning with matrices. By the end of the 1970's this work became the theoretical and methodological basis for empirically studying opportunities provided to individuals as embedded within an actor's environment; this environment consisted of other actors and the ties among them (Carlson, 2008). Comparing SNA to Graph Theory, actors are equivalent to vertices and

can range from individuals, to departments, to entire organizations; relational ties are equivalent to edges and represent a linkage between a pair of actors which can be based on the transfer of resources, association or affiliations, types of relations, etc. Actors and ties are the fundamental focus of SNA and there are four tenets that form the basis of SNA as put forth by Wasserman and Faust, 1994:

1. Actors and their actions are viewed as interdependent rather than independent, autonomous units.
2. Relational ties (linkages) between actors are channels for transfer or "flow" of resources (either material or nonmaterial).
3. Network models focusing on individuals view the network structural environment as providing opportunities for or constraints on individual action.
4. Network models conceptualize structure (social, economic, political, and so forth) as lasting patterns of relations among actors.

Within SNA studies, there are five types of relations on which to focus: similarities, social relations, mental relations, interactions, and flows. Relation studies based on similarities include location or attribute of network members. Examples of social relation studies focus on kinship or other social roles. Mental relation studies examine affective (likes or hates) or cognitive (knows about) relations. Examples of studies of the interaction type involve the type of interactions experienced such as talked to or advised. Flow relations refer to the flow of information, beliefs, money, etc. These types of relations are not mutually exclusive and researchers often use data on one type of relation to infer another relation. Social relations (friends) often lead to the sharing of advice

(interaction), and vice versa. Flows of information are often inferred to happen through interactions (Borgatti & Ofem, 2010).

Regardless of which types of relations are the focus of the study, there are three levels of possible analysis within each network: the dyad; the node; and the network as a whole. Analysis at the dyad level involves properties of pairs of actors (this level is included in all network studies); analysis at the node level involves properties of individuals; and analysis at the network as a whole level involves properties of the entire network (Borgatti & Ofem, 2010).

Social Network Analysis and Knowledge Transfer

As previously defined, MSCNs are the alliance of stakeholders that strategically aggregate the resources and competencies of each to resolve a shared social problem, issue, challenge or opportunity through their interpersonal relationships (Foundation for Development Cooperation, 2003; Johnson, 2003). MSCNs are used in a variety of areas to address complex issues and SNA is used to study various aspects of collaboration management. Within natural resource management studies, SNA has been used to study the relationship between the structure of a network and the possession of knowledge. The knowledge a stakeholder possesses regarding local ecology is constrained by their structural positions within the network. Those actors with frequent interactions within the network were more informed regarding local ecology. Although they were more informed and held a more central location within the network, they were not actively pursuing leadership positions in the governance of the natural resources. It was suggested that SNA be used to identify these central actors and incentivize them to join the local governing bodies (Crona & Bodin, 2006).

SNA studies across different areas have demonstrated a lack of awareness of knowledge and resources within their networks. Within education studies, social network analysis has been used to study teacher advice networks and have shown that teachers were largely unaware of the content and pedagogical expertise one another possesses. Without knowledge of where the expertise lies, advice seeking doesn't occur (Baker-Doyle & Yoon, 2015). Within research and development firms, often times different teams are unaware of the skills and knowledge of members of other teams even though they work on the same projects (Cross, Borgatti, & Parker, 2002).

Social Capital and Knowledge Transfer

A common theory used within SNA studies is SC. In general terms, capital implies investments for expected returns. More specifically, capital is "wealth in the form of money or other assets owned by a person or organization or available for a purpose such as starting a company or investing" (Capital, 2018). There are many types of capital including financial, human and manufacturing. All of these types of capital involve some sort of investment, such as money, education, or tools with the expectation of returns, such as increased financial profits and/or social status and these returns impact the individuals and communities to which they belong. For example, an individual investing in education produces the return of a better paying job for the individual, but also benefits the individual's company by having a more skilled worker able to perform more complicated tasks. SC involves the investments in social relations with the expectations of returns and these returns impact not only at the individual level but also at the collective level. Individual returns in social capital result from the reciprocal nature of social relationships where the resources embedded in the social relations are exchanged

by individuals (at the dyadic level) to achieve personal goals such as economic, political, or social status (Burt, 2009; Lin, 2008). Collective returns in social capital result from the development and enforcement of norms and trust (at the network level) that lead to collective action beneficial to the group as a whole (Bourdieu, 1986; Coleman, 1988; Putnam, 2001). SC can be defined as:

> "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit. Social capital thus comprises both the network and the assets that may be mobilized through that network" (Nahapiet & Ghoshal, 1998, p.243)

There are three interrelated aspects of SC: structural, relational, and cognitive. Structural SC deals with the resources available to actors based on both their individual positions within the networks and the overall network structure (Nahapiet & Ghoshal, 1998). The positions of actors within a network have been shown to influence the knowledge they possess and are privy to. An actor's centrality has been shown to positively influence knowledge transfer (Kang, M., & Kim, B., 2013). Relational SC refers to the quality of the relationship between two actors and has a positive influence on knowledge transfer (Kang, M., & Kim, B., 2013; Nahapiet & Ghoshal, 1998). The third dimension of cognitive SC refers to the SC that results from the shared languages and identity in a network. Cognitive SC has also been shown to positively impact knowledge sharing (Lefebvre, Sorenson, Henchion, & Gellynck, 2016).

Community Asset Mapping

One common practice among MSCNs that are working toward improving economic conditions in their areas is community asset mapping. Community asset

mapping is all about identifying the resources in the community; developing relationships within the community to facilitate the combination and mobilization of the resources; developing a shared vision; and finally identifying any shortcomings and procuring the necessary resources to address these shortcomings. The goal of community asset mapping is to begin the work of the collaboration by identifying the resources that are present in the community in order to highlight existing strengths and avoid a sense of deficiency that sometimes accompanies a needs-based assessment (McKnight & Kretzmann, 1996).

Beaulieu (2002) summarized these steps and applied them to economic development:

1. Map the Assets – this includes identifying the various forms of capital within the community such human, financial, manufacturing, etc. This includes mapping the "gifts, talents, and abilities of individuals, associations, and institutions" (Beaulieu, 2002, p. 11).
2. Build Relationships and Broaden the Local Leadership – a community's self-reliance improves every time community members come together for problem solving purposes. This also provides an opportunity for emerging leaders to have a voice.
3. Mobilize for Economic Development – once community members are brought together a dialogue opens and assets and resources are discussed that enables new ideas and strategies to be developed.
4. Convene the Community and Develop a Vision for the Future – all the members of the community need to have a voice in determining what the

community should look like in 5-10 years and this needs to become a shared vision amongst the entire community.

5. Leverage Outside Resources to Support Local Priority Activities – once the existing assets have been mapped and a vision has been developed, any gaps in the necessary resources need to be filled. External sources and partnerships need to be forged in order to fill the gaps and work toward the vision.

If the assets and resources in a community operate in isolation, only modest improvement will occur in the community. When these assets and resources are combined through the relationships developed amongst the members of the community, then genuine improvements can be made (Beaulieu, 2002). The resources that are made available through these relationships are the product of the community's SC.

Social Network Analysis, Social Capital, and Community Asset Mapping

Recently, SNA was used to analyze a community health improvement plan and included mapping the types of collaborations participated in, as well as the contributions/resources of the community members (Mac McCullough et al., 2016). The purpose of Mac McCullough's study was to identify network characteristics of a large urban community implementing a community health improvement plan. The study used SNA to map collaboration that occurred at the following intervals: quarterly, monthly, weekly, and daily. It also mapped collaborations based on the following activity types: cooperative, coordinated, and integrated. The study also mapped the time in collaborations as well as where the contribution/resources lie in relation to the other members in the coalition. The data was used to determine the overall network density, closeness centrality, and trust of the coalition. Network density and closeness centrality

are both measures of structural SC. Density can be calculated at both the individual and network levels and represent the percentage of ties present in relation to the total number of ties possible. Closeness centrality measures the distance between actors based on the number of ties between each actor. The trust of the coalition was based on a ranking the respondents provided on each coalition member according to the categories of reliability, in support of mission, and open to discussion.

Innovation Collaboration Management and Social Capital

Much of the literature focused upon SC and knowledge transfer appears in business management studies, particularly within innovation management. Globalization has made the ability to innovate a necessity in order to stay competitive. The basis of this innovation is known as open innovation. Open innovation depends on seeking external resources and collaborations in order to develop new products, services, or processes that wouldn't have otherwise been possible (Chesbrough, 2003). Innovation management studies have looked at the relationship between the three dimensions of SC and innovation. Relational SC is important for innovation because it generates trust which leads to open communication and sharing of important resources which are necessary for exploring new opportunities (Kohtamäki, Partanen, & Möller, 2013; Portes, 1998). While these studies have shown a positive correlation with Relational SC and innovation, some studies have shown an inverted U-shaped relationship where there is an "optimal" level of relational capital before producing diminishing returns (Li, Zhang, & Zheng, 2016).

The second dimension of structural SC refers to the pattern of connections present in a network based on the existence of connections and their configurations (Villena et

al., 2011). One of the most used structural SC variables used in innovation studies is centrality. Freeman (1978) articulated three major centrality measures: degree, closeness, and betweenness. Degree centrality refers to the extent to which an actor is directly connected to all other actors, a high degree centrality demonstrates an actor that is directly connected to many other actors in the network. Degree centrality has been shown to have a positive relationship to innovation through increasing resource accessibility, ability to transfer greater amounts of information, exploitation of new information, and easier information diffusion (Burt, 1992; Dittrich & Duysters, 2007; Lazer & Friedman, 2007; Wei, Zheng, & Zhang, 2011). However, degree centrality has also been shown to have a negative relationship to innovation through reducing information diversity (Lazer & Friedman, 2007). Closeness centrality is a measure of the average graph theoretical distance of an actor to all other actors in a network. Within innovation projects, closeness centrality has been shown to be positively related to creativity (von Held, 2012). Although, it has also been shown to have no significant influence on innovation (Fox, Smith, Cronin Jr, & Brusco, 2013). The third centrality metric articulated by Freeman (1978) is betweenness. Betweenness centrality is a measure of the extent to which an actor is positioned as an intermediary between otherwise unconnected actors. Actors with high betweenness centrality are in positions to moderate the flow of information, have access to non-redundant sources of information, and has been shown to be positively correlated with innovation (Fox et al., 2013; Shaw-Ching Liu, Madhavan, & Sudharshan, 2005).

Chapter 3: Methodology

Research Design

This exploratory study sought to answer the following question: What is the relationship between the features of multi-stakeholder collaborative networks (MSCNs) and the resource awareness of the members? This study explored the relationships between the network features of the Omaha STEM Ecosystem (OSE) and the resource awareness of its members. A document analysis of a digital survey administered via emailing a listserv by the director of the OSE was used. Social network analysis (SNA) and traditional statistical methods were used in this study. This section begins with a general overview of the research design then explains each step in further detail.

The first part of the study identified the resource awareness of members of the OSE regarding the resources present within the Omaha community. The method used for this portion of the study was an application of an expert agreement method and was conducted in SPSS. First, the respondents were divided into the stakeholder categories of which they identified in the survey. Then for each stakeholder category, the resource status of each resource listed on the survey was determined. Next, each resource was assigned a resource status as either belonging or not belonging to it for each stakeholder category. Once each resource had a resource status, a resource status percent agreement (RSPA) was assigned to each respondent for each stakeholder category that compared the respondents' resource status with the resource status of each stakeholder category. This data was then used to determine RSPA within stakeholder categories and between the stakeholder categories.

The second part of the study identified if a relationship existed between the network feature of relational social capital (SC) and the resource awareness of the members in the OSE. The relational social capital was determined by the interaction level of which the respondents selected in the survey. Each individual respondent received an interaction level for each of the organization types listed on the survey based on their responses. Then a Kruskal Wallis ANOVA test was conducted using the three different interaction levels as the grouping variables to determine if there is a difference in the distribution of the RSPA in each group. A difference in the distributions of the RSPAs based on the interaction level would imply a relationship between the interaction levels and the distributions of RSPAs. This difference would demonstrate a relationship between the relational social capital of the network and the resource awareness of its members.

The final portion of the study was to identify if a relationship existed between the network feature of structural social capital and the resource awareness of the OSE members. For this portion of the study, the frequency of interaction level between each organization type was used to determine the informal and formal networks at the organization type level. Then, the betweenness centrality for each organization type in the two networks, informal and formal, was calculated. This betweenness centrality was the structural social capital variable. Each organization type received an average RSPA for each stakeholder category along with an overall RSPA. A Kendall's Tau correlation between the betweenness centrality and RSPAs was conducted to determine if a relationship existed between the structural social capital of the network and the resource awareness of its members.

Social Network Analysis

Social network analysis was used to calculate the betweenness centrality variable of each organization type based on the informal and formal networks. Betweenness centrality is a measure of the magnitude for which an actor is positioned as a bridge between two otherwise unconnected actors in a network (L. C. Freeman, 1977).

Traditional Statistical Analysis

A Spearman correlation helped determine if there was a relationship between the various RSPAs. A Kruskal Wallis ANOVA test was used to determine the existence of a relationship between the variables of resource awareness and interaction levels, using the interaction levels of no relationship, informal relationship, and formal relationship as the grouping variable. A Kendall's Tau correlation was used to determine if there was a relationship between the degree centralities of the organization types and their RSPAs.

Population

The population of this study consisted of the individuals that elected to complete an online survey sent to them by the director of the OSE. The number of respondents that completed the survey was 86.

Instrumentation

The survey was developed by members of the OSE in order to evaluate levels of engagement and network development and was sent electronically through a listserv. The survey was a questionnaire composed of five different blocks: introduction block, attitude block, academic stakeholder category block, business stakeholder category block, nonprofit stakeholder block, and closing block. The introductory block asked questions regarding the name of the respondent, the organization they worked for, and how long

they had been a member of the OSE. The attitude block asked questions regarding the respondent's organization type and what kind of resources their organization brought to the OSE. It also inquired about the level of knowledge the respondent felt they had regarding the collaborative efforts of the OSE and the community's capabilities of engaging in collaborative efforts. The academic, business, and nonprofit stakeholder blocks each asked about the level of interaction the respondent had with individuals belonging to the other organization types in the OSE as well as what resources the respondent thought the stakeholder category possessed. The final block thanked the respondents for participating in the survey and whether or not they would be willing to complete a follow-up survey concerning contacts that would be beneficial to the OSE.

Procedures

Data Collection

The first step in the data collection process was to assign an identification number to each of the respondents. The next step was to codify the various categorical factors of organization type, stakeholder category, asset type and interaction level. Each organization received a nominal value and the possible organization types the respondents could select included: 2 Year College; 4+ Year College; Business with less than 50 employees; Business with 51-200 employees; Business with more than 200 employees; Career or Technical Training; Charitable Foundation; Civic Organization; Faith Based Organization; Parent/Neighborhood Organization; Private P-12 Education; Public P-12 Education; Science Centers and/or Museums and Libraries; Youth Serving Organizations; Military; Government; and Other. Next, a nominal identifier based on the three stakeholder categories of Academic, Business, or Nonprofit was assigned.

Academic stakeholders were assigned a stakeholder category of "1". Business stakeholders were assigned a stakeholder category of "2". Nonprofit stakeholders were assigned a stakeholder category of "3". The nominal values for the organization type can be found in Table 1. Table 2 shows a hypothetical list of respondents and how their responses would be categorized. Throughout this chapter, this hypothetical data provided in Table 2 is used to provide examples of how the data was collected and analyzed.

Table 1

Nominal IDs for the Organization Types

Organization Type	Abbreviation	Nominal ID
2 Year College	2 Yr	1
4+ Year College	4+ Yr	2
Career and/or Technical Training	CTT	3
Private P-12 Education	Prv P-12	4
Public P-12 Education	Pub P-12	5
Business with less than 50 Employees	Bus. <50	6
Business with 51-200 Employees	Bus. 51-200	7
Business with more than 200 Employees	Bus. >200	8
Charitable Foundation	CF	9
Civic Organization	CO	10
Faith-based Organization	FBO	11
Parent/Neighborhood Organization	PNO	12
Science Centers/Museums/Libraries	SCML	13
Youth Serving Organization	YSO	14
Military	Mil.	15
Government	Govt.	16
Other		17

Table 2

Hypothetical Respondent Survey Data

Hypothetical Respondent	**Personal ID**	**Self-selected Organization Type**	**Organization Type ID**	**Stakeholder Category ID**
Ted	A	< 50 employees	6	2
Todd	B	Public P-12 Education	5	1
Terri	C	>200 employees	8	2
Tyler	D	51-200 employees	7	2
Travis	E	Civic Organization	10	3
Tracie	F	2 Year College	1	1
Trent	G	Military	15	3
Tanner	H	CTT	3	1
Talon	I	YSO	14	3

Each asset type was assigned a nominal identifier. The asset types include: Academic Coaching; Competition Sponsorship; Continuing Education Courses; Dual Credit Opportunities; Family STEM Experiences (family STEM nights, etc.); Funding for expanding high quality in school STEM programming; Leadership; Mentoring Support (Students); Mentoring Support (Teachers); Professional Development Resources; Providing students and staff to volunteer in out of school STEM programs; Providing administrative and logistical support to expand STEM programs; student internships; Teacher Externships; Other. The nominal values of the asset types can be found in Table 3.

Table 3

Nominal IDs for Asset Types

Asset Type	Nominal ID
Academic Coaching	1
Competition Sponsorship	2
Continuing Education Courses	3
Dual Credit Opportunities	4
Family STEM Experiences (family STEM nights, etc.)	5
Funding for expanding high quality in school STEM programming	6
Leadership	7
Mentoring Support (students)	8
Mentoring Support (teachers)	9
Professional Development Resources	10
Providing students and staff to volunteer in out of school STEM programs	11
Providing administrative and logistical support to expand STEM programs	12
Student internships	13
Teacher externships	14
Other	15

Finally, the interaction levels were assigned ordinal values of "0", "1", or "2". The possible interaction levels include: "I am not familiar with anyone in this category"; "I am familiar with someone in this category but we did not work together in a professional manner"; "We shared professional advice and/or materials when opportunity arose"; "We worked side by side as separate organizations but did not have a formal agreement"; and "We worked together as a formal team with an established formal agreement (such as a memorandum of understanding)". The statement of "I am not familiar with anyone in this category" belonged to the interaction level of No Interaction and received a value of "0". The statements of "I am familiar with someone in this category but we did not work together in a professional manner", and "We shared professional advice and/or materials when opportunity arose" belonged to the interaction level of Informal Interaction and received a value of "1". The statements of "We worked

side by side as separate organizations but did not have a formal agreement", and "We worked together as a formal team with an established formal agreement (such as a memorandum of understanding)" belonged to the interaction level of Formal Interaction and received a value of "2". The ordinal values of the interaction levels can be found in Table 4.

Table 4

Ordinal Values Assigned to Interaction Levels

Relationship	Interaction Level	Ordinal ID
I am not familiar with anyone in this category	No Interaction	0
I am familiar with someone in this category but we did not work together in a professional manner	Informal Interaction	1
We shared professional advice and/or materials when opportunity arose	Informal Interaction	1
We worked side by side as separate organizations but did not have a formal agreement	Formal Interaction	2
We worked together as a formal team with an established formal agreement (such as a memorandum of agreement)	Formal Interaction	2

The resource status of each asset as identified by each respondent was codified. For each asset a respondent identified as belonging to that stakeholder category, a nominal value of "1" was assigned. For each asset a respondent identified as not belonging to that stakeholder category, a nominal value of "0" was assigned. Once this step was completed, the resource status for all asset types in the three stakeholder categories as identified by each respondent had a nominal value of either "1" or "0". Table 5 shows an example of a hypothetical codification of responses for the Academic stakeholder category resources.

Table 5

Hypothetical Codification of Responses for the Academic Stakeholder Category Resources

Respondent	Academic Stakeholder Asset Category													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	1	0	0	1	0	0	0	1	0	1	0	0	1	1
B	0	1	0	0	1	0	0	1	0	0	1	0	1	1
C	0	1	1	0	1	1	1	0	0	0	1	0	1	1
D	1	1	1	1	0	0	1	1	1	0	0	0	1	0
E	1	0	0	1	1	1	1	0	0	1	1	0	0	0
F	1	1	1	0	1	1	0	1	1	1	1	0	0	1
G	0	0	1	1	1	1	1	0	0	0	0	0	1	1
H	1	1	1	1	1	0	1	0	0	1	1	0	1	1
I	0	0	1	0	0	1	0	0	0	0	1	1	0	1

Data Analysis

Research Question 1

RQ 1.a. dealt with determining the resource status percent agreement within stakeholder categories so the first step was to determine the stakeholder category resource status (SCRS) for each asset for each stakeholder category. In order to do this for the academic stakeholder category, the sum value for the "1" responses for each asset type provided by those individuals belonging to the academic stakeholder category was compared to the sum value for the "0" responses for each asset type and whichever number was larger determined whether or not that asset was considered to belong to the academic stakeholder category. If the sum value of "1" was larger, then that asset was considered to belong to the academic stakeholder category and the SCRS for that asset was assigned a nominal value of "1". If the sum value of "0" was larger, then that asset was not considered to belong to the academic stakeholder category and the SCRS was assigned a nominal value of "0". If the sum value of "1" and "0" were equal, the SCRS was assigned a nominal value of "1". This process was then conducted for the assets of

the business stakeholder category then the nonprofit stakeholder category. Table 6 provides an example of the determination of the SCRS for the Academic stakeholder category. The responses of respondents B, F, and H were used because they were the hypothetical respondents that had selected as belonging to an Academic stakeholder category.

Table 6

Hypothetical Determination of SCRS for the Academic Stakeholder Category

Respondent	**Academic Stakeholder Asset Category**													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
B	0	1	0	0	1	0	0	1	0	0	1	0	1	1
F	1	1	1	0	1	1	0	1	1	1	1	0	0	1
H	1	1	1	1	1	0	1	0	0	1	1	0	1	1
Sum "1"	2	3	2	1	3	1	1	2	1	2	3	0	2	3
Sum "0"	1	0	1	2	0	2	2	1	2	1	0	3	1	0
SCRS	1	1	1	0	1	0	0	1	0	1	1	1	1	1

Once the resource status for each asset was identified, each stakeholder's responses for each asset was compared to the SCRS of the stakeholder category to which they belonged. If the individual's response matched the resource status, then it was assigned a value of "1". If the individual's response did not match the resource status, it was assigned a value of "0". In order to calculate the resource status percent agreement (RSPA), a percent match was calculated by adding up the total value of matches for an individual and dividing by 14, which is the total number of possible assets. This value was then multiplied by 100 to provide a percent. This was the RSPA for each individual in their respective stakeholder categories. The equation is:

Resource status % agreement = (x/14)100

Where x = the total number of matches of the individual's resource status of each asset category as compared to the determined SCRS. Table 7 provides an example of

how the "within category" SCRS will be determined for each individual belonging to the Academic stakeholder category, which again are individuals B, F, and H.

Table 7

Hypothetical Determination of "Within Category" RSPA for the Academic Stakeholder Category

Asset	SCRS	Respondent B RS	Respondent F RS	Respondent H RS
1	1	0	1	1
2	1	1	1	1
3	1	0	1	1
4	0	0	0	1
5	1	1	1	1
6	0	0	1	0
7	0	0	0	1
8	1	1	1	0
9	0	0	1	0
10	1	0	1	1
11	1	1	1	1
12	1	0	0	0
13	1	1	0	1
14	1	1	1	1
RSPA		71.43	60.43	71.43

Research Question 2

RQ 2 was concerned with determining a relationship between the relational social capital and the resource awareness of the members of the OSE. The two variables used to determine this were the interaction levels and RSPAs. During the data collection portion, each respondent's interaction level for each organization type received a nominal value of either "0", "1", or "2" based on their responses. In order to determine the Academic stakeholder category interaction level, the frequencies of the interaction levels for the organization types belonging to the academic stakeholder category were calculated. Whichever interaction level occurred with the highest frequency was the Academic stakeholder category interaction level for that individual. This was repeated for each respondent's interaction level for the organization types belonging to the business

stakeholder category and then for the organization types belonging to the nonprofit stakeholder category. Once completed, each individual respondent had a single representative interaction level for each of the three stakeholder categories and then the overall interaction level was determined.

Each respondent had also already received an RSPA for each stakeholder category during the previous data analysis section. A Kruskal Wallis ANOVA test was conducted where the grouping variable was the interaction level of each respondent for the various stakeholder categories and the dependent variable was the RSPA of each respondent for each stakeholder category. A significant difference in the distribution of RSPAs based on the interaction levels would imply a relationship between the RSPAs and the interaction levels. In order to do this, a Kruskal Wallis ANOVA test was conducted to determine a relationship between the interaction levels for the Academic stakeholder category and the RSPAs of the Academic stakeholder category. This determined if there was a relationship present between the interaction level of respondents toward the academic stakeholder category and the respondents' RSPA of the academic stakeholder category. This process was then conducted for the business stakeholder category, the nonprofit stakeholder category, and the overall RSPAs. Once completed, a Kruskal Wallis ANOVA test had been conducted to determine a relationship between the interaction level and RSPA for each stakeholder category and the overall RSPA.

Research Question 3

RQ 3 examined the relationship between the structural social capital of the network and the resource awareness amongst the members of the OSE. This question required looking at the OSE at the organization type level rather than the individual level

so the actors for this level of examination were the organization types represented by the respondents. The variable used for the structural social capital was betweenness centrality. Each organization type needed a representative interaction level for each other organization type in order to determine betweenness centrality. Each individual's interaction level had already been determined for each organization type so the respondents were divided into their organization types and the frequencies of the interaction levels were determined. The interaction levels that occurred most frequently became the interaction level for that organization type regarding one another. Once this step was completed, each of the twelve organization types had a representative interaction level for one another. These interaction levels then were then used to examine the relationships through two networks: informal and formal. The informal network consisted of the level 1 relationships and the formal network consisted of the level 2 relationships. The relationships were then entered into an adjacency matrix and the betweenness centrality metric was calculated for both networks.

Each organization type also needed a representative RSPA which was calculated as an average for each organization type. A Kendall's Tau correlation was then conducted to look for relationships between the degree centralities for both networks and the Academic RSPA, Business RSPA, Nonprofit RSPA, and Overall RSPA. The correlations were then used to determine if relationships existed.

Chapter 4: Results

This study explored the relationship between the features of a multi-stakeholder collaborative network (MSCN) and the resource awareness of its members. This chapter presents the findings of the analysis by beginning with the population demographics, then goes into the findings as reported by research question.

Population Demographics

There were 86 total surveys used in this analysis and respondents self-selected which organization types to which they belonged, and included: 2 Year College; 4+ Year College; Business with less than 50 employees; Business with 51-200 employees; Business with more than 200 employees; Career or Technical Training; Charitable Foundation; Civic Organization; Faith Based Organization; Parent/Neighborhood Organization; Private P-12 Education; Public P-12 Education; Science Centers and/or Museums and Libraries; Youth Serving Organizations; Military; Government; and Other. These organization types belonged to one of three stakeholder categories: Academic, Business, and Nonprofit. Figure 1 represents the number of respondents per organization type and Figure 2 represents the percentage of each stakeholder category represented by the respondents. The majority of the respondents belonged to the Academic stakeholder category at 50% with the 4+ Year College organization type having the most respondents at 27 and Career or Technical Training organization type with the least at 0. The second most represented stakeholder category was Nonprofit with 33% of the respondents with Youth Serving Organizations having the most respondents in this category with 10 and Military and Government organization types had the least, each with 0. The Business stakeholder category had the third largest

representation with 15% and Businesses with less than 50 employees represented the largest organization type with 8 respondents and Businesses with more than 200 employees representing the smallest organization type with 2. There were 2 respondents in the Other organization type.

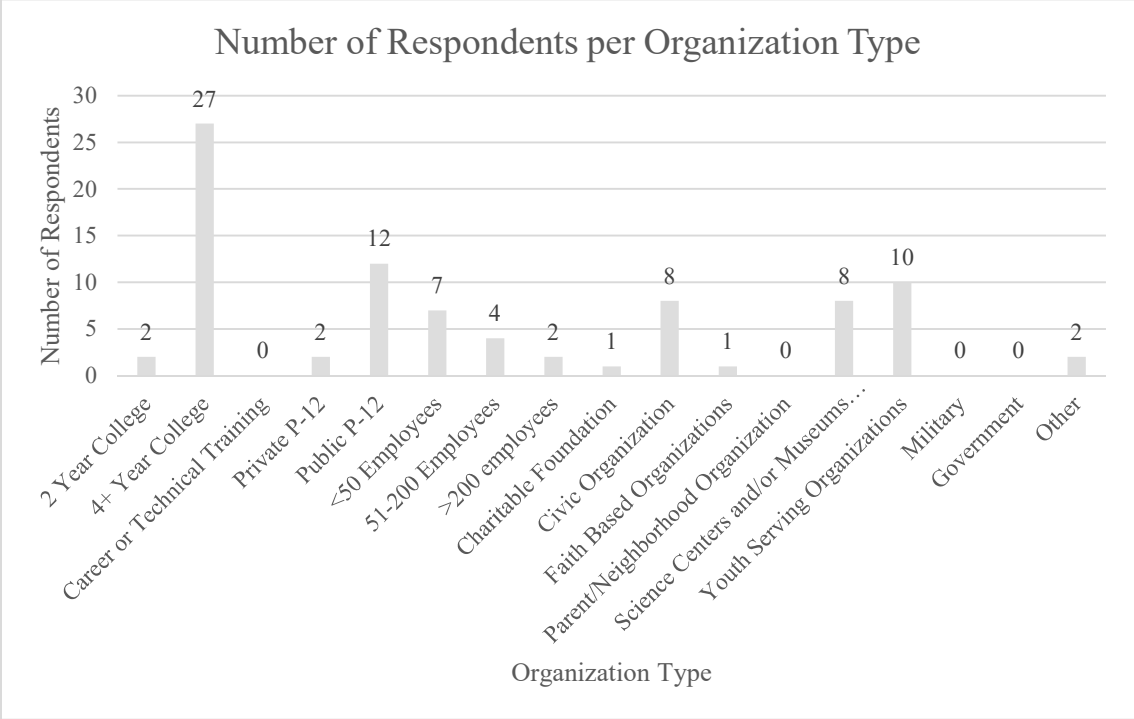

Figure 5. Number of Respondents per Organization Type

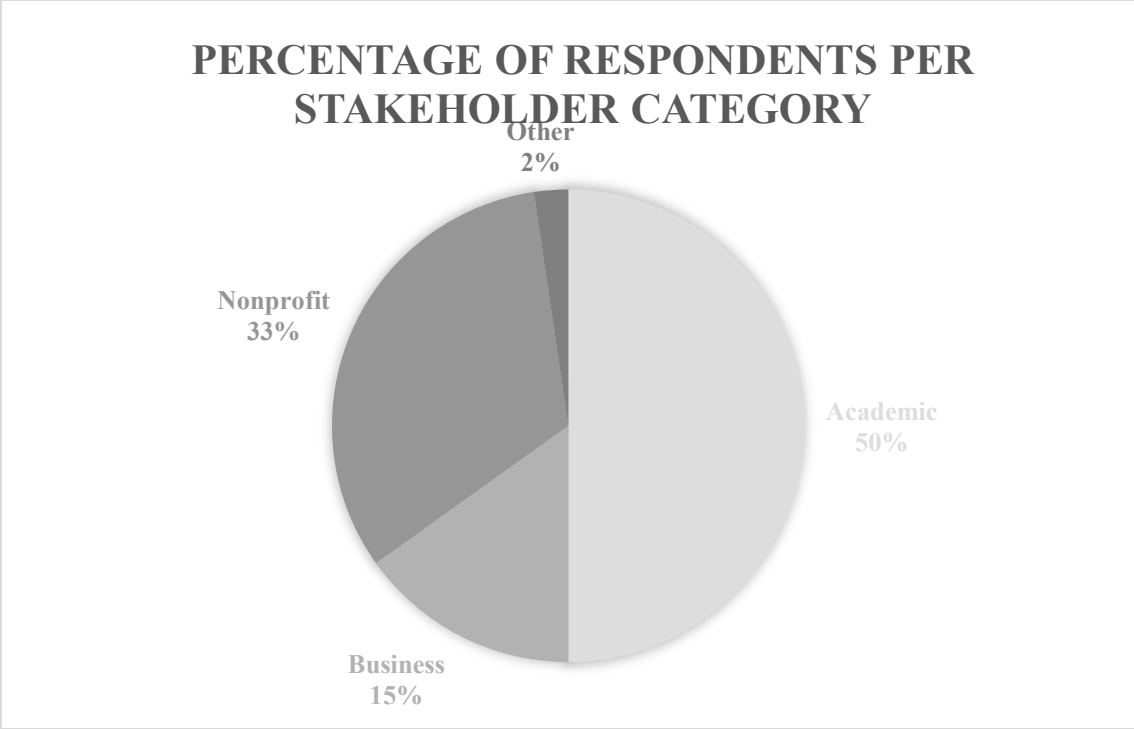

Figure 6. Percentage of Respondents per Stakeholder Category

Research Question 1

The following questions were posed within RQ1:

1. What is the extent of resource awareness in the Omaha STEM Ecosystem?
    a. What is the resource status percent agreement for members within a stakeholder category of the Omaha STEM Ecosystem?
    b. What is the resource status percent agreement between the stakeholder categories of the Omaha STEM Ecosystem?
    c. What is the relationship between the resource status percent agreement between the stakeholder categories of the Omaha STEM Ecosystem?

To determine the extent of resource awareness in the Omaha STEM Ecosystem (OSE), resource status percent agreements (RSPAs) were calculated first for individuals, then averaged for their organization types. The range of RSPAs of the organization types

was between the minimum of 48.57% which was the RSPA of the Business with less than 50 employees organization type, and for the Academic stakeholder category and the maximum of 86.67% which was the RSPA of the Faith-based Organizations for the Business stakeholder category. While this range demonstrates a variety, the overall variance of the RSPAs was relatively small at 0.009. The overall average (RSPA) of the survey respondents for all the stakeholder categories was 66.36% which means that on average, a respondent can identify whether or not a certain resource belongs to a stakeholder category 66.36% of the time. The Academic stakeholder category respondents had the highest overall RSPA of 68.06%, which means that on average, a respondent that belonged to the Academic stakeholder category could correctly identify which resources belonged to each of the stakeholder categories 68.06% of the time. Next was the Business stakeholder category overall RSPA at 67.40%. Finally, the Nonprofit stakeholder category had an overall RSPA of 63.57%. Refer to Table 8 for a full listing of all RSPAs.

The stakeholder category with the highest RSPA within the category was Business at 74.00%, which means that 74% of the time, a Business stakeholder respondent correctly identified a resource as belonging to the Business stakeholder category. Next was the Academic stakeholder category with an RSPA of 68.53% within the Academic stakeholder category. Finally, the Nonprofit stakeholder category had an RSPA of 67.14% within the Nonprofit stakeholder category.

The greatest RSPA between two stakeholder categories was the RSPA of Academic stakeholder category respondents for the Business stakeholder category with an RSPA of 71.32% which means that on average, a respondent from the Academic

stakeholder category can correctly identify whether or not a resource belongs to the Business stakeholder category 71.32% of the time. The next greatest RSPA between two categories was 70.26% RSPA of Business stakeholder category respondents for the Nonprofit stakeholder category. The RSPA of the Nonprofit stakeholder category respondents for the Business stakeholder category was the next largest at 65.71%. Next, the Academic stakeholder category respondents had an RSPA of 64.34% for the Nonprofit stakeholder category. The RSPA of the Business stakeholder category respondents for the Academic stakeholder category was 57.95%. Finally, the least RSPA between two stakeholder categories was the RSPA of Nonprofit stakeholder category respondents for the Academic stakeholder category at 57.86%.

In addition to determining the RSPAs of the individuals for each stakeholder category, a Spearman correlation was run to determine if there were any relationships amongst the RSPAs. There were very strong positive correlations for the RSPAs of all stakeholder categories and the overall RSPA. The strongest correlation was between the Academic RSPA (ARSPA) and Overall RSPA (ORSPA) with a coefficient of 0.716 ($p < 0.01$). The next strongest correlation was between the Business RSPA (BRSPA) and ORSPA with a coefficient of 0.658 ($p < 0.01$). The correlation between the Nonprofit (NRSPA) and ORSPA was 0.437 ($p < 0.01$). There was also a moderate to low correlation between the ARSPA and BRSPA with a coefficient of 0.308 ($p < 0.01$). There were no significant correlations between the NRSPA and the ARSPA or the BRSPA. Refer to Table 9 for a full listing of the correlations.

Table 8

Resource Status Percent Agreement (RSPA) by Stakeholder Category

Stakeholder Category	Academic Stakeholder Category RSPA (%)	Business Stakeholder Category RSPA (%)	Nonprofit Stakeholder Category RSPA (%)	Average RSPA (%)
Academic	68.53	71.32	64.34	68.06
2 Yr College	70.00	70.00	70.00	70.00
4+ Yr College	70.86	69.88	65.68	68.81
*Career or Technical Training**				
Private P-12	76.67	73.33	60.00	70.00
Public P-12	61.67	74.44	61.11	65.74
Business	57.95	74.00	70.26	67.40
< 50 Employees	48.57	75.00	65.71	63.10
51 - 200 Employees	68.33	70.00	76.67	71.67
> 200 Employees	70.00	76.67	73.33	73.33
Nonprofit	57.86	65.71	67.14	63.57
Charitable Foundation	60.00	73.33	66.67	66.67
Civic Organization	50.83	61.67	70.83	61.11
Faith Based Organization	86.67	86.67	60.00	77.78
*Parent/Neighborhood Organization**				
Science Centers and/or Museums or Libraries	52.00	59.33	70.00	60.44
Youth Serving Organizations	68.33	74.17	60.83	67.78
*Military**				
*Government**				
Other	70.00	63.33	53.33	62.22
Average	63.49	69.69	65.89	66.36

*Note. *No data for these organization types because they were not represented by any of the respondents.*

Table 9

Spearman Correlations of Resource Status Percent Agreements (RSPAs)

		ARSPA	BRSPA	NRSPA	ORSPA
ARSPA	Correlation Coefficient		0.308**	-0.104	0.716**
	Significance		0.004	0.339	0.000
BRSPA	Correlation Coefficient	0.308**		0.082	0.658**
	Significance	0.004		0.453	0.000
NRSPA	Correlation Coefficient	-0.104	0.082		0.437**
	Significance	0.339	0.453		0.000
ORSPA	Correlation Coefficient	.716**	0.658**	0.437**	
	Significance	0.000	0.000	0.000	

*Note. ** is significant at $p < 0.01$.*

Research Question 2

2. What is the relationship between the relational social capital of the Omaha STEM Ecosystem members and the resource awareness of its members?

The variable used to measure the relational social capital was the interaction level. Overall, the largest type of interaction level reported was an informal relationship, composing of 49.825%. This means that on average, each respondent had an informal relationship with someone from 49.83% of the organization types included in the survey. The next largest interaction level type was the formal relationship at 31.41%, meaning on average, each respondent had a formal relationship with someone from about 31.41% of the organization types listed in the survey. Finally, on average, each respondent would have no relationship with anyone from 18.78% of the organization types listed on the survey. Refer to Table 10 for a list of the average interaction levels by stakeholder category.

Table 10

Average Interaction Levels by Stakeholder Category

Stakeholder Category	No Relationship (%)	Informal Relationship (%)	Formal Relationship (%)
Academic	29.04	46.74	28.88
Business	15.14	51.84	28.44
Nonprofit	17.62	44.05	38.33
Other	13.33	56.67	30.00
Overall	18.78	49.83	31.41

When looking more closely at the interaction levels within the stakeholder categories, the largest percentage of interaction levels occurred at levels one and two for the Business Stakeholder category, each with 46.15%. This means that on average, a Business stakeholder category respondent would have either an informal or formal relationship with someone in 46.15% of the organization types represented in the Business stakeholder category. The smallest percentage of interaction levels occurred at level zero for the Business stakeholder category at 7.69%. This means that on average, a Business stakeholder category respondent would have no relationship with someone in 7.69% of the organization types represented in the Business stakeholder category.

For the interaction levels that occurred between stakeholder categories, the largest percent belonged to the level one interaction of the Business stakeholder category for the Nonprofit stakeholder category at 54.95%. On average a Business stakeholder respondent would have an informal relationship with someone from 54.95% of the Nonprofit organization types. The smallest percent belonged to the level two interaction of the Academic stakeholder category for the Business stakeholder category at 16.41%. On average, an Academic stakeholder respondent would have a formal relationship with

16.41% of the Business organization types. Refer to Table 11 for a full listing of the interaction levels for each stakeholder category.

Table 11

Percent of Interaction Levels for each Stakeholder Category

	Academic			Business			Nonprofit		
	IL0 (%)	IL1 (%)	IL2 (%)	IL0 (%)	IL1 (%)	IL2 (%)	IL0 (%)	IL1 (%)	IL2 (%)
Academic	19.07	36.28	44.65	31.25	52.35	16.41	25.25	51.83	22.92
Business	13.33	52.00	21.33	7.690	46.15	46.15	20.88	54.95	24.18
Nonprofit	17.14	42.14	40.71	23.80	47.60	28.00	15.30	43.88	40.82
Average	16.51	43.47	35.56	20.91	48.70	30.21	19.48	50.22	29.31

Note. IL0 represents no relationship, IL1 represents informal relationships, and IL2 represents formal relationships.

To answer the question regarding what is the relationship between the interaction levels of the Omaha STEM Ecosystem members and their resource awareness, a Kruskal Wallis ANOVA test was performed where the distribution of RSPAs from the various stakeholder categories, along with the overall RSPAs were examined by grouping the RSPA's according to the three interaction levels of no relationship, informal relationship, and formal relationship and determining if there was a difference in their distributions of the RSPAs. In order to determine if a relationship existed, the distribution of the RSPAs between the categories would have to be different. For example, if a significant difference had been determined, it would be possible that the highest ranked RSPAs would all be within the informal network group demonstrating a relationship between the highest ranked RSPAs and the level of interaction. However, no significant p-values were determined. The largest p-value was determined for the distribution of the Nonprofit stakeholder RSPA's within the Nonprofit stakeholder category interaction levels at 0.519. The smallest p-value of 0.121 was determined for the distribution of the business stakeholder category RSPA's within the Business stakeholder category

interaction levels. The p-value of the distribution of the Overall RSPA's within the Overall stakeholder category interaction levels was 0.321, which was also the p-value for the distribution of the Academic stakeholder category RSPA's within the Academic stakeholder category interaction levels.

Research Question 3

3. What is the relationship between the structural social capital of the Omaha STEM Ecosystem organization types and the resource awareness of its members?

The quantity used to measure the structural social capital of the Omaha STEM Ecosystem was the betweenness centrality of each of the organization types represented by the respondents of the survey. Betweenness centrality is a metric based on how well an actor is connected to otherwise unconnected actors and holds an intermediary position between them. The first step in determining the betweenness centrality of the OSE's organization types was to determine the interaction level for each actor with respect to each other actor in the network and use this information to develop adjacency matrices for both the informal network and the formal network. For this question, the actors were the organization types. Table 12 shows the Informal Network Adjacency Matrix. Figure 3 is the sociogram of the informal network and represents the actors (OSE organization types) as the nodes and the reported relationships are the arcs (arrows). The organization types' nodes are represented by certain shapes: Academic stakeholder category nodes are squares; Business stakeholder category nodes are circles; and Nonprofit stakeholder category nodes are triangles. This graphically represents the organization types and their relative positions to one another based on their reported relationships. Refer to Table 1

for a list of the organization type abbreviations. Table 13 shows the Formal Network Adjacency Matrix and Figure 4 shows the Formal Network sociogram. The organization types of Career or Technical Training, Parent/Neighborhood Organizations, and Military are absent in all of these results because there were no respondents within these categories. The organization type of "Other" is also absent because it is not an actual organization type but rather a broad category for any respondents that felt they didn't belong to any of the organization types listed.

Table 12

Informal Network Adjacency Matrix of OSE Organization Types

	OSE Organization Types											
	2yr	4yr	Prv P12	Pub P12	<50	51-200	> 200	CF	CO	FBO	SCML	YSO
2yr	0	0	0	0	1	0	1	0	1	1	1	1
4yr	1	0	1	0	1	0	0	1	1	1	1	1
PrvP12	1	0	1	0	1	1	1	1	1	1	0	1
PubP12	1	0	0	1	1	1	1	0	1	1	1	1
<50	1	1	1	0	0	1	1	1	1	1	1	0
51-200	1	1	1	1	1	0	0	1	0	1	1	1
>200	1	1	1	0	1	1	1	1	1	1	0	0
CF	1	1	1	1	1	1	1	1	1	0	0	0
CO	1	0	0	1	1	1	1	1	1	1	1	1
FBO	1	0	0	0	1	0	0	0	0	0	1	0
SCML	1	0	0	0	0	1	1	0	0	1	0	0
YSO	0	0	0	1	0	1	0	0	0	1	0	0

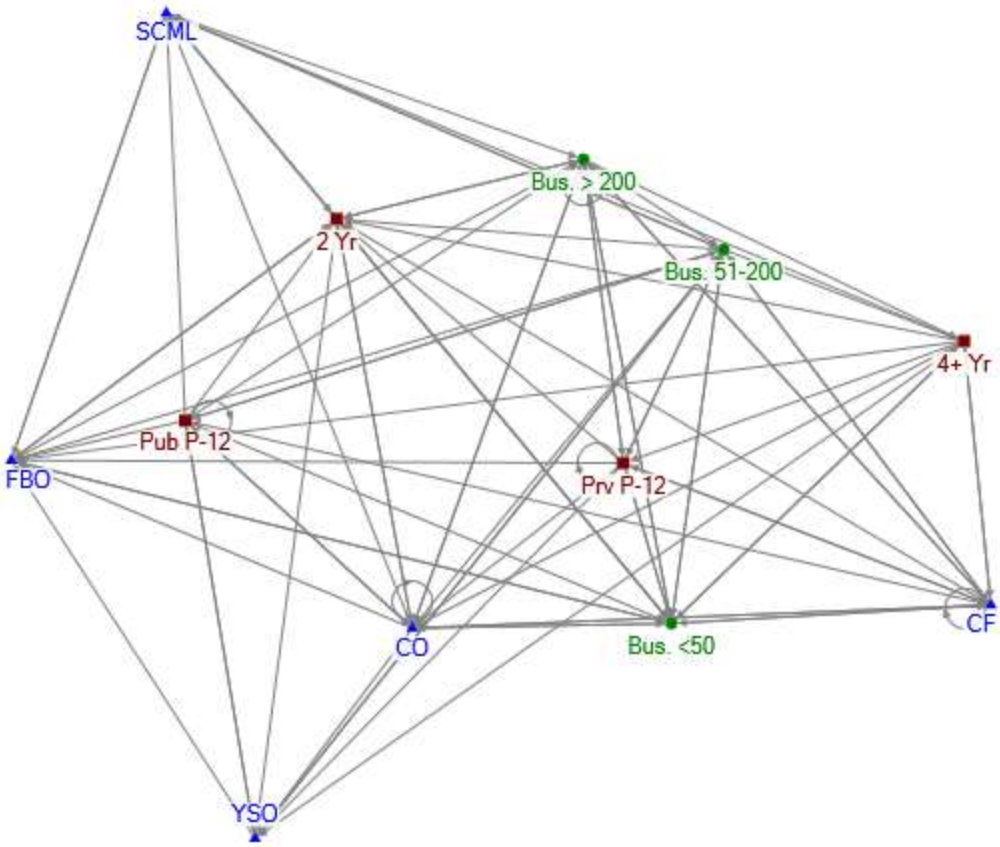

Figure 7. Sociogram of the Informal Network of the OSE Organization Types

Table 13

Formal Network Adjacency Matrix of OSE Organization Types

	OSE Organization Types											
	2yr	4yr	Prv P12	Pub P12	<50	51-200	> 200	CF	CO	FBO	SCML	YSO
2yr	1	1	1	1	0	1	0	1	0	0	0	0
4yr	0	1	0	1	0	0	0	0	0	0	0	0
PrvP12	0	1	0	1	0	0	0	0	0	0	1	0
PubP12	0	1	1	0	0	0	0	1	0	0	0	0
<50	0	0	0	1	1	0	0	0	0	0	0	1
51-200	0	0	0	0	0	1	1	0	1	0	0	0
>200	0	0	0	0	0	0	0	0	0	0	0	0
CF	0	0	0	0	0	0	0	0	0	0	1	1
CO	0	1	1	0	0	0	0	0	0	0	0	0
FBO	0	1	1	1	0	0	0	1	1	1	0	1
SCML	0	1	1	1	1	0	0	1	1	0	1	1
YSO	1	1	1	0	1	0	0	1	1	0	1	1

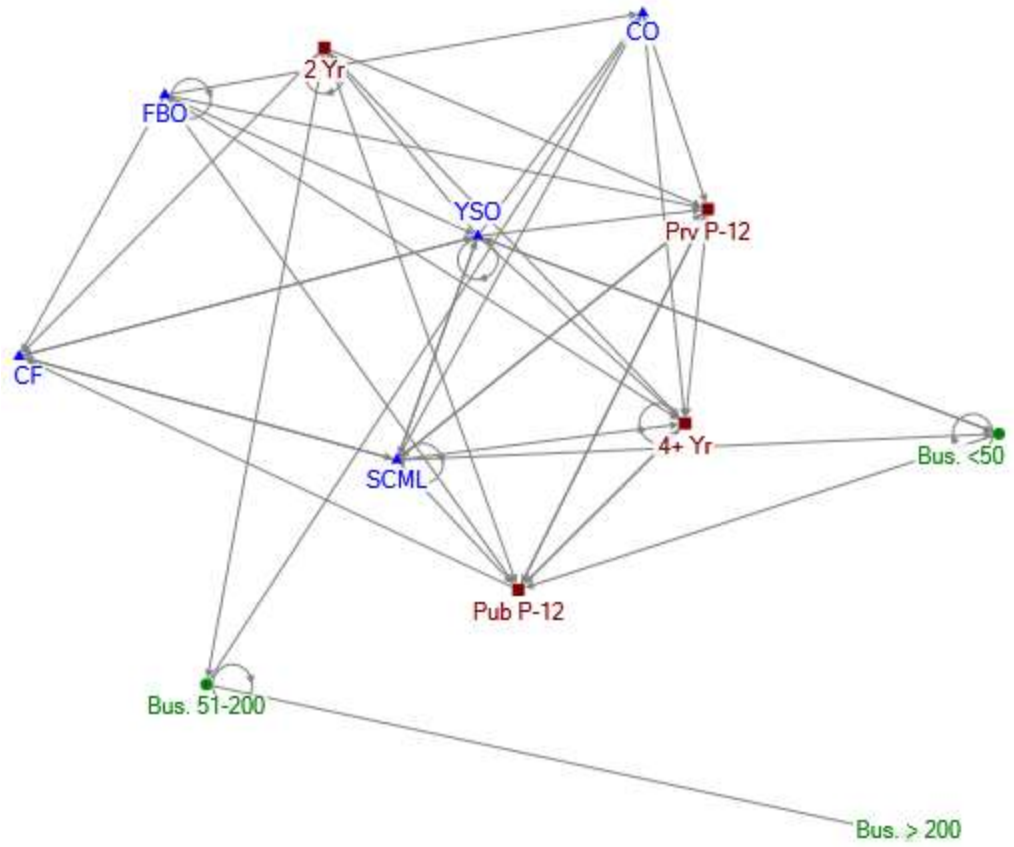

Figure 8. Sociogram of the Formal Network of the OSE Organization Types

Once the adjacency matrices were developed, the betweenness centralities (BC) were calculated. The RSPAs for the organization types were also calculated. For the informal network, the organization type of Businesses with 51-200 employees had the greatest BC of 10.36 and the organization type of 4+ Year College had the lowest BC of 1.08. For the formal network, the Youth Serving Organizations organization type had the highest BC of 30.46 and both the organization types of Businesses with more than 200 Employees and Faith Based Organizations had BCs of 0. The greatest RSPA belonged to the Organization Type of Faith-Based Organizations with 86.67% for both the Academic and Business Stakeholder categories while the lowest RSPA belonged to the organization type of Businesses with less than 50 Employees for the Academic stakeholder category

with 48.57%. Table 14 shows the degree centralities and RSPAs for all organization types.

Table 14

Betweenness centrality and RSPAs of Organization Types

Organ-ization Type	Informal Network Betweenness Centrality	Formal Network Betweennes s Centrality	Academic RSPA (%)	Business RSPA (%)	Nonprofit RSPA (%)	Overall RSPA (%)
2yr	4.67	16.55	70.00	70.00	70.00	70.00
4yr	1.08	1.70	70.86	69.88	65.68	68.81
PrvP12	1.24	14.58	76.67	73.33	60.00	70.00
PubP12	3.45	11.21	61.67	74.44	61.11	65.74
<50	8.51	.18	48.57	75.00	65.71	63.10
51-200	10.36	10.00	68.33	70.00	76.67	71.67
>200	5.07	.00	70.00	76.67	73.33	73.33
CF	2.58	12.88	60.00	73.33	66.67	66.67
CO	4.02	7.27	50.83	61.67	70.83	61.11
FBO	1.47	.00	86.67	86.67	60.00	67.78
SCML	1.55	19.73	68.33	74.17	60.83	67.78
YSO	1.47	30.46	52.00	59.33	70.00	60.44

In order to determine whether a relationship existed between the betweenness centrality and RSPAs of the organization types, a Kendall's Tau correlation was performed. There was one significant, positive correlation between the informal network betweenness centrality and the NRSPA at 0.543 *($p < 0.05$).* There were no other significant correlations found. Table 15 shows all of the Kendall's Tau correlations between the betweenness centrality and RSPA's of the Organization Types.

Table 15

Kendall's Tau Correlations of Organization Type Betweenness Centrality and Resource Status Percent Agreement (RSPA)

Network Centrality	Betweenness	Academic RSPA	Business RSPA	Nonprofit RSPA	Overall RSPA
Informal	Correlation Coefficient	-0.295	0.140	0.543*	0.047
	Significance	0.189	0.534	0.016	0.836
Formal	Correlation Coefficient	-0.140	-0.388	-0.047	-0.140
	Significance	.534	0.084	0.836	0.534

**Significance at $p < 0.05$*

Chapter 5: Discussion

The purpose of this study was to explore the following question: How can multi-stakeholder collaborative networks manage the awareness of resources of their members? As more and more collaborations are formed to address complex issues, the management of these collaborations becomes more complex as well because an increasing number of stakeholders are actively engaged in the collaboration process (Poutanen et al., 2016). These types of collaborations form multi-stakeholder collaborative networks (MSCNs). Due to the importance of sharing resources for the success of any collaboration, it is necessary to understand and manage the resource awareness of MSCNs. This exploratory study looked at the results of 86 surveys of members of the Omaha STEM Ecosystem (OSE), an MSCN serving the Omaha, NE community to improve STEM educational pathways for all learners. This chapter presents a brief summary of the findings, discusses each research question by interpreting the findings, looks at the implications of the findings applied on a larger scale, identifies the limitations of this study, and provides directions for future research.

Summary of Findings

The first question in this study addressed the resource awareness of the members of the OSE and looked at how accurately an OSE member could identify a resource belonging to each of the three stakeholder categories: Academic, Business, and Nonprofit. On average, an OSE member could correctly identify which resources belonged to which stakeholder category 66.36% of the time. There were positive, significant correlations between all of the stakeholder resource status percent agreements (RSPAs) and the Overall RSPA (ORSPA). There was also a positive, significant

correlation between the Academic stakeholder RSPA (ARSPA) and the Business stakeholder RSPA (BRSPA), there were no significant correlations between the Nonprofit stakeholder RSPA (NRSPA) and either the ARSPA or BRSPA. The second question looked at the relationship between the relational social capital of the OSE and the resource awareness of its members. Using the methodology in this study, no relationships were found to exist. The third question looked at the relationship between the structural social capital of the OSE and the resource awareness of its members. One relationship was found to exist between the informal network betweenness centrality and the NRSPAs. There were no other relationships found to exist using the data and methodology in this study.

Research Question 1

RQ 1 dealt with the resource awareness amongst the OSE members and on average, on OSE member could accurately identify whether a resource belonged to one of the three stakeholder categories 66.36% of the time. This average seems appropriate within the methodology of this study. This number seems appropriate because of the generic nature of the categorization of the organization types into only three stakeholder categories. Although there were a total of 15 different organization types, the question regarding resource awareness only asked the respondents to identify whether a resource belonged to one of the three stakeholder categories, not individual organization types. The results may be quite different if the respondents were asked to identify whether a resource belonged to a specific organization type, it would be expected that the RSPA in this case would be lower than 66.36% because of the more specific awareness that would

be required. While this would be a reasonable future direction of this research, the time required to complete a survey like that would be a consideration.

The first question also addressed if there was a relationship between the different stakeholder RSPAs. There were positive, significant correlations between all of the stakeholder RSPAs and the Overall RSPA (ORSPA), which is not surprising because the ORSPA was based on the average of the ARSPA, the BRSPA, and the NRSPA. There was also a low to moderate correlation between the ARSPA and the BRSPA but no significant correlations between the NRSPA and either the ARSPA or BRSPA. It wasn't expected that there would be a correlation between the stakeholder RSPAs because of the novelty of this study, there was no way of anticipating which stakeholder categories would have greater RSPAs. It is interesting that there was a correlation only between ARSPA and BRSPA and not with the NRSPA, even though when looking at the stakeholder category RSPAs, they are very similar and the average NRSPA lies in between the average ARSPA and the average BRSPA. Further research is needed to determine the connection between the ARSPA and the BRSPA and the disconnect with the NRSPA.

Research Question 2

The second question looked at the relationship between the relational social capital of the OSE and the resource awareness of its members. It was expected that there would be a difference between the various interaction levels and the resource awareness of the members, especially with the interaction level of "no relationship". This does not necessarily mean that there is no relationship that exists between the two variables of relational social capital and resource awareness, although that is one possibility. It does

mean that the methodology used in this study did not produce significant results. There are many possible reasons this did not happen. As previously mentioned, the respondents were asked to identify which resources belonged to which stakeholder categories which encompassed many different organization types. This broad categorization within a stakeholder category allowed for a less specific knowledge base. It is possible that if respondents had been asked to identify the resources that belonged to each organization type, there would be more variance in the RSPAs because more specific knowledge would be required. A larger variance in the RSPAs may have produced different distributions within the interaction level groups. The interaction levels themselves were narrowed to three categories, when they could have been expanded to the five original statements. This may have generated groupings with larger variation in distributions. The specific context of the relationship may also have impacted their resource knowledge base. The context of the various interaction levels was not measured. If those members had relationships based on STEM centered collaborations or conversations, that may have impacted their resource awareness for this study. Including the specific context of the interaction level may impact the relationship between the interaction levels and the RSPAs within the STEM context, which is a possible future direction for this research.

It is also possible that the confounding variable of time, which was not explored in this study, influenced both the RSPAs and the interaction levels. The amount of time a respondent had belonged to the OSE may have influenced the amount of resource awareness they possessed as well as the types of relationships they had developed with other members of the OSE. If this variable had been accounted for, results may have been different.

Research Question 3

The third question looked at the relationship between the structural social capital of the OSE and the resource awareness of its members. One relationship was found to exist between the informal network betweenness centrality and the NRSPAs. There were no other relationships found to exist using the data and methodology in this study. These results were not expected, it was expected that greater betweenness centrality would result in greater RSPA in all the stakeholder categories because betweenness centrality implies access to unique knowledge that others don't have (Shaw-Ching Liu et al., 2005). It's not surprising that it is the informal network betweenness centrality because the informal knowledge pathway is the pathway where actual knowledge travels (Inkpen & Tsang, 2005). Because these results are based on the previous determinations of the RSPAs and interaction levels, these results would also be impacted by broadening the categorization of interaction levels to the five original levels and by broadening the resource awareness to the organization types rather than the stakeholder categories. This would most likely affect the structure of the network, which would in turn affect the betweenness centralities. In future studies, it would be beneficial to have a roster format of the member organizations and use the actual member organizations as the actors rather than averaging organization type. Again, the time required to complete a survey that lists all of the member organizations may be intensive.

Implications

The purpose of this study was to develop a method to help manage the resource awareness amongst members of an MSCN using traditional statistical methods and social network analysis. This study presents a new analytical model and perceptual framework

in which to examine the resource awareness of the members of an MSCN. MSCNs could build upon this model and modify it to help evaluate the structure of their network, as well as the resource awareness of their members. They could use this analytical model to examine their network composition in terms of organization types and which organization types were most central to the network. It could be used to track the development of the network over time through examining the evolution of the network membership, resource awareness, and interaction levels. It also provides a framework in which to encourage MSCNs to foster resource awareness amongst its members with the goal of self-organization of the collaborators based on their ability to identify where the resources are located within their network.

Limitations

As with any study, it is important to note the limitations. As an exploratory study, the analytical method used is new and further research will be needed to validate its usefulness and its ability to be used in other contexts. Another limitation includes the data source which relied on a self-reporting survey. There are two types of survey bias that impact the data from these types of surveys: social desirability bias and reference bias. Social desirability bias occurs when a respondent selects "better" ratings in order to appear more attractive to peers (West, 2014). It's possible that respondents selected "better" interaction levels than they actually experienced in order to be perceived as popular and important. Reference bias occurs when there is a difference in comparison of standards (West, 2014). While the instrument used attempted to minimize reference bias by including specific language regarding interaction levels in order to minimize different interpretations, it's possible that respondents viewed the requirements of each interaction

level differently. This variation in interpretation may have occurred for the nature of the resources listed as well.

The overall nature of the survey that asked respondents to identify interaction levels of members from the organization types within the OSE presents limitations. When responding to a statement concerning an interaction level with any member of an organization type, there is no way of knowing whether the individual in mind is a member of the OSE. While using this format does allow for some indication of ego-centric interaction levels of the OSE members, it is impossible to use this data to form a complete whole-network view. Averaging the interaction levels of the organization types presents an incomplete representation of the OSE network. However, it does provide a meso-level analysis of the network to use to guide future activities of the OSE. These activities could include recruiting more organizations within an organization type that may be lacking, or arranging forums where members can explicitly discuss their resources and brainstorm.

Future Research

This exploratory study serves as a springboard for future research into this area of STEM educational pathway MSCNs management. If this study were replicated, it may be advisable to keep the interaction levels spread through the five different possible levels in order to create a greater variety in the interaction levels and to be able to tease out the different types of interactions rather than aggregating them into only three possible levels. It would also be beneficial to specify the context of the interactions at the various levels to include STEM specific collaborations/conversations. If possible, a roster format of the actual member organizations would be preferable to the organization type format used in

this study, although the time required to complete a survey like that would most likely result in a small completion percentage. The time a member has been involved with the OSE is also an important variable that should be included.

Future research specific to the OSE will include the other survey data which inquired about the level of knowledge the respondents had regarding the collaborative efforts of the OSE and the community's ability to engage in efforts to improve STEM educational pathways. This data is indicative of the collective efficacy of the members of the OSE. Collective efficacy is "a group's shared belief in its conjoint capabilities to organize and execute the courses of action required to produce given levels of attainments" (Bandura, 1997, p. 477). Bringing in the variable of collective efficacy will add an informative dimension to this research. Collective efficacy has been shown to impact motivation, resiliency, and performance (Bandura, 2000). The relationship between collective efficacy and social capital has grown in popularity in the areas of environmental and community governance, education, organizational management, and innovation (Goddard, Hoy, & Hoy, 2004; Kim & Shin, 2015; Liu, Chen, & Tao, 2015; Ostrom, 2010; Westermann, Ashby, & Pretty, 2005).

Conclusion

Suggestions for future research regarding the methodology in this study have already been mentioned, this section takes a step back and looks at the overall purpose of resource awareness within MSCNs and suggests new avenues of research. The purpose of this study was to explore the relationship between the resource awareness of the members of an MSCN and its network features to help with the management of innovative collaboration. While this study sought to quantify the resource awareness of

the members of an MSCN, resource awareness within an innovative collaboration is much more complex than the method used in this study. Resource awareness isn't as simple as identifying that some organization types in the Academic stakeholder category can provide Dual Credit Opportunities; this is typically common knowledge and that's why the results in this study were relatively high at 66.36% RSPA. The fact that the types of resource awareness in this study were fairly common knowledge helps to explain why there were no relationships between the RSPA and interaction levels; the resource awareness was not dependent upon relationships because it was common knowledge.

Resource awareness has multiple meanings. While it can mean the ability to identify which organization types can provide certain services, even more valuable, it can also mean knowing the individuals that can help with the access, mobilization, and integration of those resources. Within innovative collaboration and knowledge transfer, resource awareness is only the first step of the collaboration process. Identifying external resources is important, but so is the ability to access the resources, discern which resources are necessary, and knowing how to combine the resources in a productive way. If this study had included specific questions regarding the ability to access, mobilize, and integrate desired resources, the results would have been different, the relationships would have mattered.

At the beginning of this research project an assumption was made that it mattered if all members of a MSCN were aware of the resources within their network, but upon further reflection, this is not necessarily true. The reality is that the explicit awareness of resources amongst all the members of a MSCN such as the OSE does not mean they will all be involved in innovatively collaborating. Only a few members will be the

innovators, the individuals that are able to solve problems by combining resources of different organizations, which is typically around 2.5% of the population (Rogers, 2003). There are also a few members of the network that will be connectors. They are not necessarily the ones that will be innovating, but they will be the ones with the knowledge of where the resources lie and know how to bring the right people together because they have relationships with many people from different areas (Gladwell, 2006). In social network analysis (SNA) studies, these connectors are known as bridges. As previously discussed, in large MSCNs where it is impractical to use a roster format, the use of SNA to identify these connectors/bridges would be unlikely. It is possible that these connectors/bridges are the ones with the highest average RSPA across the different stakeholder categories as measured in this study. This could be one extension of the methodology in this study, the identification of these connectors based on their overall RSPA, although it is unlikely there would be much correlation with connectors and the overall RSPA because of the nature of the generic knowledge required for the categories used in this study. It is possible to use the interaction level data to determine the connectors, these individuals would most likely have the greatest number of level 1 and level 2 interactions with the various organization types.

The innovators would be much harder to find using the methodology in this study, but the connectors/bridges would most likely know who they are. Finding the connectors/bridges is important for the successful innovative collaboration because they will have the awareness of the resources that really matter, the right people. This is the knowledge the steering committee needs to use to help guide further activities. While the methodology used in this study is a good starting point for determining general resource

awareness in a MSCN, further research needs to be conducted on how to identify the connectors/bridges of large networks which would most likely rely on a self-reporting survey for data and where a roster format would not likely provide useful data because of the time that would be involved in completing a survey with 86 or more actors listed in roster format. The next step would be to use the connectors/bridges to identify the innovators and bring them together.

Within the OSE, there are many organizations that offer very similar programming and there are redundancies within the Omaha metro area not only with the types of programming, but also which populations are being served. These resources are not being used to their full potential and need some direction and innovative guidance so they can impact the greatest number of STEM learners. Not only are there redundant programs, there are areas of growth and opportunity that haven't yet been conceived and this is what spurred this research project, the abundance of untapped resources that could be used to ensure equitable access to STEM learning opportunities throughout the Omaha metro area. Resource awareness is a vital aspect of the innovative process that needs to happen in order to ensure this equitable STEM learning access in the OSE but the resources that need to be known are the connectors/bridges and innovators. This is where the process starts, getting the right people together to identify and solve problems through the innovative combination of their resources.

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