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Organizational Information Dissemination Within Collaborative Networks Using Digital Communication Tools

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Organizational Information Dissemination Within Collaborative Networks
Using Digital Communication Tools

by

Cristelia Zarate Hinojosa

A dissertation submitted in partial fulfillment of the requirements for the degree
of Doctor of Philosophy
in
Information Systems

College of Engineering and Computing
Nova Southeastern University
2017

We hereby certify that this dissertation, submitted by Cristelia Hinojosa, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

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An Abstract of a Dissertation Submitted to Nova Southeastern University
in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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March, 2017

While knowledge is one of an organization's greatest assets, it remains a challenge to facilitate knowledge transfer between people within an organization. Social influence has been studied in its role of facilitating information diffusion, which is necessary for knowledge transfer to occur. Among this research, tie strength, a quantifiable characteristic of a social network that determines the link between two nodes, has been measured to determine the impact of social influence on knowledge transfer and information dissemination within a social network. Current research that explores the impact of social influence on information diffusion has been conducted within public social networks due to the availability of data that can be gathered from public social online network systems, such as Facebook. With the emergence of collaboration technologies that exist in online social network tools being utilized within organizations, there is an opportunity to digitally collect information regarding information dissemination within a collaborative network. This study captured data from an online social network, specifically a unified communication tool, being used within a collaborative social network at a mid-sized South Central corporation. A content analysis of Lync messages for 1,749 connections was performed to quantitatively measure the influence of tie strength on information dissemination within a collaborative social network. The results demonstrated that tie strength had a significant impact on information dissemination using a collaborative system. Multivariate analysis of variance showed that tie strength had the largest impact on information dissemination using the instant messaging modality of a collaboration system.

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Chapter 1

Introduction

Information flow is necessary for maximizing profits and performance within an organization (Durugbo, 2014). Sharing knowledge is essential to an organization's ability to gain a competitive advantage (Donate, 2011). An organization that has the ability to make use of its collective knowledge has a higher probability of increased innovativeness, efficiency, and effectiveness in the marketplace (Levin & Cross, 2004; Sighn, 2012). Companies that leverage all information available to them rather than subsets of data have a competitive edge, as it allows the company to gain more insight and make better decisions (Sighn, 2012). Knowledge sharing is essential for effective knowledge management and organizations are increasingly dependent upon effective knowledge management for gaining a competitive advantage (Chandra, Iyer, & Raman, 2015; Zhang & Jiang, 2015).

Organizational survival is increasingly dependent upon socialization, which is defined by communication between employees, that is being supported by emerging technology to make communication more dynamic and transparent (Correia, Medina, Romo, & Contreras-Espinosa, 2014). An advantage of social interaction is the access to knowledge that it provides (Hansen, 1999; Rejeb-Khachlouf, Mezghani, & Quelin, 2011; Zhou, Sui, & Wang, 2010). Research has been conducted to demonstrate that relationships between individuals are critical to information transfer (Bakshy, Marlow, Rosenn, & Adamic, 2012; Friedkin, 1982; Granovetter, 1973; Levin & Cross, 2004; Wei & Bu, 2014).

However, all relationships should not be treated equally, because the strength of a relationship varies as individuals maintain ties that affect how they interact with other members of the same network (Luarn & Chiu, 2015).

Tie strength is a relationship factor theorized to moderate the strength of social influence, and as a result, has been used to measure social influence within a network (Aral & Walker, 2014; Bakshy et al., 2012). Tie strength, a multidimensional theoretical construct, is the nature of ties between an individual and other members of the same network and characterizes the closeness and interaction frequency of a relationship between two people (Granovetter, 1973). Understanding relational ties can assist in more efficient dissemination of information (Luarn & Chiu, 2015). Granovetter proposed that tie strength can be measured by evaluating a combination of four dimensions: amount of time, emotional intensity, intimacy, and reciprocal services. This quantifiable characteristic of a social network can be measured to determine the link between nodes, which are two points in a relationship (Luarn & Chiu, 2015). Original studies that measured tie strength's impact on information diffusion relied on observational methods (Bakshy et al., 2012; Friedkin, 1982; Granovetter, 1973; Hansen, 1999). The availability of online social networks allows information to be measured quantitatively by collecting data through digital communication tools.

A collaborative network is formed by members who work together to achieve specific goals (Miao et al., 2012). While collaborative networks are a type of social network, they have significantly different characteristics from the public social networks that have been commonly evaluated when examining the role of tie strength and information diffusion. Collaborative networks require adequate information flow to overcome organizational

complexities (Durugbo, 2014). While recent studies have evolved to quantitatively measure the influence of tie strength within public social networks, studies are lacking on measuring tie strength's impact on information diffusion within a collaborative social network.

Unlike public social networks, collaborative networks do not typically use public social media platforms for communication but rather use information and communication tools (ICT), such as email, videoconferencing, teleconferencing and information databases, for information flow (Durugbo, 2014). However, due to the similarities of social media platforms and collaborative tools used within organizations, research regarding social media platforms and information sharing can be studied to understand information sharing within a collaborative network. Modern collaborative networks have begun using the newly emerging unified communication tools (UCT) such as Microsoft Skype for Business (also referred to as Lync). Lync is reported to be used by nearly 90% of Fortune 500 companies (McGrath, 2014). Since studies regarding tie strength have focused on public social networks that use social media platforms (Adali, Sisenda, & Magdon-Ismail, 2012; Aral & Walker, 2014; Chiu, Chen, Joung, & Chen, 2014; Gilbert, 2012), there is a need to understand information diffusion in a collaborative social network that uses an online social network collaborative technology.

Problem Statement

There is not a complete understanding of the impact of tie strength on information dissemination within a collaborative social network. While studies have been conducted to determine the impact of relationships on information diffusion and knowledge transfer

within a public social network by examining social media platforms, research has not been conducted within a collaborative social network that uses online social networking tools (Bakshy et al., 2012; Bharati, Zhang, & Chaudhury, 2015; Friedkin, 1982; Levin & Cross, 2004; Luarn & Chui, 2015; Wei & Bu, 2014; Zhou et al., 2010). Private, collaborative social networks are subject to organizational constraints, such as conversations that involve problem solving, that make the knowledge sharing process different from that of a public social network (Durugbo, 2014; Maio et al., 2012). As a result, the studies conducted on knowledge sharing and tie strength within a public social network might not be applicable to that of a collaborative environment. There is a need to investigate the social influences of utilizing a unified communication tool to share knowledge within a private collaborative network.

Bakshy et al. (2012) and Steeg and Galstyan (2012) explored social influence on information diffusion with a public social network. Prior to this research, there were few experimental studies performed on social influence in information diffusion, as previous studies relied on observational methods. As Shalizi and Thomas (2011) identified, monitoring social media by observational methods poses difficulty as individuals tend to participate in similar activities as their peers. Studying purely observational data makes it difficult to determine whether the correlation occurs due to similarities or peer behavioral influence, because the strength of the relationship is being determined by observing the conversation rather than collecting data to determine tie strength.

Technology can be used to spread information instantaneously as well as overcome barriers of accessibility, context and relevancy (Correia et al., 2014). The studies of Bakshy et al. (2012) and Steeg and Galstyan (2012) digitally captured data transmitted

within a public social network and measured information diffusion by tracking the transfer of specific data rather than relying on surveys or interviews. However, these two studies were performed by collecting data from public social networks, which limited them to the analysis of messages and posts within a social environment. The current study was performed within a collaborative network using modern online social network collaboration technology that supports the knowledge transfer process by disseminating information. Information dissemination was measured by tracking the dissemination of specific information via a collaboration tool within an organization.

Aral and Walker (2014) leveraged the work of Bakshy et al. (2012) by using a statistical method to investigate how social influence within a network impacts sharing information relative to product adoption. The study also utilized Facebook as the avenue for testing the effect that tie strength and structural embeddedness have on influence. Aral and Walker's and Bakshy et al. research used statistical methods to validate if social influence is a factor of information diffusion within an online social network. The current study leveraged statistical methods to examine the impact of social influence within a unified communication tool that was being used within a collaborative network in a business environment rather than a public social network. By utilizing a collaborative network within an organization, this study attempted to describe information dissemination in a corporate environment.

Dissertation Goal

The goal of the study was to empirically investigate through hypothesis testing how the personal characteristics of tie strength influence information dissemination within a collaborative network in an organization that uses online social network technology. Data were gathered from an organization utilizing a unified communication tool within its collaborative network. Statistical methods were utilized to quantitatively capture the amount of tie strength between individuals. Using the proxies that have been utilized to measure tie strength within a public social network as a point of departure, the dimensions of tie strength were modified to accommodate measuring within a collaborative network. The tie strength dimensions that were captured were used to determine the amount of influence this social structure had on content sharing. The research of Bakshy et al. (2012) and Steeg and Galstyan (2012) that investigated the influence of tie strength on information transfer within a public social network was used to model the approach.

The objective of this study was to answer the following research questions:

- How does tie strength influence the effects of information dissemination within a collaborative social network?
- How is the relationship between tie strength and information dissemination affected by the type of medium being used within the collaborative network?

Relevance and Significance

Knowledge within an organization presents value, and investing in methods that encourage employees to share knowledge allows an organization to gain competitive advantage by making information readily available to those that require it (Levin & Cross, 2004). This study contributed to the body of literature concerning social networks, knowledge sharing and organizational knowledge transfer by leveraging prior research on social media collaboration to determine if the dimensions of tie strength had an effect on information diffusion among corporate users of this technology. It also provided proxies for measuring tie strength within a collaborative social network rather than a public social network.

Prior to collecting conversations using large scale communication systems, information about social interaction was collected through observation (Adali et al., 2012; Hansen, 1999; Marsden & Campbell, 1984; Steffes & Burgee, 2009). However, statistical analysis of data can prove to be more effective than observation. Large scale online communication systems are influencing social interaction and capturing communication within networks (Aral & Walker, 2014; Rejeb et al., 2011). Online social networks are researched to understand information diffusion. Electronic social networks allow for mass collaboration (Correia et al., 2014). The rapid increase in the use of digital social interaction through online social networks has created an avenue for conversations to be captured digitally, which allows for this data to be statistically measured (Aral & Walker, 2014). This analysis of social interaction has enabled an increased understanding about the role of social behavior in information sharing and can result in improved

business and social policy. The use of digital social interaction has enabled new methods for capturing data about social interaction (Bakshy et al., 2012; Rejeb-Khachlouf et al., 2011; Wei & Bu, 2014). These outlets allow for large scale data experiments and can help determine the subtle effects of social interaction. Kirschman, and Greenstein (2002), Roberts (2000), and Boudreau, Loch, Robey, and Straud, (1998) identified specific collaboration technologies and applications that increase a company's competitiveness. Among these applications, groupware type of technology is considered the primary enabler for dispersed teams to increase knowledge sharing by allowing rapid access to information (Kirschman, & Greenstein, 2002). Groupware supports communication using various combinations of audio, video, file transfer and application sharing (Kirschman, & Greenstein, 2002). This collaborative technology integrates electronic messaging with screen sharing, meeting support and other applications (Boudreau, Loch, Robey, & Straud, 1998).

Given the limitations of measuring social influence through observational means, the availability of statistical data that can be gathered using online social networking digital communication tools presents an opportunity for empirical research. Collaborative networks within organizations now have access to large scale online social networking digital communication tools that can serve as an avenue for sharing information (Aral & Walker, 2014). Data regarding information sharing can be collected and statistically analyzed using these digital communication tools to provide a method for understanding the factors that influence and promote knowledge contribution.

Bakshy et al. (2012), Rejeb-Khachlouf et al. (2011), Wei and Bu (2014), Zhou et al. (2010), and have examined the effects of social ties on dissemination of information.

Friedkin (1982), Granovetter (1973), and Hansen (1999) measured the impact of tie strength by purely observational means, which relied on the collection of data through surveys and interviews. Performing a study based on purely observational methods is less reliable than the current method of quantitative data collection. The new emergence of online social networking communication systems have created an avenue for collecting tie strength information digitally and performing a quantitative evaluation of the effects of tie strength on information dissemination. Gilbert and Karaholios (2009), Gupte and Eliassi-Rad (2012), Luarn and Chui (2015), Petroczi, Nepusz, and Bazso (2007), and Wei and Bu (2014) have collected data from public social systems, because this information is easily gathered through publically available sites such as Facebook. While these social systems provide data that are beneficial for understanding the relationship of social ties and information sharing, they are only capturing information that is disseminated within a social setting. There is a lack of research that uses an online social network communication system to digitally capture and quantitatively measure the effect of tie strength on information diffusion within a collaborative social network. The current study has practical applications, because the analysis can be used by managers to determine how to structure teams so that knowledge sharing can be facilitated when using digital communication tools.

Barriers and Issues

Tie strength has not been measured within a collaborative network, so this research required proxies to be modified to accommodate an organizational environment. Prior to

measuring tie strength within a public social network, there were no proxies, categories that could be used for measurement, that existed for that environment, because tie strength was measured through observational means. Proxies to measure tie strength within a public social network were developed by interpreting and modifying the original measurements introduced by Granovetter (1973). The same approach was taken to develop proxies to accommodate a social collaborative network. Data were collected from a live business environment, so the researcher had the need to determine a method for selecting the appropriate sample group and size. The measurement proxies for each of the tie strength dimensions required a significant amount of data analysis, since multiple measurements were used for each dimension.

Assumptions, Limitations and Delimitations

Assumptions

This research did not take into account the factors influencing the use of the collaboration technology. For example, there are different levels of technological skills that exist within the organization. The users had various levels of experience with technology, which may have affected the usage of the system. The software contains advanced features that further promote information sharing. However, the organization may not have been making full use of the features available by the technology, so utilization of the system may have been limited by a user's inability to make use of the advanced software features. It was assumed that participants that did not utilize the system may have had technical difficulties that prevented them from making use of the

collaboration technology. Correia et al. (2014) explained that educational level can have an impact on the usability of the network. The researcher assumed that all of the meaningful users had the training and technological skills necessary to make use of the tool. Lync is a web-based system that requires an internet connection, and the researcher assumed that all of the users had an adequate internet connection and computer system requirements to be able to adequately use the Lync system. The researcher assumed that the system was set up correctly to record all data passing through the Lync system and that there would not be system or network limitations that would limit the researcher's ability to capture or keep data. There was an assumption that all meaningful users had a relationship connection, since they were all part of the same company and were all part of the Lync user community.

The content of messages and transmission of information exchanged using the instant messaging modality were able to be analyzed and measured with much more accuracy than messages within chat rooms or video/conferencing. Within a chat room, it was assumed that a message posted by one member of a chat room was received and read by all other members of a chat room. The conversations that took place while using the video/conferencing feature were not recorded, and it was assumed that each participant that was attending a video/conference received a relevant message from each other participant in attendance.

Limitations

The modalities of screen sharing and video conferencing are rich media that allow high levels of synchronicity and are being used by the current pool of meaningful Lync users. However, the conversations that took place during video conferencing and screen

sharing sessions could not be monitored, because these conversations were not being recorded by the individual users, nor were their conversation history recorded in the administrative logs. The use of these tools, including information about frequency and duration of the conversation, was the only data recorded regarding the video conferencing and screen sharing modalities, and each instance of utilizing the tool was counted as information transferred. Future research can determine if information is disseminated using the modalities of screen sharing and video conferencing by analyzing content.

Information being transferred outside of the system was not being monitored. Proximity of work space may have caused individuals to resort to higher synchronicity for their conversations, such as face-to-face conversations. Individuals that possess high levels of tie strength may prefer phone or in-person conversations, but that information was not available as a measurement of tie strength for the purposes of this study. It is likely that two individuals may not use the Lync tool yet still possess strong tie strength that was not captured during this study. Data were collected from the researcher's place of employment, which classified the researcher as an active participant in the study. Measures were taken to prevent bias. The researcher was not involved in promoting the software tool once data were being collected, and the researcher's use of the system was not included in the study.

Delimitations

All data were collected within one business environment in multiple regions of the United States, which may have limited the generalizability of the findings. While data were collected from a single work environment, it did not include a homogeneous sample, and the sample could have contained extraneous variables, such as education and

income. This study did not measure the quality of the knowledge that was passed using the collaborative system. This study evaluated knowledge sharing within an organization. Sharing information with external customers and clients is also essential to a business success, and the collaborative system can be leveraged to provide external communication. However, this study was purposefully limited to capturing information within the internal business environment and only considered internal knowledge sharing within an organization. During the course of the study, the system was not configured to allow external communication outside of the company network.

Definitions of Terms

- Collaborative network - A collaborative network is an entity whose collaborative efforts to achieve common or compatible goals are supported by a computer network (Durugbo, 2014). A collaborative network is a type of social network formed by members working together to achieve specific goals (Miao et al., 2012). Inter-organizational collaboration must enable effective communication and knowledge sharing in order to be successful (Wu & Zhang, 2015).
- Information and Communication Technology (ICT) – ICT is “any technology used to support information gathering, processing, distribution and use” (Mpofu & Watkins-Mathys, 2011, p. 184). ICTs assist knowledge creation and diffusion by their ability to rapidly collect, store and disseminate data (Mpofu & Watkins-Mathys, 2011). Hendricks (1999) explained that the use of ICT reduces the barriers of knowledge sharing, such as physical, social and temporal distances between individuals, and

improves access to information, therefore, utilizing collaboration technology can enhance knowledge sharing.

- Information flow - Nonaka (1994) explained that “information is the flow of messages, while knowledge is created and organized by the flow of information, anchored on the commitment and beliefs of its holder” (p.15). Information is the flow of messages and knowledge is created by the flow of information (Agnihotri & Troutt, 2008).
- Knowledge sharing – Knowledge sharing is the process of delivering information to provide assistance to and collaborate with others in order to solve problems, develop ideas, or implement new policies and procedures (Wang & Noe, 2010). Amayah (2013) explained that knowledge can be shared through face-to-face interactions, through channels such as technology, formally, or even unconsciously through the act of conversations and social interactions. In the current study, knowledge sharing was monitored as it was shared within an online collaborative environment.
- Knowledge transfer - The Shannon and Weaver (1972) model argued that knowledge transfer and sharing are the transmission of a message from a source to a recipient within a particular setting. Albino, Garavelli, and Gorgoglione (2004) extended the Shannon and Weaver model to propose that technology can be used to transmit information. Organizational knowledge transfer is the process in which people within organizations exchange and are influenced by the experience of others (Fang, Yang, & Hsu, 2013).
- Online social network - An online social network is a virtual social community in which users can contribute messages that can be sent to other users within their online

- community or displayed in chronological order for others to view. Barker (2015) explained that an online social network is a “set of personal relationships in cyberspace where computer-mediated space integrates/facilitates knowledge creation and sharing and is characterized by groups of people with more or less specific, complex and common goals, value systems, norms, rules, and a sense of identity which they want to enhance through electronic communication” (p. 335). The use of online social technology can increase the availability of useful knowledge in organizations by promoting knowledge sharing (Gressgard, 2014).
- Tie strength - Granovetter (1973) introduced tie strength as a relationship factor used to characterize the closeness and interaction frequency of a relationship. This theoretical construct moderates the strength of social influence within a network (Aral & Walker, 2014). Tie strength was used in this study to measure the social influence within the collaborative network that was being monitored.

Summary

Knowledge is an important resource for an organization’s sustainable competitive advantage (Teece, 1998). When knowledge is used in support of decision making or issue resolution, a company can compete more effectively and make better decisions (Donate, 2011; Gera, 2012; Mudambi, 2002). The ability to transfer knowledge represents a source of competitive advantage for organizations (Reagans & McEvily, 2003). In an attempt to improve performance, organizations are increasingly investing in knowledge management efforts, which typically involves incorporating technology to allow people to produce and share user generated content (Bharati, Zhang, & Chaudhury, 2015).

Social interactions are essential for promoting knowledge exchange (Bakshy, Marlow, Rosenn, & Adamic, 2012; Friedkin, 1982; Granovetter, 1973; Levin & Cross, 2004; Wei & Bu, 2014). Social networking systems promote employee collaborations, and usage of online social networking communication systems within an organization, such as social media and collaborative technology, has grown exponentially and is being used for knowledge management efforts by increasing access to information and experts (Bharati et al., 2015). As tools for communicating continue to evolve, online social network communication tools are becoming the new method for sharing knowledge within organizations (Levy, 2013). Research can take advantage of data that are collected while communicating within online systems. Tie strength is a social relationship factor that has been studied to understand information sharing. While most studies have relied on public social media networking systems, such as Facebook, to collect data about information sharing in relation to tie strength, there are studies lacking about information shared within a collaborative environment. This study was conducted within a single organization, which produced limitations of generalizability but allowed for an understanding of tie strength within a single collaborative network.

The rest of the paper is structured as follows: a review of the literature is performed to review previous studies regarding information diffusion within networks and the impact of tie strength on networks; a discussion is included on the analysis performed on 1749 connections among corporate users of a collaborative social network to monitor the effects of tie strength on information dissemination; and the paper is concluded with a discussion of the results and conclusions that resulted from the analysis of data collected during the study.

Chapter 2

Review of the Literature

Overview of Topics

Knowledge sharing within an organization was researched to determine the importance of sharing knowledge, its benefits, and factors that motivate knowledge sharing. The body of literature regarding knowledge transfer was reviewed to understand the effects of knowledge sharing between employees and to identify the measurements used to quantify knowledge sharing. It was important to research studies regarding organizational environmental factors that promote knowledge sharing and the motivating factors for people to participate in knowledge sharing activities. Since knowledge sharing is a social process, it was important to review the literature concerning social motivational factors that affect knowledge sharing. Previous studies that explored the impact of relationships on knowledge sharing were examined.

Collaborative networks are a type of social network and are used to spread information. The characteristics of social networks were studied to compare the similarities with collaborative networks. Previous research regarding online social networks and information dissemination were studied to understand knowledge sharing within a social network and apply it to a collaborative network.

Studies pertaining to public online social networks and collaborative networks were explored to compare the differences in structure and the information diffusion complexities within them. Previous research that explained online social networks and the manner in which information travels through networks was explored to understand how this knowledge could be applied to a collaborative network. It was important to review research that explained how to leverage collaborative networks within an organization to spread information.

Tie strength is used to measure social influence in a network. The literature concerning tie strength was researched to identify how previous studies explored the influence of tie strength on knowledge sharing within a network. Studies that measured the influence of tie strength were reviewed to identify multiple methods of measuring tie strength proxies.

Since technology is an important part of knowledge sharing, there was a need to understand the technology available and what research has concluded about the impact of this technology. The literature was reviewed regarding technology tools used to disseminate information. It was important to understand how social technology systems are being used to leverage knowledge management within organizations. Particularly studies that researched online social networking sites as a knowledge management tool were studied, since there are numerous studies on the effects of social media. Social media technology has many of the same characteristics as collaborative technology except that collaborative technology is limited to a collaborative environment. The use of collaborative networks was studied to understand how information flows in a collaborative environment.

Justification

This study highlighted the potential and limitations of using collaboration systems for transferring knowledge within an organization. It explained how an organization could manage the diffusion of knowledge and use of a collaborative system. The practical applications of this study can help an organization understand how to leverage tie strength to gain better utilization of collaborative systems for sharing information.

People are increasingly relying on online social networking systems as sources of information. Technology is an important part of knowledge management, so technology systems that support information sharing were studied, including social media platforms. Social media is rapidly becoming an information source within the United States as approximately 70 percent of U.S. online users utilize social networking sites (Kim, Lee, & Elias, 2015). Half of online users in the United States get their news from social media, so social media is evolving from a networking tool to a major information source (Kim, Lee, & Elias, 2015). Social media platforms share many characteristics of collaborative technology systems. Both are virtual environments that allow users to voluntarily share information via online technology, because they contain features that allow them to disseminate information.

Organizations are investing in collaborative systems as they understand the importance of knowledge transfer (Hharati, Zhang, & Chuaudhury, 2015). There are relationships that exist within an organization that facilitate knowledge sharing. Tie strength has been used to understand knowledge sharing in a public environment and can be utilized to understand social relationships within a private collaborative network. It

was important to study information sharing in various environments. Since there are many studies regarding social media in public environments, this was particularly studied to leverage the research performed on social media platforms and understand how it relates to information sharing within a collaborative environment.

Inter-organizational knowledge transfer is very useful to an organization to increase the value of an organization and to create sustainable competitive advantage, but it is difficult to manage and it has a high failure rate (Fang, Yang, & Hsu, 2013). This study helps organizations understand how they can leverage systems that are already in place to transfer knowledge. It offers insight into how organizations can manage relationships within a company to leverage the use of the systems in which they are investing.

Knowledge Transfer

The people within an organization possess critical knowledge, and there is a need to motivate these individuals to share their knowledge and make it readily available to those who require access to it. Including employees' knowledge in operations adds relevance to the organization as knowledge sharing improves organizational change and has both economic and social value (Mura, 2013). However, transferring knowledge between organizations is complex due to dispersal coordination and high costs (Rejeb-Khachlouf et al., 2011). Managers continue to experience difficulty leveraging employees' knowledge (Mura, 2013).

Promoting knowledge transfer has long been a challenge for organizations who rely on knowledge for decision making (Peng, 2013). An organization's knowledge creation,

innovation, and competitiveness are hindered when employees are not motivated to share knowledge (Casmir, Lee & Loon 2012). Research of Wang, Clay and Forsgren (2015) addressed the challenges of transferring knowledge within an organization to allow it to receive the full benefits of its knowledge resources. While organizations have implemented knowledge management systems designed to facilitate knowledge transfer within an organization, these organizations continue to face difficulty motivating employees to contribute knowledge (Wang et al., 2015).

Roberts (2000) defines knowledge as the productive use of information, and Shannon and Weaver (1972) explained that human cognition is what translates information into knowledge. Albino, Garavelli, and Gorgoglione (2004) also explained that human cognition is required to turn information into knowledge. Using the aforementioned interpretations, information is turned into knowledge when it is put into practice. Since data for this study were collected from a live collaborative system, and there was no confirmation that the information is being put into application, this study measured the dissemination of information rather than knowledge. The dissemination of information was monitored to determine if it followed the knowledge processes described by Alavi and Leidner (2001), which included creation, storage/retrieval, transfer, and application. Knowledge creation involves the creation of new content or the replacement of exiting content. Knowledge storage/retrieval refers to the information that is stored within the organization and available for retrieval by others. Knowledge transfer is the process of distributing knowledge, whether it be between individuals, groups or across organizations. Knowledge application is the process of putting knowledge into practice.

For the current study, the collaboration system was used as a technology mechanism to facilitate the transfer of information.

Casmir et al. (2012) performed an empirical quantitative correlation study to investigate the relationship between the perceived cost of sharing knowledge by examining if there was a positive relationship between knowledge sharing and commitment to an organization or trust in colleagues. A survey was conducted on 496 employees across 15 organizations to determine if the perceived costs of knowledge sharing are lessened when there is organizational commitment and trust. A knowledge management sharing scale developed by Van den Hoof and de Ridder (2004) was modified for determining the cost of sharing knowledge, and statistical results were generated using a five point Likert scale. The researchers determined that affective commitment is positively related to knowledge sharing where high affective trust is present ($r = 0.11$, $p < 0.05$). The study concluded that if employees are committed to an organization and trust their colleagues, the perceived costs of sharing knowledge are reduced. Employees are more willing to share when there are high levels of trust with co-workers or a commitment to an organization. Organizations that create a collaborative culture are conducive to knowledge sharing.

Mura (2013) conducted a quantitative correlation study to develop a model to understand the relationship of employees participating in knowledge sharing activities and the value added to organizational operations. A questionnaire, developed from previous scales, and a series of face-to-face interviews were conducted among 198 employees from four Italian Hospice and Palliative Care organizations using age, gender, and professional experience as control variables. Significant results included that sharing

best practices has a positive relationship with promotion and implementation of new ideas as shown by a statistical significance of ($B=0.346$, $p<0.001$) and ($B=0.193$, $p<0.001$), a positive relationship exists between sharing mistakes and idea implementation ($B=0.340$, $p<0.001$), and there is a negative relationship between relational social capital and sharing of best practices ($B=-0.205$, $p<0.05$). The study concluded that individuals who have increased relational social capital might perceive the sharing of best practices or mistakes as negative due to the perception that decision making is manipulated as individuals are persuaded to incorporate new ideas. Knowledge sharing positively affects the sharer's innovativeness by promoting the implementation of new ideas. Sharing best practices and mistakes promotes innovativeness. Individual perceptions of social capital have a role in knowledge sharing benefits. People that lack self-interest are motivated to share knowledge by acting in the best interest of an organization. The act of being innovative disrupts the status quo and could affect social bonds. As a result, strong ties may lead to conformity as people adapt to others' expectations to gain support for their actions.

Knowledge Sharing Within Online Social Networks

Knowledge sharing is a social process that is affected by social motivational factors (Lin & Lo, 2015). Interpersonal relations and the resources that are generated through social networks are vital to inter-firm knowledge transfer (Hansen, 1999). Social cohesion motivates individuals to invest in knowledge sharing efforts (Rejeb-Khachlouf, et al., 2011). Personal networks are composed of people with whom a person maintains

contact, including partners, customers, suppliers, and family members (Rejeb-Khachlouf et al., 2011). Public social networks focus on social interactions and social information exchange (Maio et al., 2012). The structural properties of a social network are exhibited in an online network (Chui, Chen, Joung, & Chen, 2014). Recent studies regarding information distribution within social networks have focused on public social networks, which commonly use social media platforms such as Facebook (Bakshy et al., 2012; Luarn & Chui, 2015; Rejeb-Khachlouf et al., 2011). Social media is increasingly being used within organizations for knowledge management (Bughin et al., 2012). Social media technology creates an avenue for user-generated content to be created and shared to a wide audience (O'Reily, 2007). Kane and Fichman (2009) indicated that social media is an effective tool for providing reusable knowledge through user-generated content.

An individual's learned knowledge is subject to external relationships. Casmir et al. (2012) argued that knowledge sharing is facilitated by organizations that promote trust. Social influence is a determining factor of what people adopt and when they adopt it (Lin & Lo, 2015). Lin and Lo identified that there remains a need to investigate how to motivate employees to share knowledge, as employees within an organization possess critical knowledge that is not always easily available to those that need access. While the motivational factors of knowledge sharing have been widely researched, gaps exist in taking into consideration the relationship between a person's position in a social network and the degree in which a person controls information (Lin & Lo, 2015). A person's position in a network can be a factor that affects knowledge sharing, because someone with a higher position can have greater influence on subordinates to share information.

Saito, Kimura, and Motoda (2013) performed grounded theory research to revise an information diffusion model to determine how social networks are affecting information diffusion within a social network that accounts for interactions between people. This research was relevant to the literature review, because the current topic studied information diffusion with a network in which subjects were interacting. The researchers collected data observationally in a retrospective setting and searched for change patterns that increased the likelihood of information diffusion sequences. Two social network information diffusion models were considered: the Asynchronous Independent Cascade (AsIC) model and the Value Weighted Voter Model (VwV). An iterative search algorithm was developed to identify the patterns of change in information diffusion, and when tested, showed an increased accuracy and enhanced computation time compared to previous models. The proposed model was able to detect and estimate hot span and diffusion probability and worked for both the AsIC and VwV diffusion models. It was concluded that the proposed algorithm was robust enough to identify correct change patterns.

Barker (2015) performed a study in which the use of a discussion forum was tracked to determine its role in knowledge creation and sharing. A quantitative content analysis was performed by tracking and critically examining the content, text and messages within a website's online discussion forum to identify themes and interpret codes. Online discussion forums are a type of online social network. The study expanded a previous theoretical framework that was developed to evaluate knowledge management in a virtual community based on content, communication, and the consumer. Prior to this study, there was a lack of research on the potential impact that discussion forums used in social

networking have on knowledge creation. The research proposed a theoretical framework based on the components of content, communication, and consumer for measuring knowledge management within an online discussion forum. A single website with an online discussion forum was analyzed for the study, because it provided an observable and measurable unit. The online threads posted within the forum were categorized as individual views, statements to stimulate debate or feedback, questions to ask opinions, and questions to obtain information. A coding system was developed to categorize the data. Non-probability convenience sampling was used, since the website with the discussion forum was open to all and was conveniently accessible. A theoretical framework was developed, and the discussion forum was monitored over two timeframes. There were 28,803 registered users that were monitored during the first timeframe and 40,803 users monitored during the second timeframe. The content was evaluated by counting the number of links, monitoring the content and messages, counting the number of replies, and monitoring feedback. The content, communication, and consumer criteria were allocated an equal weight and scored based on the content of the discussion forum. It was discovered that within an online discussion forum, knowledge creation and sharing is best supported when it is being managed by an expert within the organization and the discussion forum has expert intervention.

Sayogo and Gil-Garcia (2014) addressed the difficulty of instituting inter-organizational collaboration and information sharing by conducting a quantitative study to explore and test previously identified success factors. Prior research used case-based methodology to identify enablers and success factors for inter-organizational information sharing. Existing studies were used to determine the factors that have been previously

identified as influencing the success of inter-organizational information sharing: political and policy determinants, organizational and managerial determinants, political and organizational determinants, and technological determinants. These previous factors were used to develop the hypotheses for the study. A national survey was conducted to collect data and address questions pertaining to factors that contribute to the success of inter-organizational information sharing. A random-sampled dataset included 173 responses, but after data cleansing, the dataset was reduced to 158 responses. Cronbach Alpha was used to measure the reliability of the framework, and a seven point scale was used to collect data. The hypotheses were tested using multivariate regression analysis. Five statistical models were tested to identify the four factors that were key determinants. The study concluded that the four key factors of inter-organizational knowledge factors pertained to project managers, financial resources, interoperable standards, and compatible technical infrastructure.

Rejeb-Khachlounf et al. (2011) performed a study to prove the importance of networks on knowledge transfer. Networks are instrumental for knowledge, information, social influence and personal support. Rejeb-Khachlounf et al. identified that the effects of social networks on knowledge transfer was an area that needed to be examined. This prompted a study to determine what mechanisms within a personal network influence knowledge transfer within a network. Rejeb-Khachlounf et al. study concluded that absorptive capacity was the primary mechanism in which personal networks influence inter-firm knowledge transfer. Network size is the number of people in which an individual maintains a direct relation. An increased number of contacts in a personal network increases the possibility of receiving diversified knowledge. Network density is

the number of current contacts between network members divided by the number of possible mutual contacts. Dense networks contribute to faster diffusion of information between members of the network (Rejeb-Khachlouf et al., 2011).

Wang et al. (2015) recently conducted a study to investigate the effects of intrinsic and external motivation on knowledge contribution. While acknowledging theories that suggest social factors can only encourage knowledge contribution through motivation rather than directly cause knowledge contribution, they discovered a need to examine the effects of motivation on specific types of knowledge contribution tasks. A theoretical model was developed, and the study concluded that intrinsic motivation is positively associated with knowledge contribution that is more difficult in nature, such as unstructured content.

Bharati et al. (2015) studied the impact of social media on organizational knowledge quality based on social capital and resource exchange. Prior to this study, research was lacking on social media's contribution to enhancing organizational knowledge.

Technology systems are being used within organizations to facilitate knowledge transfer, and this study hypothesized that a higher level of organizational social media assimilation is associated with a higher level of organizational emphasis on knowledge management.

The research tested a theoretically derived model against real world data by conducting a web based survey on employees that were familiar with utilizing social media technologies for supporting knowledge management within a single company that used social media technologies such as web services, blogs, LinkedIn and Facebook. The sample was generated by screening 725 individuals according to those that proved most representative of the organization, which narrowed the participants to 283 information

systems professionals and managers. The survey instrument was a seven point Likert scale developed from previous literature. The research used formative constructs and a previous approach of measuring structural capital with the Guttman scale based on quality and time spent communicating. The study refocused and extended the Tsai and Ghoshal framework to include knowledge management, knowledge quality and social media. The model was evaluated using partial least squares, which was appropriate for exploratory research since this was a phenomenological study. Reliability was measured using Cronbach's alpha and determined that the instrument would provide an acceptable measurement for the study. The model allowed for 38% of the variance in organizational emphasis on knowledge management. The authors argued that social media positively affects social capital and organizational knowledge management, which extends the quality of organizational knowledge. The hypothesis was supported, and there was a significant and positive impact on the organizational emphasis of knowledge management on knowledge quality ($B=0.74$, $p<0.001$) and a positive and significant relationship between organizational social media assimilation and organizational emphasis on knowledge management ($B=0.12$, $p<0.01$). The study concluded that social media does promote organizational efforts in knowledge management and leads to higher levels of organizational knowledge quality, and there is a significant relationship between an organization's emphasis on knowledge and knowledge quality. The study proved that social media usage can facilitate organizational knowledge management efforts by showing a positive link from organizational social media assimilation to organizational emphasis on knowledge management. It showed that social media usage facilitates social interactions, which promotes increased communication between the organization and

produces higher levels of social capital. The study was limited by quantitative data collected based on individual perceptions gathered during a survey.

Relationships are an influencing factor of knowledge sharing. The similarities between a public social and a collaborative network can allow for research concerning knowledge sharing to be applied to both networks. Research regarding relationships within a social network can be utilized to understand the similarities of knowledge sharing within an organizational network. Since tie strength is a relationship factor, it can be used to understand the knowledge sharing process within a network. The proxies used to determine tie strength within a social network can be measured within an organizational network.

Collaborative Networks

Collaborative networks can be on the web or within the private sector, but because they are included in organizational networks, they are subject to organizational constraints. There are drastic differences in how knowledge flows in a collaborative network as opposed to a public social network due to the random factors involved in human decision making (Maio et al., 2012). Public social networks focus on social interactions and social information exchange, and information is first derived at a particular source and then spread by members of the network forwarding activities (Maio et al., 2012). Maio et al. concluded that in a public social network, the information begins to lose its value at the same time as the forwarding activities begin to diminish. In contrast, information flow in a collaborative network is driven by specific tasks and the

expertise of the members assigned to the network as tasks in collaborative networks travel along long sequences of steps before being completed (Maio et al., 2012).

While the use of collaboration tools within an organization could provide many benefits, Dulipovici and Vieru, (2015) identified that misconceptions about benefits of these tools are keeping organizations from implementing them. Statistically measuring the motivators can facilitate an understanding of the benefits of utilizing collaboration tools within an organization.

Durugbo (2014) performed a comparative case study on six industrial firms to investigate the flow of information within a collaborative networked organization. The study was conducted through semi structured interviews based on interpretivism epistemology to capture information about knowledge flow and people's willingness to share knowledge. The interviews were conducted during a six-month period, and the notes were analyzed, categorized, and coded based on grounded theory procedures. It was concluded that the flow of information could be enhanced within an industrial firm when procedures and policies are prioritized. Collaborative networks are enhanced with the information flowing through industrial firms. Information is built from relationships which allow firms to collaborate.

Miao et al. (2012) performed grounded theory research to develop a network model and a routing model based on real world collaborative networks from Information Technology communities within the public and private industries. These models simulated collaborative networks with specific structural constraints and analyzed how information flows through a collaborative network. While many models existed for social networks, there was a need to develop models specifically for task related

information flow within a collaborative network. Since collaborative networks are subject to organizational constraints, Maio et al.'s study involved the development of a routing model that emulates task driven information flow in order to determine how information can be routed efficiently for different types of collaborative networks. The researchers tested the power-law hypothesis on the degree of distributions of the collaborative network. A clustering coefficient was used to measure how closely the nodes were connected, and statistical calculations were performed on the node distributions to calculate various probabilities. Ten collaborative networks were generated with 10 to 100 domains, each routed the same set of 100,000 tasks. The node degree in the collaborative networks followed a truncated power-law distribution. It was concluded that members of collaborative networks make decisions based on factors such as availability of neighbors and priority of tasks.

Levy (2013) researched the utilization of social media within an organization to enable knowledge management. The research was conducted as an empirical study in which data were gathered from 34 organizations and analyzed both quantitatively and qualitatively. The study considered the various levels of social media implementation that are occurring within businesses by examining organizations of various sizes with various levels of knowledge management processes, including companies with formal process to those with no existing knowledge management processes. Implementing social media is a process that requires collaboration. The act of moving from traditional knowledge management concepts to social media is a large step, and therefore the researcher suggested a four stage implementation. The hypotheses which suggested that social media implementation conforms to formal knowledge management activities was

supported. Organizations that did not have a formal knowledge management process were not able to fully implement social media into the organization. It was found that social media complemented traditional knowledge management tools rather than replacing them. The research discovered that organizations implemented different levels or no social media, for visibility purposes only, for functional services, or a full implementation. This finding proved that social media can be implemented gradually within an organization, and the level of implementation can vary according to the purpose the organization is attempting to achieve. Organizations can utilize partial social media implementation, and therefore, do not need to wait for a full implementation to receive knowledge management benefits. The results suggested a four stage architecture for gradually implementing social media within an organization as part of the knowledge management framework in order to receive knowledge management benefits. Rather than previous studies that considered a yes or no approach to inserting social media within an organization, this study suggested that social media can be implemented at various levels and allow an organization to achieve various levels of benefits to their knowledge management process.

Sung, Na, Lee and Chang (2015) conducted structured research on performance analysis based upon ICT collaboration. A survey was used to collect data within the automobile industry that included one parent company and their partner companies. Survey instruments and models developed in previous research were used to conduct the study. Three survey items were used to measure the concept of corporate performance, which involved testing if competitiveness, satisfaction of trading and sales increased after collaboration. The analysis concluded that sharing range of collaborative information

was low before the introduction of an IT collaboration system. Overall performance improved 10.2% through the incorporation of the collaborative system.

Since it has been concluded that relationships play an important role in knowledge sharing, a social network can provide an avenue for monitoring the knowledge transfer process. An online social network platform, such as Facebook, provides an environment for digitally collecting information regarding social networks. Since there are vast differences between social networks and collaborative networks, the studies that examine knowledge sharing should be replicated within each type of network. The process of how research is conducted within a social public network can be applied to collaborative social networks that also utilize technology platforms for transferring information.

Knowledge Sharing Through Technological Modalities

Literature was reviewed regarding the various modalities of a collaborative system to determine how previous research has collected and analyzed data, both quantitatively and qualitatively, within a collaborative system. The current study used preferred modality as a moderating variable, and this literature review enabled an understanding of previous conclusions regarding the usage of the various modalities of a collaborative system. Studies were reviewed in which researchers evaluated the use of different modalities within organizational collaborative settings. Particularly, the collection of data within video conferencing can prove difficult to analyze, so understanding previous researchers' methods for collecting this modality was evaluated.

Biehl, Avrahami, and Dunnigan (2015) performed a lab study to compare the use of different video conferencing technology in a collaborative setting to address the lack of research on the impact of video technology on actual collaborative engagement. Usage of video tools can change collaborative behavior by allowing more interactions among distant workers. Previous studies concluded that embodied devices, such as video, lessens the known barriers that exist in distributed collaboration. The study consisted of groups of three people monitored while evaluating and interacting in a sales presentation. Two of the participants attended the presentation in person, and the third participant attended remotely using a video call. There were three different scenarios in which different types of video conferencing devices and positioning were used to determine which video conference technology was the most effective. The participants were recruited by various advertisements that offered an incentive for participation. A total of 27 participants were included in the study. Pre and post study questionnaires were given to the participants in which they answered questions regarding their familiarity with video tools and commented on the challenges of working as a group using mediated communication. The video was analyzed by recording the session and coding gestures and manipulations of devices and artifacts. The video and audio recordings were hand-coded. The researchers compared the behavior and attitude from the remote and face-to-face participants. The study concluded that remote participants' participation was significantly less than those attending face-to-face ($t(25)=2.184$; $p=0.039$). This was consistent with the information collected from the questionnaires in which remote participants rated their contribution lower than those that attended in person. Despite the different video technology that was used that offered advantages such as adjustment of camera point of view, the remote

participants contributed less and rated their experience less than those participants who attended face-to-face.

Scholl and McCarthy (2006) performed a case study to compare the modalities of chatting, video and audio. Data were collected regarding the usage patterns of each of the modalities to determine if chat was an effective communication tool even when media-rich modalities such as audio and video were readily available. Two separate case studies, one in a research setting and one in an educational setting, were administered within communication groups in a University setting in which users had the modalities of video, audio, and chat readily available to them through conferencing technology. Qualitative data were gathered through interviews and observations over a period of six months. In order to monitor private video conversations that are not visible to a third party not involved in the video conference, the researcher performed “spot checks” that involved spontaneously entering the conference, and the interactions were taped and recorded. Quantitative data were gathered from the database that contained the system usage information. A total of 66 users, who were unaware that the study regarding usage was being conducted, were observed in the study. Personal information about the users were gathered from an e-mail survey. It was concluded that chat supplemented with video provided advantages among internal communication. The subjects reported that audio was preferred for formal meetings, but not when participants were in close physical proximity and could be more easily contacted in person. Users reported the advantage of using the chat feature was because it provided tractability of the discussion. Users also felt that chat was less intrusive than the modalities of audio and video, therefore less disturbing. The main usage reported for chat was for informal communication. Video

and audio were typically initiated by a request within the chat function. Quantitative data of the usage logs complimented the qualitative data collected during the interviews. Data revealed that the preference for chat usage was significant ($Z=-3.95$, $P<0001$). Of the 67 chat messages sent in one day, the top 10 users accounted for 60 of the messages, and a single active user accounted for 21 messages. Previous studies have indicated that workplace chat usage is typically below one message per active user per day. The second case study was conducted in which students were enrolled in a course and the collaboration tool was an option for receiving remote assistance on assignments rather than physically interacting with instructors to ask questions. The usage of the online system was not mandatory but was encouraged. Instructors reported the benefit of using the remote tool was that it allowed them to be more productive by continuing to work on other tasks and only interact with students when requested. The students were asked to complete a questionnaire that used a 7 point Likert scale to rate their experience with the various modalities of the communication tool. The study concluded that there was not a significant bias for chat when asked to choose between audio and chat ($\chi^2(1)=3.2$, $p=0.7$). The users however did rate chat more useful than audio in both public and private communications ($F(1,79)=48$, $p<0.001$).

Tie Strength

Granovetter (1973) was the originator of the tie strength theory, which included four dimensions to define the strength of two people's relationship. Tie strength is defined by Granovetter as "a combination of the amount of time, emotional intensity, intimacy, and

reciprocal services devoted to a relationship” (p. 1361). Tie strength is a relationship factor that has been used to measure social influence within a network (Aral & Walker, 2014; Bakshy et al., 2012). Tie strength characterizes the closeness and interaction frequency of a relationship between two people (Granovetter, 1973). It has often been assumed that relationships within a network are equal, but that fails to consider that people maintain relationships with varying tie strength (Chui et al., 2014). The role of ties within a network varies depending on the network’s strength, and different tie strengths affect the social structure differently (Chui et al., 2014). Individuals with strong ties have greater similarities and share more intimate information, so treating all relationships as equal degrades predictive modeling (Luarn & Chui, 2015). Verifying the frequency and duration of interactions allows a better method of determining tie strength (Luarn & Chiu, 2015).

Strong ties are present among relatives, friends, and individuals that are familiar with and understand each other well (Granovetter, 1973). People with strong ties have similar knowledge structures, values, and experiences (Granovetter, 1973). Weak ties are constructed of individuals that have little in common and maintain geographical or sociocultural distance, which causes lessened shared understanding (Granovetter, 1973). Hansen (1999) explained that strong ties ensure the transfer of complex knowledge, and weak ties can support simple knowledge transfer.

Zhou et al. (2010) performed causal modeling research using structural equation modeling to investigate the role of social ties in the interpersonal knowledge transfer process by distinguishing between instrumental and expressive ties and their effects on knowledge transfer. Zhou et al. discovered the importance of utilizing appropriate ties

when planning knowledge sharing communities, because a trusted environment promotes knowledge sharing. The researchers used Cumming's (2004) scale to measure general and explicit knowledge transfer, and tacit knowledge was measured using a scale adopted from Lin (2007). A total of 450 responses from a survey questionnaire were collected. The researchers created a research model with seven constructs that could each be measured with multiple items that were adapted from literature, and structural equation modeling (SEM) was used to examine the research model. The results demonstrated that participation has a significant effect on subjective norm as seen by $\gamma=0.81$, $p<0.001$, and subjective norm was shown to have an effect on behavioral intention. However, when both social identity and group norm exist in the model, the effects on behavior intention to share knowledge are not significant.

Luarn and Chiu (2015) performed a correlation study to develop a predictive model to quantitatively measure tie strength within social network sites by examining user profile similarities and user interactions of passing data on Facebook as well as user responses to an online questionnaire. The study was conducted in a controlled lab environment on 145 undergraduates that were recruited specifically for the study. The participants were asked to answer questions regarding their friends through questionnaires developed according to theories from Granovetter (1973) and Marsden and Campbell (1984). There was a program developed to collect the interactions from Facebook, but certain data had to be eliminated due to privacy concerns. Subjective tie strength was measured from the online questionnaire while objective tie strength was perceived from the dataset that included the participant's interaction records to determine the strength of the friendships within Facebook. Previous studies focused specifically on relationships and did not consider

interactions when measuring tie strength. A dataset of 6,477 ties was evaluated. The model was able to distinguish between strong and weak ties with over 50% accuracy. The findings concluded that friends that had higher levels of intimacy, as measured by the number of private messages sent to each other, were considered to have stronger ties. When the level of intimacy is high, users tend to choose a communication method other than private messages. There was a negative correlation in the amount of time, which is the frequency and duration of contact, and job regression, which indicated that amount of time is not a main variable to predict tie strength on a social media site. Emotional intensity had the strongest effect of any of the interaction variables. Emotional intensity best reflects tie strength. Emotional intensity variables had stronger effects than other interaction variables. The measurements of tie strength that were developed based on offline relationships cannot fully explain online relationships.

Kim, Lee, and Elias (2015) conducted a study to identify the personal and environmental factors, including tie strength, that affect information sharing within social networking sites. The goal of the study was to improve understanding of information sharing behaviors and the characteristics of information shared within social networking sites. The researchers hypothesized that perceived technology and information self-efficacy and social outcome expectation are positively associated with information sharing behaviors on social networking sites. An online survey was conducted on university students within a single class at a public university to produce a homogeneous sample that would reduce the likelihood of extraneous variables, such as age, education, and income. The study included 308 participants with an average age of 19.5 years and various ethnicities. The students participated in the study in exchange for extra credit.

Data concerning information sharing and social ties were collected by asking participants questions about frequency of behavior and measured using a seven-point Likert scale adopted from Kankanhalli et al. (2005). The reliability of the scale was tested using Cronbach's Alpha. Hierarchical regression was utilized to test the hypothesis while controlling the factors regarding the use of the social networking systems. The survey was used to question the participants about the frequency of their information sharing behaviors and measured several independent variables, such as perceptions of technology and information self-efficacy, positive social outcome expectations, and sharing enjoyment. It was determined that technology self-efficacy did not significantly influence information sharing behaviors on social networking sites ($B=-0.075$, $p>0.05$), but there was a positive influence of information self-efficacy on information sharing behaviors ($B=0.166$, $p<0.05$). Personal factors were found to be significant predictors of sharing activities, but the size of a social network is not significantly related to information sharing behaviors ($B=-0.08$, $p>0.05$). The study concluded that there are environmental factors of the social networking sites, such as the size of the network and strength of ties that affect information sharing. Social network users that are more confident in giving their opinions are more likely to share information on social networking sites, which explains that users need to feel knowledgeable and competent about a specific piece of information are more willing to share this data. Information sharing can be increased by stimulating discussions and writing about a topic using a social networking site. People with strong ties are most likely to share the same information, so weak ties in networks provide the opportunity to share novel information. The conclusions support

Granovetter's argument that weak ties are better suited for disseminating new information or ideas compared to stronger ties.

Tie Strength and Information Diffusion

Bakshy et al. (2012) utilized an experimental method to explore social media's role in information diffusion by investigating the use of a social digital collaboration tool and the influence of strong and weak ties. Using Facebook as a platform, the researchers randomized whether participants were shown information about their friends' sharing behavior and measured how this tie strength influenced their likelihood of sharing a Uniform Resource Locator (URL) with others. They discovered that subjects who receive signals about friends' sharing behaviors have a higher probability of sharing information than those that are not exposed to this information.

Similar to Bakshy et al. (2012), Aral and Walker (2014) conducted an experiment by randomizing data within a networked environment and performing statistical analysis. Over a period of 44 days, 7,730 Facebook users were selected as subjects. Throughout the duration of this study, a total of 41,686 randomized automated messages regarding film industry preferences were delivered to 1.3 million peers of 7,730 Facebook users. Making use of automated notifications, the researchers randomly delivered information to random peers concerning the senders' personal attributes and use of the application. In order to make tie strength more measurable than previous studies, this research controlled the channel of influence by using randomized recipient selection and by including the same content within each message. The tie strength measures collected were age, gender, relationship status, home town, current town, college attendance, affiliations, Facebook pages, Facebook group membership, and tagged appearance in photos.

The researchers utilized the Cox proportional hazard model to determine the impact of social embeddedness and multiple measures of tie strength on product adoption. The Cox proportional hazard modeling estimates the hazards of peer adoption. Multiple coefficients were included to capture and measure the impact of influence of variables, including tendency of peers to adopt a product. The results were 967 peer adoptions and a 13% increase in product adoption. The study concluded that people are more influenced by peers with whom they are embedded. The individual effects of each measure of tie strength upon influence was identified. Some statistically significant findings included were that attending the same college results in a 1355% increase in influence, and living in the same current town results in 622% more influence.

Tie Strength Measurements

Research concerning tie strength continues to use the original dimensions proposed by Granovetter (1973), which consist of four dimensions to define the strength of two people's relationship: amount of time, intimacy, emotional intensity, and reciprocal services. While Granovetter proposed the seminal theory defining tie strength that has been used for decades, he indicated in his study that the empirical measurement methods for measuring tie strength were to be determined by future studies. Researchers have interpreted these dimensions throughout the years and have developed various models to measure tie strength. Adali et al. (2012), Chiu, Chen, Joung, and Chen (2014), Gilbert and Karaholios (2009), Gupte and Eliassi-Rad (2012), He, Zhang, and Ji (2012), Luarn and Chui (2013), Marsden and Campbell (1984), Petroczi et al. (2007), and Steffes and Burgee (2009) have conducted studies that adopt the criteria of Granovetter (1973) to construct models for measuring the various dimension of tie strength. Granovetter's

work has been adapted, and current literature now includes a total of seven dimensions for examining tie strength: duration and frequency of contact, intimacy, intensity, emotional support, reciprocal services, structural variables, and social distance (Gilbert, 2012).

Each dimension can be evaluated and used to calculate the total strength of a tie. Duration and frequency of contact measures the amount of time spent within a tie (Granovetter, 1973). Intimacy refers to the affection felt between two entities which creates reliance and security and is believed to promote willingness to talk openly and provide recognition and support (Mardsen & Campbell, 1984). Emotional support is defined as willingness to convey messages of emotional concern such as understanding, caring and empathy (Gilbert, 2012). Reciprocal services refer to the different interactions or specific services on communication such as sharing information, providing resources or giving access to information circulating within a network (Krackhardt, 1992). Structural variables include shared affiliation, overlap of social circles and social homogeneity (Luarn & Chui, 2015). Social distance is the difference in socioeconomic status, such as education level, political affiliation, race and gender (Mardsen & Campbell, 1984). Social similarity in terms of background characteristics such as race, sex and level of education is an indicator of common knowledge (Reagans & McEvily, 2003). Common knowledge has a positive effect on knowledge transfer, because it is easier for a person to gain knowledge in areas in which they are familiar.

While the original measurement models assumed physical interaction as the definition stated, the new models for measuring public social networks consider social media sites and assume that interaction takes place online (Aral & Walker, 2014; Bakshy

et al., 2012; Gupte & Eliassi-Rad, 2012; He et al., 2012). As such, these models have focused on measuring tie strength through characteristics that can be captured through social media platforms. Although studies do not exist that provide a model for measuring tie strength in a collaborative network, measurements of tie strength within a public network will be analyzed to determine how the models can be applied to a collaborative network.

Chui et al. (2014) performed a correlation study to develop a model for quantitatively measuring the role of tie strength within an online social network by using a crawling agent to digitally collect data within an online blog. Data were collected from an online blog for seven months to monitor 80,617 blogs. An online blog network was chosen because it is interactive and allows participants to leave comments or make recommendations. Relationships were established between participants by investigating interactions and common interests within the social network. Information about interactions within the blog were collected online for analysis. Tie strength was quantified as the frequency of interactions between two actors, which was the number of comments a user posted for another user. The “friends” list within the blog was also considered, and if one actor considered another a “friend” it was categorized as a friendship relationship. The study determined that the structural properties of a social network are exhibited in an online network, and tie strength may be the cause of certain network behavior. Within an online social network, there is a strong association between tie strength and reciprocity and tie strength and transitivity.

Since tie strength identifies the level of intensity of a social relationship, it has been widely used to examine the effects of social influences on knowledge transfer. Rejeb-

Khachlouf et al. (2011) argued that more investigation was needed about how social interactions affected knowledge transfer between people. Houghton and Joinson (2010) determined that tie strength affects the nature and frequency of online interactions. Zhou et al. (2010) explored the role of social tie content in the knowledge transfer process and determined that knowledge transfer among co-workers can be enhanced by strengthening social ties. Levin and Cross (2004) studied whether strong or weak ties provide more useful knowledge and validated the importance of relational ties for knowledge transfer.

Summary

Knowledge provides economic value to an organization. Companies are investing in methods for transferring information between members of their organizational network in order to retain knowledge and increase their competitive advantage. Previous literature provided an increased understanding about the factors that contribute to knowledge sharing within an organization. Casmir et al. (2012) concluded that a collaborative culture within an organization promotes knowledge sharing. Mura (2013) determined that trust within an organization produces an environment in which knowledge sharing is conducive. These findings support the idea that knowledge sharing is a social process that requires social interactions between knowledge contributors and receivers. The literature validates the relevance of further observation of social factors that contribute to knowledge sharing in an organizational environment.

Reviewing literature regarding relationship factors within an organization provided an understanding of how to produce a more collaborative environment in which knowledge sharing can be increased. Lin and Lo (2015) validated that knowledge sharing is a social

process that is affected by social motivational factors. Tie strength is a relationship factor that has been studied within public social networks to understand the role of information diffusion within a network. Luarn and Chiu (2015) developed a predictive model for measuring tie strength within social networking sites. Bakshy et al. (2012) determined that stronger ties within a social networking environment increase the probability of information sharing. Studying how an organization can promote relationships increased an understanding of the knowledge sharing process.

A collaborative network is a type of social network, which prompted the review of studies performed on social media systems within organization to understand a system's impact on knowledge transfer within organizations. Public social networks and collaborative social networks differ in structure and the manner in which information flows within each network. Saito, Kimura, and Motoda (2013) produced a model that can be used to determine how social networks are affecting information diffusion. Rejeb-Khachlouf et al. (2011) concluded that dense networks contribute to faster diffusion of information. Durugbo (2014) concluded that within collaborative networks, information is built from relationships that allow firms to collaborate. Chui et al. (2014) validated that structural properties of a social network are exhibited in an online network and that tie strength is an influencing factor of certain network behavior. Barker (2015) performed a study concerning management of knowledge creation and sharing within a virtual community and concluded that knowledge intervention by an expert within the organization is necessary to ensure new knowledge is created and continuously shared within an online social network's discussion forum.

The studies conducted on tie strength and information diffusion within a public social network can be applied to a collaborative social network, since both networks utilize digital communication systems. Social networking technologies facilitate knowledge management, so studies were evaluated to understand what contributes to the use of social networking sites. Kim, Lee, and Elias (2015) concluded that personal and environmental factors significantly predict information sharing behaviors on social networking sites. Levy (2013) researched the utilization of social media within organizations to enable knowledge management and determined that social media can be gradually implemented within an organization and still achieve gradual levels of benefits to the knowledge management process. Bharati et al. (2015) concluded that social media usage facilitates social interactions and promotes organizational efforts in knowledge management, leading to higher levels of organizational quality. The literature provided an understanding that a collaborative environment increases knowledge sharing, and this motivated the need to recognize methods to facilitate collaboration within an organization to increase knowledge sharing.

Chapter 3

Methodology

Effective knowledge management increases an organization's competitive advantage, but it remains a challenge to facilitate knowledge transfer within an organization. This study leveraged existing research that investigated the impact of relationships on information dissemination within an organization in order to determine if the dimensions of tie strength had an effect on information dissemination among corporate users of social media technology. Quantitative data were collected, and hypothesis testing was performed to determine if tie strength was a factor that enhanced information dissemination among employees.

The hypotheses were first tested using SEM to determine if it could be utilized to measure the influence of each tie strength indicator on information dissemination. A model was generated following seminal work of Muthen (1984). Confirmatory Factor Analysis (CFA) was conducted to establish the reliability of the model and specify which variables loaded onto which factors (Bowen & Guo, 2011). A variety of fit indices were evaluated to determine the fit of SEM (Hooper, Coughlan, & Mullen, 2008; Yuan, 2005). Absolute Fit indices were used to calculate how well the *a priori* model fit the sample data (Joreskog, 1993). Chi-Square was used to measure the discrepancy between the sample and fitted covariance matrices (Hu & Bentler, 1999). Based on Exploratory Factor Analysis, the observed factors with low factor loadings were removed, and a series of iterations were performed on the model by deleting factors and retesting the model to

increase the overall fit. The indicator variables loaded significantly on the latent factor, but several of the fit indices did not indicate that the model fit was established. CFA tests revealed that the model fit was not appropriate, and SEM was not a viable solution for testing the hypothesis. The CFA results of the adjusted model can be found in Chapter 4. MANOVA was then utilized to test the hypotheses.

Research Questions and Hypothesis

Hypothesis One

Employees within the same professional occupational group can be considered members of a community of practice, which are informal groups with shared expertise. Members of communities of practice often have shared memory and knowledge, which allows information to be openly diffused within their community (Del Guidice, Peruta & Maggioni, 2015). As such, it was hypothesized that members with the same job classification would have significantly stronger tie strength, which would increase the likelihood of information dissemination within their group. Employees that have social commonalities may also be more inclined to communicate. Tie strength is a latent variable comprised of intimacy, structural variables and social distance. H1 was generated to determine tie strength's impact on information dissemination and address the research question, "How does tie strength influence the effects of information dissemination within a collaborative social network?" The stronger the tie strength, the more information will be disseminated using the multiple modalities of the ICT tool. This hypothesis determines the impact that tie strength has on information dissemination within a collaborative network. It was hypothesized that the stronger the tie strength, the

greater the amount of information that would be diffused. Therefore, H1 was defined as follows:

H1: Relationships that exhibit higher levels of tie strength will disseminate significantly higher levels of information via instant messaging, chat room and video/conferencing modalities of a collaboration system.

Hypothesis Two

This study also sought to determine if the type of communication modality chosen moderated the relationship between tie strength and information dissemination. The modalities of instant messaging, chat rooms, and video/screen sharing conferencing were evaluated to determine their usage in the dissemination of information concerning information relevant to training. Ou, Davison, and Wong (2016) conducted a study that focused on knowledge sharing that was mediated by an interactive system such as instant messaging and found that these systems facilitate direct and dynamic conversations among participants.

H2 was developed to answer the research question, “How is the relationship between tie strength and information dissemination affected by the type of medium being used within the collaborative network?” The instant message feature is a one-to-one relationship where each message posted is received by a single recipient. The chat rooms are a persistent and asynchronous communication in which the items/entries in the chat room are a contribution from one person to multiple people at the same time. In a chat room, a message posted by one person has multiple recipients, which classified this as a one-to-many relationship. The video/conferencing feature also has the one-to-many

relationship effect, as information that is shared by one person on a video/conference can be heard and viewed by multiple people using the modality.

The stronger the tie strength, the more likely an intimate or person-to-person communication would occur between connections. Instant messaging is the only communication modality that supports one-on-one communication between connections and constitutes a one-to-one relationship. Consequently, instant messaging offers the most intimate level of communication of the three ICT modalities measured in this study. Therefore, it was hypothesized:

H2: Relationships that exhibit higher levels of tie strength will disseminate significantly higher levels of information via the instant messaging modality of a collaboration system.

Environment

Previous studies have utilized observational methods to collect data regarding intention to use or best recollection of use, but as Bakshy et al. (2012) identified, using purely observational methods imposes difficulty in determining correlation between subjects, because subjects have already been influenced by one another. With an increase in the use of digital social interaction, there are now tools available to capture analytic data to statistically identify how social ties influence information dissemination. Since the research of Daft and Lengel (1986), which identified that rich media could be used to facilitate knowledge transfer, researchers have shown that technology can facilitate the knowledge sharing process by disseminating information within an organization (Albino et al., 2004; Gressgard, 2011; Gressgard, 2014; Hedgebeth, 2007;

Panahi, Watson, & Partridge, 2013; Roberts, 2000). The current study was performed by digitally collecting data from subjects in their natural environment without interaction from the researcher. Data regarding information dissemination within a collaborative network were collected digitally from a single company by tracking the use of a collaborative system. Similar to Aral and Walker (2014), this study utilized a large scale communication system to digitally collect data and employ statistical methods to investigate the effect of tie strength. Previous studies have explored information sharing using digital communication tools, but they did not utilize a collaborative network within a business setting.

To extend the work of Bakshy et al. (2012) who researched the effects of social characteristics on information diffusion, this study monitored a collaborative network within an organizational environment rather than a social communication network. Lync is an online collaboration technology that contains multiple modalities with various levels of richness, including instant messaging, groupware, video conferencing, screen sharing, audio conferencing, chat rooms, and file transfer. Lync was utilized as the platform for collecting data regarding content sharing. Data were collected from a single, live business environment within the United States that has been using Lync as an online collaborative network within their organization for at least 12 months. The use of the collaboration tool was monitored by gathering data from system usage and communication logs to determine the effects of tie strength on the information that was diffused through the system.

Within this research environment, Lync was made available to employees that were distributed across the organization and had various roles, responsibilities, and

relationships throughout the company's multiple business divisions. The use of Lync for company communication was voluntary. To ensure that greater potential of the software being utilized, the company that was monitored was making use of the instant messaging, chat room, video conferencing and screen sharing modalities of Lync, as well as Lync integration capabilities, such as integration with SharePoint, OneNote and Outlook.

Within the company that was monitored, Lync was being used to supplement training. Subject matter experts within the company were sharing their knowledge through training sessions. Participants attended the training in-person or through the Lync video/conferencing feature. The training was supplemented through the use of Lync chat rooms that were created by meaningful users to continue discussions related to the training subject matter. The chat rooms allowed the participants to stay connected and continue exchanging information relevant to the subject matter discussed during the training.

The Lync chat rooms had the capability of being integrated with Microsoft SharePoint to allow for added collaboration opportunities, such as document storage, discussion boards, and surveys. Each chat room had the capability of being integrated to a private SharePoint site that could only be viewed by Lync users and accessed through the chat room in which they were associated. The information that was shared within the chat rooms was monitored for information sharing.

Sample

For the purpose of this study, a relationship was defined as the connection between two Lync users. Each person in a chat room had a potential relationship with every other person within their chat room, and each of these relationships was considered a

connection that was used as the unit of analysis for the study. Participants were selected from a population of employees that utilized Lync within an organization.

Chat rooms that were created to supplement training topics and were in existence for at least one month were monitored for the purposes of this study. The chat rooms that were selected shared information about various training topics and had at least 10 members dispersed geographically throughout the company. The chat rooms monitored during the study were making use of multiple modalities of the Lync system. Subject matter experts of the training subjects were included in each chat room in accordance with the research of Barker (2015) that determined knowledge sharing is best supported within an online environment when there is intervention by an expert.

For the instant messaging modality, Lync communication logs were monitored to determine how the collaboration tool was used to disseminate information related to specific training topics. Any information related to the training subject areas that was passed between Lync users through the collaboration tool was tracked by contextual analysis of messages sent within the system. The data were quantified to determine how information was disseminated using the collaboration tool. The goal of the study was to determine if tie strength influenced information dissemination, as measured by monitoring the information sent via the collaboration tool that supports knowledge transfer within an organization.

Determining Participants and Connections

Once the chat rooms were selected for the study, the researcher examined the chat room administrative settings to aggregate a list of members of the chat room. All of the users that were members of the selected chat rooms were considered to have a connection

with all other members of the chat room. The relationship between each of the participants is illustrated in Figure 1:

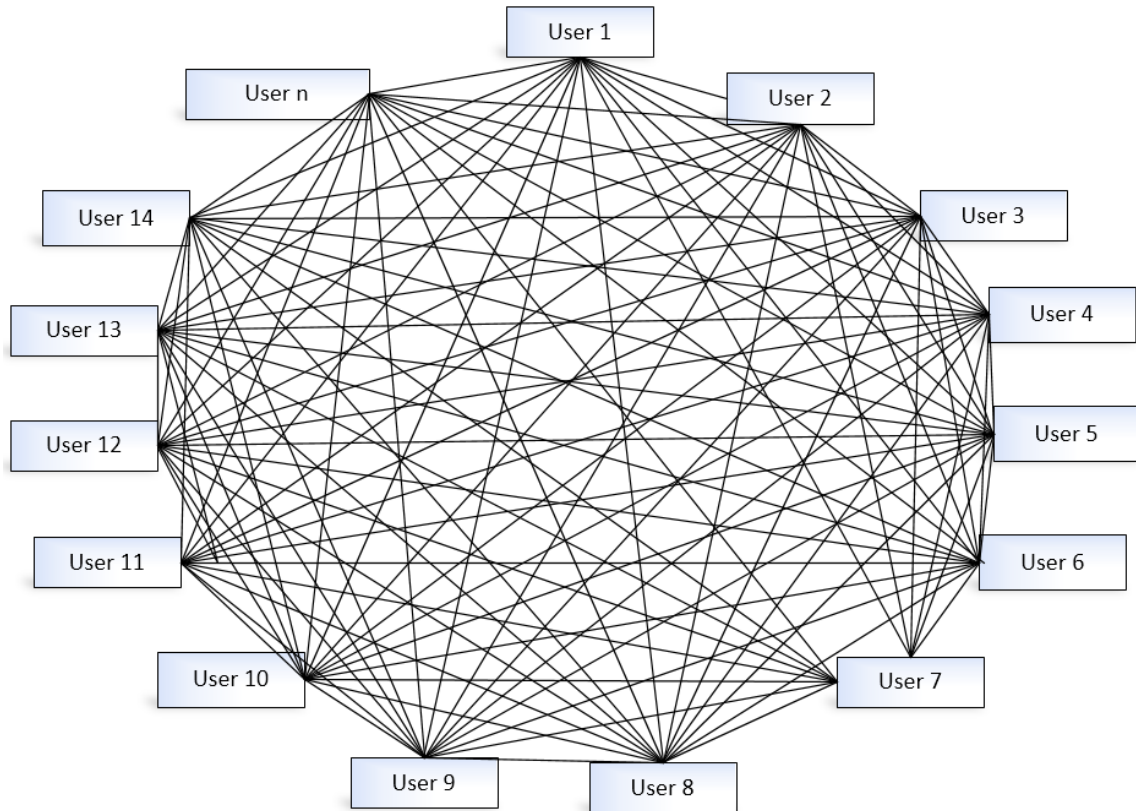


Figure 1: Relationship Model

Participants who did not send any instant messages related to the training subject matter, did not attend any video conferences, and did not post any messages within the chat room were removed from the study. It was assumed that these participants chose not to utilize the Lync system or may have had technical difficulties that prevented them from making use of the collaboration technology. The relationships between these individuals and the remaining participants were not counted.

Using the historical features of the e-discovery tool and Lync system logs, the researcher was able to collect one year's worth of data from August 2015 to August 2016.

Data for all connections were gathered, which accounted for 1,749 connections.

Connections that were repeated in multiple chat rooms were only counted once. A total of 763 connections were removed for non-participation, which reduced data to a final sample size of 986 connections.

The Lync logs identified users by their email address, so the researcher anonymized the users by replacing their email address username with an alpha numeric code. Each connection was given an alpha numeric label such as “AA1 -> AB1,” and so forth. The first alpha of the username indicated the chat room, so that user data could be sorted by chat room if needed. The connections that existed within each chat room were evaluated separately, but the comprehensive data were collectively included into the study.

Variables

The independent variable was tie strength, which was measured by evaluating three tie strength proxies that have been identified within the literature (Gilbert, 2012; Luarn & Chui, 2013). Since tie strength is a quantifiable characteristic of a social network, the current study utilized this multidimensional construct to determine the influence of social relationships on information dissemination (Luarn & Chiu, 2015). The dependent variable was information dissemination, which was measured by tracking the amount of information transmitted via a collaboration tool within an organization. Information dissemination was divided into: information dissemination via instant messaging, information dissemination via chat room, and information dissemination via video/conferencing. Information dissemination was also an aggregated variable developed by adding instant messaging, chat room and video/conferencing. The

variables that were used within this study are summarized below in Table 1 and described in the following paragraphs:

Variable	Type
Total Tie Strength (Includes Intimacy, Social Distance and Structural proxies)	Independent Variable (Categorical)
Information Dissemination	Dependent Variable
Information Dissemination via Instant Messaging	Dependent Variable
Information Dissemination via Chat Rooms	Dependent Variable
Information Dissemination via Video/Conferencing	Dependent Variable
Modality of Communication	Moderating Variable

Table 1: Variables

Independent Variable

Ties capture the function of relationships based on statistical properties of communication patterns. Tie strength was used as a predictor of information dissemination. Tie strength consists of dimensions that will be used as latent variables. The dimensions of tie strength cannot be directly measured. However, each of the tie strength dimensions contain proxies that can be used as observed variables. These proxies are behaviors that can be observed and have been used in previous studies to measure tie strength. The tie strength dimensions that were used for this study were:

1. Intimacy
2. Structural Variables
3. Social Distance

The identification of the multiple dimensions of tie strength were based upon the work of Gilbert and Karaholios (2009) and Luarn and Chui (2013), who captured user information from social networks to quantify the strength of a tie within a social network. The proxies utilized were based upon characteristics that could be captured from a public social network rather than surveys, and these proxies best reflect the type of data that can

be captured from a collaborative network. The dimensions used to measure tie strength may vary according to what is being studied (Haythornthwaite, 1996). Combinations of the different tie strength proxies have been used as measurements and are selected according to what is most appropriate for the study being performed (Haythornthwaite, 1996). While tie strength is a multi-dimensional theoretical construct, Aral and Walker (2014) explained that most studies use frequency of contact to represent the strength of ties.

Original tie strength proxies only classified face-to-face communication, and recent research has evolved the proxies to accommodate purely online communication that takes place in a public social network. With the emergence of online social networks, recent literature has dissected Granovetter's (1973) theory to begin forming their own interpretations and developing models for measuring tie strength that fits the online social network environment. Krackhardt (1992) measured tie strength by using the dimensions of duration and frequency of contact and reciprocal services. He (2012) measured tie strength using the dimensions of emotional intensity and intimacy. Gilbert and Karaholios (2009) measured tie strength using the dimensions of structural variables and social distance. Gilbert and Karaholios developed models that were generated by the aspect of tie strength that was most measurable within an online environment. These new models allow measurement of tie strength through pure online interaction, rather than physical interaction that was originally theorized.

Three dimensions of the independent variable tie strength were used as predictor variables and measured to determine the strength of relationships: intimacy, structural variables, and social distance. The multiple dimensions of tie strength were developed

based upon previous studies that have measured multiple tie strength proxies. The work of recent researchers that measured tie strength within an online environment were used as a basis for defining proxies that should be used within a collaborative environment. The relationships between the participants were determined by cross-referencing the organization's human resource database and the communication logs within Lync. The current study also modeled the work of Wang et al. (2011) who cross-referenced information from an organization's database in order to identify employee personal characteristics.

Each of the tie strength proxies contained five categories that were determined by the number of indicators that existed within each proxy. The categories were represented by numbers (1-6). A category of '1' represented that zero indicators were present and a category of '6' represented that five indicators were present. The total tie strength for each connection was then developed by aggregating all three categories into one combined total. The indicators that were used to determine the categories are listed below in Table 2 and described within the following sections:

Independent Variable Categories	Possible Categories (1-6)	Indicators Used to Determine Category
Tie Strength Intimacy Variable	1= No intimacy tie strength indicators are present 2= One intimacy tie strength indicator is present 3= Two intimacy tie strength indicators are present 4= Three intimacy tie strength indicators are present 5= Four intimacy tie strength indicators are present 6= Five intimacy tie strength indicators are present	(1) determining if two people live in the same zip code (2) determining if two people have exchanged a private Lync communication message (3) determining if two people have worked on the same project team (4) determining if two people are related (5) determining if two people are currently part of multiple Lync groups.

Independent Variable Categories	Possible Categories (1-6)	Indicators Used to Determine Category
Tie Strength Structural Variable	1= No structural tie strength indicators are present 2= One structural tie strength indicator is present 3= Two structural tie strength indicators are present 4= Three structural tie strength indicators are present 5= Four structural tie strength indicators are present 6= Five structural tie strength indicators are present	(1) determining if two people have the same job classification (2) determining if two people are members of the same department or division (3) determining if two people report to the same direct supervisor (4) determining if two people work in the same building (5) determining if two people are assigned to the same geographic location
Tie Strength Social Distance Variable	1= No social distance tie strength indicators are present 2= One social distance tie strength indicator is present 3= Two social distance tie strength indicators are present 4= Three social distance tie strength indicators are present 5= Four social distance tie strength indicators are present 6= Five social distance tie strength indicators are present	(1) determining if two people are the same gender (2) determining if two people are within the same age range (3) determining if two people have the same language status (4) determining if two people are the same ethnicity (5) determining if two people have the same occupational prestige

Table 2: Independent variable categories

Intimacy

Since social networking sites such as Facebook often include more intimate relationships than those occurring within a collaborative network within a work environment, the proxy of intimacy was modified to measure this proxy within a professional setting. Within Facebook, intimacy has often been identified by viewing user's relationship status and the number of friends that users have in common. Gilbert (2012) utilized proxies such as days since last communication and the number of intimacy words used within a conversation. Bakshy et al. (2012) identified the frequency of private online communications between users. For the purpose of this study, the data

from other company systems including the Human Resource system were cross-referenced to identify five factors that were used to form a value to categorize intimacy.

Intimacy was measured by shared relationships between two people. To evaluate the tie strength of intimacy, five factors were identified based on literature review of the definition of the intimacy proxy. The five elements for intimacy included: (1) determining if two people lived in the same zip code; (2) determining if two people exchanged a private Lync communication message (3) determining if two people worked on the same project team; (4) determining if two people were related; and (5) determining if two people were part of multiple Lync groups. Using the Human Resources system and Lync administrative logs, a database was created that listed the individual factors for each participant. The data were compared against each of the users within a relationship to determine the value that existed. Each relationship within the study was examined separately, and the researcher determined the number of intimacy factors that were present for each relationship to establish the category. For example, if no factors were present for a relationship, that relationship was assigned a category of 1, and if five of the factors were present for a relationship, that relationship was assigned an intimacy category of 6.

Structural Variables

Structural variables were identified in previous research by determining the number of mutual friends and relations between two individuals such as a classmate, friend or two people attending the same college (Gilbert, 2012). These data are more easily determined within a social network platform in which users identify this characteristic within their

profiles. For the current study, five factors were identified and used to categorize the structural variable category.

Structural variables were measured by identifying shared affiliation or networks between two people. To evaluate the structural variable, five factors were identified to categorize the tie strength relationship: (1) determining if two people had the same job classification; (2) determining if two people were members of the same department or division; (3) determining if two people reported to the same direct supervisor; (4) determining if two people worked in the same building; and (5) determining if two people were assigned to the same geographic location. The process of identifying the value that existed for the structural variable proxy was the same as the intimacy value.

Social Distance

Social distance had previously been measured by identifying commonalities in gender, age, hometown, degree of education, race, and language status. For the purpose of this study, information that was captured within employee's records and linked to the system profile was utilized for this measurement. Social distance has been measured by identifying commonalities in employee characteristics. Five factors of social distance were identified to categorize the relationship: (1) determining if two people were the same gender; (2) determining if two people were within the same age range (3) determining if two people had the same language status; (4) determining if two people were the same ethnicity; and (5) determining if two people had the same occupational prestige. The value of social distance tie strength was calculated the same as intimacy and structural.

Dependent Variables

Information dissemination was derived by counting the number of relevant communications recorded for each connection across all communication modes. The output variable of interest was information dissemination within an organization as measured by tracking content that was sent within the Lync system and determining how information related to the training topics was sent through the Lync system. Information dissemination, the dependent variable, was measured by quantifying the number of references made to information related to the training subjects via the Lync tool. The information was tracked by analyzing the Lync system logs and identifying relevant information passed. Three separate dependent variables were created by counting the amount of information that was diffused by each of the Lync modalities of instant messaging, chat rooms and video conferencing/presenting. The number of information dissemination communications counted through each of the modalities was measured.

Bakshy et al. (2012) and Steeg and Galstyan (2012) both measured tie strength's impact on information dissemination by tracking the transfer of data within a public social network, which was pioneer work, because information transfer was measured through digital data collection to quantify if information sharing was taking place rather than performing surveys and questionnaires. Wang et al., (2011) tracked the forwarding of an email to determine information diffusion. Wang's research cross-referenced a company's dataset that contained personal characteristics, such as job role, performance, and hierarchal data. It tracked the email to determine how information diffuses through a social network and utilized large-scale data collection to allow a better understanding of how information is spread.

Data Collection

IRB approval was submitted and reviewed under 45 CFR 46.101(b) Exempt Category 2. A signed consent form was provided by the company being observed that allowed the researcher to collect and utilize data for the study with the understanding that all data and analysis would be anonymized to protect the company, proprietary information, and the employees whose data were collected. IRB approval was obtained and is located in Appendix A.

Calculating Independent Variable

The tie strength relationship between each connection included in the study was evaluated. A category of 1-6 was assigned for each of the tie strength variables by determining the number of factors present for each relationship. Tie strength was first evaluated separately for each of the three proxies, then, a collective tie strength was computed by adding the values of the three proxies for each relationship.

Chat Room Data Collection

The researcher counted the number of times each participant posted a Lync message within the chat room that referred to subject matter discussed within the training and determined who received the message by monitoring the people involved in the chat room. It was assumed that all members of a chat room received and read each message posted, so people that were members of the chat room during the time the message was sent were considered a person that received the message. The chat room data could not be collected within the system logs, since it was considered a perpetual message, much like an online forum. To collect the data, the chat room was monitored by the researcher.

The chat rooms were configured to store all messages from conception of the chat room. The researcher copied and pasted the conversations into a document and created a log that reflected the Lync system logs.

Instant Messaging Data Collection

Instant messaging was captured within Lync system and conversation logs. The researcher used the system logs, e-discovery, and search tools to discover the number of times each participant sent an instant message that was relevant to the training topics. Manual contextual analysis was performed to determine if a conversation contained relevant information. If the conversation contained relevant information, then each relevant individual message within the conversation thread was counted along with responses, questions and confirmation responses. The logs and e-discovery tool indicated the participant that sent and received the message. Each instance of an applicable message was counted for each connection.

Video Conferencing Data Collection

Blau, Weiser, and Eshet-Alkalai (2016) conducted a study using an advanced videoconferencing platform that allowed participants to maintain spontaneous educational interactions and examine if knowledge acquisition is affected by the communication channel. The research of Taylor et al. (2016) that tested the effectiveness of video conferencing detailed a procedure that could be used to ensure if video conferencing was effective. To capture video conferencing information within the current study, attendance was captured within the system logs. The researcher counted the number of times that each connection attended a video conference together by reviewing the video logs that record the attendees of each video conference.

Calculating Dependent Variables

Communication occurring within any of the Lync modalities was used to measure the dependent variable, information dissemination. For each relationship within the chat room, the data gathered regarding use of the entire Lync system were used to count the number of times that each relationship made reference to information relevant to a training topic. Relevant messages sent within conversations were considered information dissemination. The data regarding usage were separated by modality to allow for an analysis of the preferred communication for each user.

The administrative logs of the Lync system were downloaded by the researcher. The administrative log recorded the response counts and timestamp information for each conversation that took place between users. The number of messages exchanged between two users was recorded. The type of modality used for communication was listed. The data were recorded into a spreadsheet for analysis. The researcher utilized formulas within the spreadsheet to create a database of only the communications that occurred among each of the connections that were included in the study.

In order to determine if information was disseminated during the instant message conversations, the messages between each of the relationships were evaluated to determine if the content exchanged was related to the training topics. For the instant messaging modality, the actual conversation logs existed within each participant's conversation history folder within Microsoft Outlook, since Outlook and Lync are integrated. To capture the actual text of each message exchanged between a relationship, an E-discovery tool was used to search the communications based on username, and the data were extracted into a file. The conversation logs were then transferred into a word

processor, so that the conversations could be manually analyzed. Each conversation extracted contained a thread of messages exchanged between two users. A list of key words was developed for each of the training subject matter. Manual contextual analysis was performed on each conversation to determine the relevant messages within each instant message conversation. Each message within a relationship that contained one of the relevant key words was counted as a relevant message in which information exchange occurred. Messages that included information, questions, or discussions about the key word were counted as a relevant message, along with confirmation responses by those participating in the conversation. Relevant messages were recorded into a document for storage. Since the messages recorded contained work related information, the messages were anonymized by coding any information that could reveal the identity of the participants or release proprietary information of the company. Words that were anonymized included work names, client names, company names, departments, and numbers. The number of messages that contained key words relevant to the training, separated by modality, was recorded for each relationship. The messages that did not relate to the training topic were eliminated and not included in the study.

The total number of messages, separated by modality, per relationship were captured within a database using the methods described above. For each relationship, the number of messages that were exchanged using each modality were counted. These numbers were used to determine the preferred mode of communication by analyzing the pattern of communication exhibited by each relationship.

Data Aggregation

After the proxies of tie strength were utilized to determine the tie strength for each connection, and use of the collaboration technology was used to measure information dissemination, the data were aggregated into one database. The raw data that were collected from the usage logs and filtered from textual analysis was aggregated into Microsoft Excel in which the rows represented relationships and the columns indicated the observable variable outcomes. The database indicated the tie strength category for each of the observed variables, the tie strength category for each of the three tie strength proxies, the total value of tie strength, and the number of messages that took place separated by modality for each relationship. The total number of messages exchanged for each user was determined by the sum of messages exchanged through each modality for each relationship. A column was created for each observable construct:

- Individual columns created for each of the factors of tie strength that contained values of 0 or 1
- Intimacy column contained a category of 1-6 for each relationship
- Structural column contained a category of 1-6 for each relationship
- Social column contained a category of 1-6 for each relationship
- Total Tie Strength column contained the sum total of all of the individual tie strength factors (contained a category of 1-16)
- Video column contained the number of video conversations for each relationship
- Instant Message column contained the number of relevant instant messages for each relationship

- Chat column contained the number of chat messages for each relationship

Data Analysis

The research was performed by following the processes of Aral and Walker (2014), Bakshy et al. (2012), and Steeg and Galstyan (2012) to identify how the variables of tie strength influence information dissemination within a social network. Aral and Walker (2014) utilized causal modeling, because it has the ability to determine the combined impact of the dimensions of tie strength on information dissemination. This study introduced a new dimension to Aral and Walker's (2014) and Bakshy et al. (2012) studies by employing hypothesis testing to determine the influence of social ties on information diffusion within an organization.

As Terrell (2012) explained, there are many statistical tests available, and the information known about the dependent and independent variable can assist the researcher in deciding which test is the most appropriate. Both SEM and MANOVA models were tested to determine their appropriateness for this study. It was determined that MANOVA testing was most appropriate for conducting the analysis. The process shown in Figure 2, which is described in the following sections, was used to test the model and hypotheses. The analysis was performed using SPSS (Statistical Package for the Social Sciences) and AMOS.

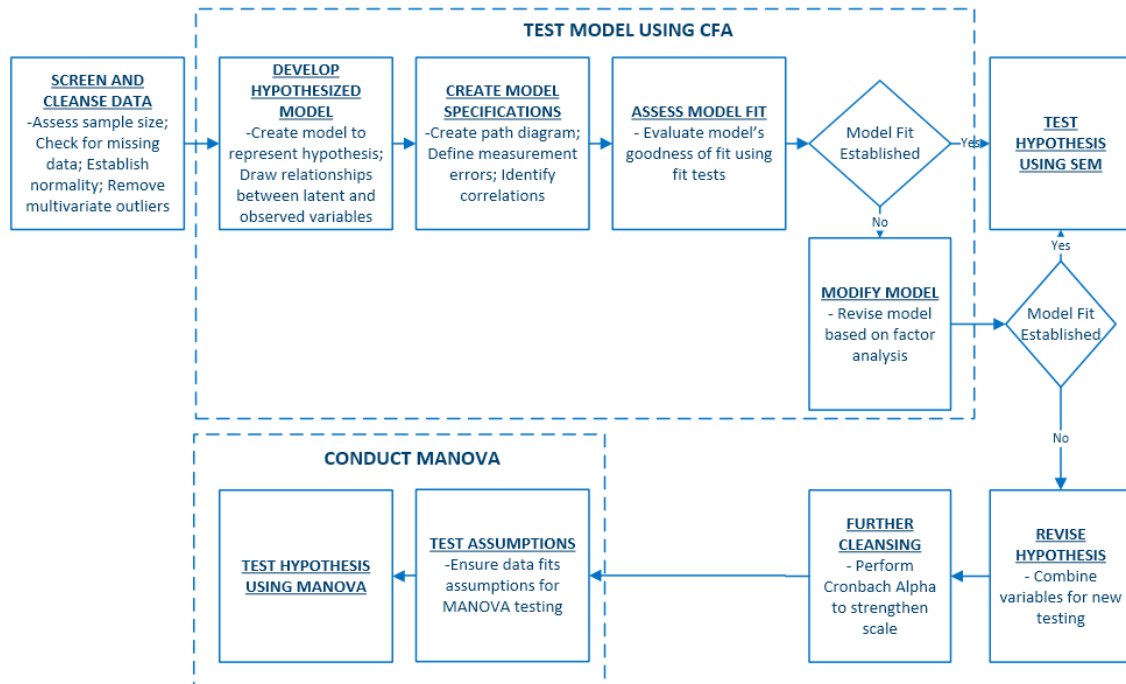


Figure 2: Methodology Outline

Data Screening and Cleansing

The aggregated data were imported into the statistical software, and screening was conducted to ensure the data were prepared for testing. It was established that no missing data were included within the sample. Other cleansing methods were performed, which included establishing normality, determining correlations that would affect the outcome of the data, and removing multivariate outliers.

Establishing Normality

The dependent variables were tested for normality to ensure that the data were normally distributed. Standard deviation can be used to compute a z score that can assist a researcher in determining exactly how far one value is from another value in a dataset

(Terrell, 2012). The Descriptives feature was used to calculate the z score for each of the dependent variables. The z score for each of the dependent variables was calculated, and the data were sorted by z score to determine what data, if any, were outliers and needed to be removed to improve skewness and kurtosis of the entire data set.

Outliers were defined as values associated with z scores of $z < -3.29$ and $z > +3.29$.

From performing this analysis, it was determined that 36 connections contained outliers and needed to be removed from the study. The data were reduced to a sample size of 952 connections after the outliers were removed.

Correlation Analysis

Correlation analysis was employed to explore the linear dependence between the variables in the hypothesis. The linearity of the variables was tested to determine if they were normally distributed and maintained a linear relationship. This measurement was performed by calculating Pearson's R using Correlation/Bivariate to determine if the factors were significantly correlated at $r > 0.9$. Correlations are positive if their values increase together and negative when their values decrease together. The results calculated a number between 0 and 1, in which 1 is a total positive linear correlation. The outcome indicated how well one could be predicted from another. Variables correlated greater than .9 were considered to have a strong correlation, which assumes they were essentially performing the same measurement. To compensate for this, those items with strong correlation were evaluated to determine if they would be removed from the study. Variables that functioned as constants by virtue of having the same value for all participants were removed from the study.

Model Selection

Cronbach's Alpha was used to identify the set of proxies that best described the unified tie strength variable. The variables evaluated using Cronbach's Alpha allowed a more robust tie strength scale to be created. MANOVA was then performed to allow for testing H1, which hypothesized that tie strength would affect the amount of information dissemination via a collaboration system. The R^2 calculation produced during the MANOVA was used to test H2 to determine if the amount of tie strength affected the amount of information disseminated via the instant messaging modality of the collaboration system.

MANOVA

Multivariate analysis of variance (MANOVA) tests the hypothesis to determine differences between one or more independent variables on two or more continuous dependent variables while accounting for inter-correlations among dependent variables. Unlike ANOVA that measures only one dependent variable, MANOVA has the ability to measure multiple dependent variables (Terrell, 2012). The current study used one aggregated tie strength value as the independent variable and three outcomes of information dissemination as the three dependent variables to determine if there were differences in the amount of tie strength and information dissemination using instant messaging, chat room, or video/conferencing.

Further Data Cleansing

Cronbach's Alpha was calculated to test the validity and reliability of the indicators used in the measurement scale. Cronbach Alpha provides an explanation of the internal consistency associated with the scores derived from a scale and explains the proportion of the indicator variance described by the corresponding latent variable. It was important to establish reliability of the scale, since scores from the individual observed variables were aggregated to create a single tie strength independent variable. Using this information, it was decided which variables should be removed from the measurement scale in order to produce a Cronbach Alpha value of at least 0.700, which is the minimum threshold for establishing reliability (Hair et al., 2005; Kim et al., 2015; Levin and Cross, 2004; Nunnally, 1978; Ranucci and Souder, 2015).

The scale was first calculated with the 14 observed variables remaining from the initial data cleansing process. After reviewing the initial results, it was decided which variables should be removed from the study in order to increase the reliability of the scale. A total of eight observed variables were removed from the study based on the results of Cronbach's Alpha, and the scale was recalculated to have an alpha of 0.700, which was considered acceptable reliability.

Test MANOVA Assumptions

Assumptions regarding the data must be met for the MANOVA to produce a valid result. These assumptions include normal distribution of data, homogeneity of the covariance matrices, and independence of observations (Grimm & Yarnold, 1995). These assumptions were evaluated prior to conducting the MANOVA.

Normal distribution assumes that the dependent variables are normally distributed for each group identified by the independent variables (Grimm & Yarnold, 1995). Normal distribution of data was established after the data collection stage when outliers were removed to reduce skewness and kurtosis. The original data were paired using the standard of excluding any values with a corresponding score of $z < -3$ and $z > +3$. Only the normalized data were included in the final MANOVA analysis, so the assumption of multivariate normality was satisfied.

Homogeneity of covariance matrices assumes that there are equal variances for each of the dependent variables. Similar to Levene's test for testing homogeneity assumption in ANOVA, Box's M is used to test homogeneity in MANOVA and determine if the covariance of the dependent variables is significantly different across levels of the independent variables (Grimm & Yarnold, 1995). Box's M test was performed, and the data produced a significant Box's M result ($p < 0.001$), signifying that the data failed to meet the MANOVA's assumption of homogeneity of covariance. However, literature searches revealed that although the assumption was violated, it was still justifiable to continue interpreting results, because the dataset contained equal sample sizes for each of the dependent variables. Tabachnick and Fidell (2007) validated the decision by stating, "If sample sizes are equal, evaluation of homogeneity of variance-covariance matrices is not necessary" (p. 315). Tabachnick and Fidell (2007) further explained that when sample sizes are equal, robustness of significance tests are expected, and the outcome of Box's M test can be disregarded. Cohen and Cohen (1983), Harris (1975), and Kozlowski and Doherty (1989) also indicated that MANOVA is robust to a violation of homogeneous variance assumptions. Research also explained that when multivariate significance is

realized, it is more appropriate to use Pillai's Trace rather than Wilk's Lambda results to interpret the MANOVA results (Tabachnick & Fidell, 2007). Using the justifications found in existing research, it was decided to continue interpreting the results of MANOVA, and the final analysis of MANOVA was based on the results of Pillai's Trace.

Independence of observations assumes that there is no relationship between the observations in or between the groups, which can be tested by ensuring that participant's scores on the dependent variable were not influenced or related to scores of the other subjects (Terrell, 2012). Each of the scores on the dependent variable used in the current study were independent of the other subjects. This study did include different participants in each group, so the assumption of independence of observations was satisfied.

Perform Hypothesis Test

After it was verified that the assumptions of MANOVA were satisfied, the hypothesis were tested using the General Linear Model/Multivariate feature. Three dependent variables were input into the model, which included total messages disseminated using instant messaging, total message disseminated using chat rooms, and total message disseminated using video/conferencing. The model was set up to include observed power, descriptive analysis, and homogeneity tests, so that these calculations could be performed during the analysis of the MANOVA. The results were interpreted and are included within Chapter 4. Since multivariate significance existed, MANOVA was interpreted using the results of Pillai's Trace rather than Wilk's Lambda, following the

advice of Tabachnick and Fidell (2007). The tests reported significant results in support of both hypotheses.

Summary

Hypothesis testing was performed to determine if tie strength influences information dissemination within a collaborative network. Data regarding information dissemination were collected from subjects in their natural environment that were using a collaborative system. Tie strength was used as the independent variable, and the dependent variable was information dissemination. Data was screened and cleansed by removing outliers and performing correlation analysis to ensure that variables were normally distributed. Further cleansing was performed using Cronbach's Alpha to test the viability and the reliability of the indicators within the measurement scale. It was determined that MANOVA was most appropriate for testing the hypothesis, and the results can be viewed in Chapter 4.

Chapter 4

Results

Introduction

Data were collected from a live environment to perform analysis on the effect of tie strength on information dissemination in a collaborative network. The data were prepared for testing by assessing the sample, ensuring that no data were missing from the dataset, and removing multivariate outliers. CFA was then performed to test the validity of using SEM to test the hypothesis. Various Absolute Fit, Incremental Fit and Parsimony Fit Indices were performed, which indicated that model fit was not established. The model was modified, and CFA and fit tests were performed again. However, the initial tests held true in which model fit was not established for several fit indices, as seen below. The contingency approach of using MANOVA to test the hypothesis was then implored. The hypothesis was modified to treat tie strength as a single independent variable. Tie strength's impact on information dissemination was then tested against three dependent variables.

Descriptive Data Analysis

One year of data were collected from August 2015 to August 2016. A total of 1,749 connections were gathered from 68 users across three chat rooms. After reviewing the conversations, 14 non-participating users were removed from the study, which resulted in the removal of 763 connections. A total of 54 participating users, resulting in a sample size of 986 connections for each of the dependent variables, were included in the study for analysis. The final sample size of 986 connections included 6,021 relevant instant messages, 4,395 chat communications, and 422 video communications. The data collected are summarized in Table 3:

Sample Size	Connections	Total Messages
Original Connections Collected	1,749	10,838 (6,021 IM; 4395 Chat; 422 Video)
Removed for Non Participation	763	0
Connections Included in Sample	986	10,838 (6,021 IM; 4395 Chat; 422 Video)

Table 3: Sample Size

The average number of messages was calculated by the strength of tie from each of the tie strength proxies, and is summarized in Table 4, Table 5 and Table 6. The connections that had the highest level of tie strength for each tie strength proxy exhibited the highest averages of messages sent. Connections that had the lowest level of tie strength had the lowest level of average messages sent. Noticeably more messages were sent by connections that had higher tie strength for each of the tie strength proxies.

Intimacy Tie Strength Factor	Average Number of Messages
1	0.00
2	0.00
3	4.37
4	79.19
5	267.00
6	647.00

Table 4: Average Messages Per Intimacy Tie Strength

Structural Tie Strength Factor	Average Number of Messages
1	0.14
2	1.76
3	6.95
4	53.20
5	212.89
6	610.00

Table 5: Average Messages Per Structural Tie Strength

Social Tie Strength Factor	Average Number of Messages
1	0
2	1.68
3	4.97
4	4.57
5	16.36
6	337.00

Table 6: Average Messages Per Social Tie Strength

The tie strength levels for each of the proxies was combined to determine the number of connections that existed, and summarized data can be viewed in Table 7. The highest level of connections fell into the intimacy category of 2. The majority of the connections had lower levels of tie strength (below 4). For the structural variable tie strength proxy, 402 connections exhibited no tie strength.

		Intimacy Variables	Structural Variables	Social Variables
# Connections Per Tie Strength Value	Tie Strength Value = 1	0	402	0
	Tie Strength Value = 2	848	445	59
	Tie Strength Value = 3	100	103	403
	Tie Strength Value = 4	27	25	449
	Tie Strength Value = 5	10	9	73
	Tie Strength Value = 6	1	2	2

Table 7: Connections Per Tie Strength

Data Screening and Cleansing

Establishing Normality

The data were first screened for missing values, which were not found within the dataset. The data then were cleansed by identifying and removing multivariate outliers.

The process of removing outliers consisted of normality testing to identify and remove outliers that contained a z score of $z < -3.29$ and $z > +3.29$. The z score for the dependent variable of information dissemination using instant messaging ranged from $z = -0.15211$ to $z = 16.63661$. The z score for the dependent variable of information dissemination using chat rooms ranged from $z = -0.49227$ to $z = 6.57576$. The z score for the dependent variable of information dissemination using video/conferencing ranged from $z = -0.13445$ to $z = 15.25839$. The data that fell outside of the $z < -3.29$, $z > +3.29$ criteria were considered outliers, and the connections and all of their collected data were removed from the study and not included in the final analysis. It was determined that 36 connections contained data that were considered outliers, and they were removed from the study. After the outliers were removed, there were 952 connections remaining in the sample size for each dependent variable to be included for final analysis. The new z score for the dependent variable of information dissemination using instant messaging then ranged from $z = -0.15211$ to $z = 2.91171$. The new z score for the dependent variable of information dissemination using chat rooms then ranged from $z = -0.49227$ to $z = 2.93131$. The new z score for the dependent variable of information dissemination using video/conferencing then ranged from $z = -0.13445$ to $z = 2.69281$. As a result of data cleansing, the strength skewness statistic measured at .963 and kurtosis statistic measured at 1.994. These measurements were within the normality ranges, which recommend that skewness values remain less than 2 and kurtosis values remain less than 7 for normally distributed data (Tabachnick & Fidell, 2007).

Correlation Analysis Results

Correlation Analysis was performed to calculate the linear dependence between the variables and determine if variables should be removed from the study. The data was examined for multicollinearity to determine if variables contained redundant information that were not necessary and should be removed from analysis (Tabachnick & Fidell, 2007). Person's R was performed to determine if variables were highly correlated at $> .90$ and should be removed from the analysis (Tabachnick & Fidell, 2007). The descriptive data for the correlation analysis can be seen in Table 8.

	Mean	Std. Deviation	N
Zip	.052	.2216	986
Priv_Com	.099	.2993	986
Proj_Team	.032	.1773	986
Related	.007	.0840	986
Lync_Grp	.233	.4231	986
Job_Class	.049	.2153	986
Dept_Div	.070	.2552	986
Supervis	.013	.1141	986
Building	.096	.2952	986
Geo_Locat	.555	.4972	986
Gender	.914	.2808	986
Age_Range	.118	.3224	986
Lang_Stat	1.000	.0000	986
Ethnicity	.472	.4994	986
Occ_Prest	.234	.4238	986

Table 8: Correlation Descriptive Statistics

When the correlation analysis was performed, it was determined that the factor of language status was considered to be a constant, because all of the users had their software language status set to English, resulting in the same tie strength value for this factor across all participants. As a result, the one factor of language status was removed from the dataset, and 14 factors remained for calculation. Pearson's R revealed that no

variables were correlated significantly at values greater than .90, as can be seen in Table

9.

	Zip	Priv_ Com	Proj_ Team	Relat ed	Lyn c_G rp	Job _Cl ass	Dep t_Di v	Super vis	Buil din g	Geo _Lo cat	Gen der	Age _Ra nge	Lan g_S tat	Eth nici ty	Occ _Pr est
Zip	1	.106	.086	.089	.109	.096	.080	.093	.048	.209	.042	.014	.	.019	.010
Priv_ Com	.106	1	.532	.255	.282	.114	.427	.289	.397	.250	.007	.058	.	.008	.032
Proj_ Team	.086	.532	1	.394	.210	.145	.376	.380	.348	.153	.046	.057	.	.013	.034
Relat ed	.089	.255	.394	1	.153	.037	.308	.732	.259	.076	.017	.044	.	.090	.018
Lyn c_G rp	.109	.282	.210	.153	1	.087	.272	.125	.332	.234	.155	.052	.	.055	.006
Job _Cl ass	.096	.114	.145	.037	.087	1	.104	.056	.022	.063	.053	.049	.	.006	.398
Dep t_Di v	.080	.427	.376	.308	.272	.104	1	.282	.301	.174	.013	.023	.	.020	.011
Super vis	.093	.289	.380	.732	.125	.056	.282	1	.264	.104	.004	.068	.	.069	.020
Buil din g	.048	.397	.348	.259	.332	.022	.301	.264	1	.286	.157	.051	.	.067	.002
Geo _Lo cat	.209	.250	.153	.076	.234	.063	.174	.104	.286	1	.108	.105	.	.078	.107
Gen der	.042	.007	.046	.017	.155	.053	.013	.004	.157	.108	1	.067	.	.189	.025
Age _Ra nge	.014	.058	.057	.044	.052	.049	.023	.068	.051	.105	.067	1	.	.002	.058
Lan g_S tat	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eth nici ty	.019	.008	.013	.090	.055	.006	.020	.069	.067	.078	.189	.002	.	1	.024
Occ _Pr est	.010	.032	.034	.018	.006	.398	.011	.020	.002	.107	.025	.058	.	.024	1

Table 9: Pearson Coefficient

SEM-CFA

Structural Equation Modeling was first evaluated to determine if this measurement method was appropriate for testing the proposed hypothesis. The measurement model that was constructed can be viewed in Figure 3. This model included each of the tie strength proxies (intimacy, structural, and social) as latent variables, and the factors that they were composed of were included as observed variables. It can be seen in Figure 3 that the factor of Language Status was not included for the Social variable, because this variable was determined to be a constant and was removed during the data cleansing stage.

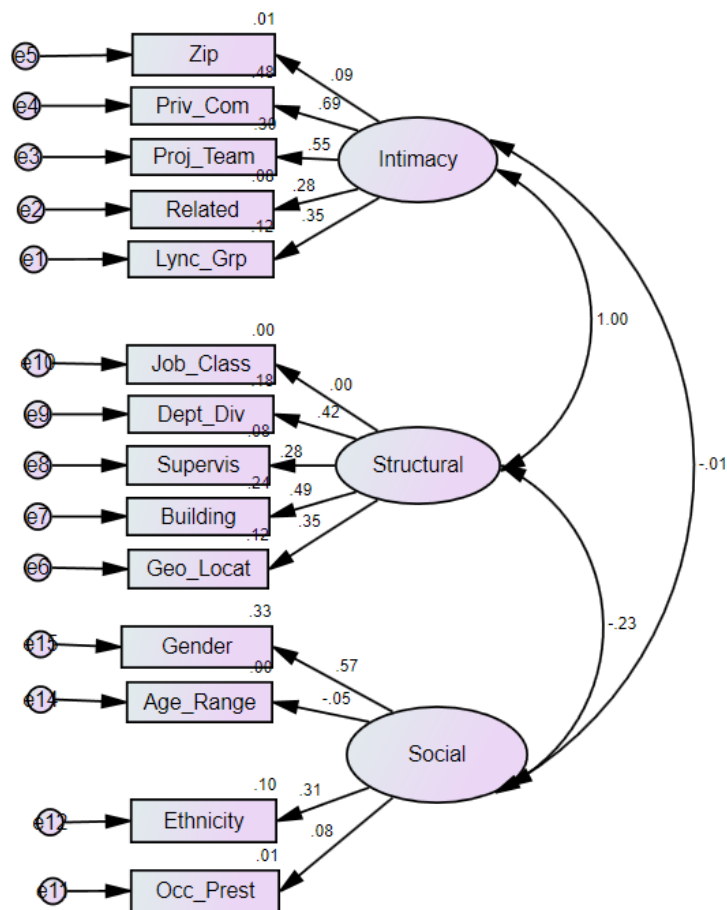


Figure 3: Original SEM Model

As is the procedure with SEM, Confirmatory Analysis was first performed to test the validity and reliability of the model. To perform CFA, the model was specified, estimated, and tested for reliability and validity. The hypothesis was expressed in a diagram using intimacy and structural tie strength proxies as the latent variables and the factors associated with them as the observed variables. For each latent variable, one factor loading was set to 1.0 so that the remaining factors would be tied to a reference point. Covariances were established between the latent variables, and measurement errors were established for each of the observed items. Regression estimates indicated that all of the indicator variables loaded significantly on the latent factor, except for Zip Code, as shown in Table 10. Private Communications were significant at a regression estimate of 1.335, which was the highest for the Intimacy latent variable. The structural factor of Building was significant at a regression estimate of .739, which was the highest for the Structural latent variable.

			Estimate	S.E.	C.R.	P	Label
Lync_Grp	<---	Intimacy	1.000				
Related	<---	Intimacy	.064	.011	5.864	***	
Proj_Team	<---	Intimacy	.523	.064	8.112	***	
Priv_Com	<---	Intimacy	1.335	.158	8.474	***	
Zip	<---	Intimacy	.139	.060	2.319	.020	
Geo_Locat	<---	Structural	1.000				
Building	<---	Structural	.739	.094	7.868	***	
Supervis	<---	Structural	.128	.022	5.955	***	
Dept_Div	<---	Structural	.550	.074	7.408	***	
Job_Class	<---	Structural	.005	.045	.119	.905	
Occ_Prest	<---	Social	1.000				
Ethnicity	<---	Social	4.427	2.879	1.538	.124	
Age_Range	<---	Social	-.451	.543	-.832	.406	
Gender	<---	Social	4.070	3.095	1.315	.188	

Table 10: SEM Regression Weights Default Model

The regression weights were relatively low for the majority of the variables, which can be seen in Table 11. The highest regression weight for the Intimacy variable was Private Communication, which achieved an estimate of .693. There were no factors that reached a regression weight higher than .70. Four factors produced regression weights less than .10: Zip Code, Job Class, Occupational Prestige, and Age Range.

		Estimate
Lync_Grp	<--- Intimacy	.352
Related	<--- Intimacy	.280
Proj_Team	<--- Intimacy	.547
Priv_Com	<--- Intimacy	.693
Zip	<--- Intimacy	.092
Geo_Locat	<--- Structural	.352
Building	<--- Structural	.487
Supervis	<--- Structural	.284
Dept_Div	<--- Structural	.421
Job_Class	<--- Structural	.005
Occ_Prest	<--- Social	.084
Ethnicity	<--- Social	.314
Age_Range	<--- Social	-.051
Gender	<--- Social	.571

Table 11: SEM Standardized Regression Weights

The covariance between intimacy and structural was significant with an estimate of .025, as listed in Table 12. However, the covariances between Structural and Social and Intimacy and Social were not significant, with estimates of -.001 and .000 respectively.

	Estimate	S.E.	C.R.	P	Label
Intimacy <--> Structural	.025	.004	6.391	***	
Structural <--> Social	-.001	.001	-1.262	.207	
Intimacy <--> Social	.000	.000	-.096	.924	

Table 12: SEM Covariance

The correlation between Intimacy and Structural tie strength recorded a value of .997, as listed in Table 13. However, negative correlations were calculated for the relationships between Structural and Social and the relationship between Intimacy and Social.

	Estimate
Intimacy <--> Structural	.997
Structural <--> Social	-.226
Intimacy <--> Social	-.006

Table 13: Correlations

Model Fit Tests

CFA included testing various fit indices that are essential to conduct before SEM (Yuan, 2005). The model fit was assessed using Absolute Fit, Incremental Fit, and Parsimony Fit indices. Absolute Fit indices that were measured included Chi-Square, GFI, RMSEA, AGFI, and RMR. Incremental Fit indices that were measured included NFI and CFI. Parsimony Fit indices that were measured included PGFI and AIC. Described in the following sections are the fit values achieved for each index, along with literature interpretation of acceptable fit results.

Absolute Fit Indices

Chi-Square tests the significance of the difference between the designated structural parameters across groups and is an indicator of model fit (Tabachnick & Fidell, 2007). In order to indicate appropriate fit, the model should produce an insignificant value of $p > .05$. The model showed significant results by calculating a value of $p < 0.05$, as seen in

Table 14. Chi-Square/degrees of freedom should be less than 2 (Tabachnick & Fidell, 2007), but the value calculated was 6.989, which is less than marginal acceptability.

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	31	517.189	74	.000	6.989
Saturated model	105	.000	0		
Independence model	14	1232.752	91	.000	13.547

Table 14: SEM Chi Squared Fit Test

Root mean square error approximation (RMSEA) was also calculated to test the fit of the model. Acceptable results for RMSEA range from .06 (Hu & Bentler, 1999) and as high as .08 (MacCallum et al., 1996; McQuitty, 2004). Tabachnick and Fidell (2007) state that values larger than .10 indicate poor fitting models. When tested, the default model produced a RMSEA of 0.079, which is considered acceptable according to MacCallum et al. (1996) and McQuitty (2004). These results can be seen in Table 15. RMR measured a value of .006, which is considered acceptable according to Blunch (2008) and Bryne (2010). GFI produced a value of .929, which is considered acceptable fit according to Miles and Shelvin (1998) who recommend $GFI < .95$, but this value is not acceptable according to Bollen (1990) who recommend $GFI < .90$. AGFI should be less than .90, and it was calculated to be .899 (Tabachnick & Fidell, 2007).

Model	RMSEA	RMR	GFI	AGFI
Default model	.079	.006	.929	.899
Saturated Model		.000	1.000	
Independence model	.115	.011	.815	.786

Table 15: Absolute Fit Tests

Incremental Fit Indices

Incremental Fit indices that were tested were NFI and CFI, and the results can be viewed in Table 16. NFI measured at .580, which is not considered acceptable according

to Bentler and Bonnet (1990) that recommend a value of $NFI > .90$. CFI produced a value of .612, which is not considered acceptable according to Hu and Bentler (1999) that recommended $CFI > .95$.

Model	NFI Delta1	CFI
Default model	.580	.612
Saturated model	1.000	1.000
Independence model	.000	.000

Table 16: Incremental Fit Tests

Parsimony Fit Indices

Parsimony Fit Indices that were measured included PGFI and AIC, and the results can be viewed in Table 17. PGFI measured at .498, which is considered acceptable according to Mulaik et al. (1989) but not acceptable according to more stringent rules of Blunch (2008) that recommend a threshold of .90s. The AIC value measured at 579.189.

Model	PGFI	AIC
Default model	.498	579.189
Saturated model	.000	210.000
Independence model	.000	1260.752

Table 17: Parsimony Fit Tests

CFA on Adjusted Model

Based on EFA, the model was adjusted in an effort to establish better fit. As seen in the tables above, the factors of Zip Code, Job Class, Occupational Prestige, and Age Range produced factor loadings less than .10. These factors were removed from the model, and CFA was repeated to determine if improved fit would be established. The revised model can be seen in Figure 4, which included four factors for determining Intimacy, four factors for determining Structural, and only two factors for determining

the Social tie strength proxy. The revised model included 10 observable factors as opposed to the original model that included 14 factors.

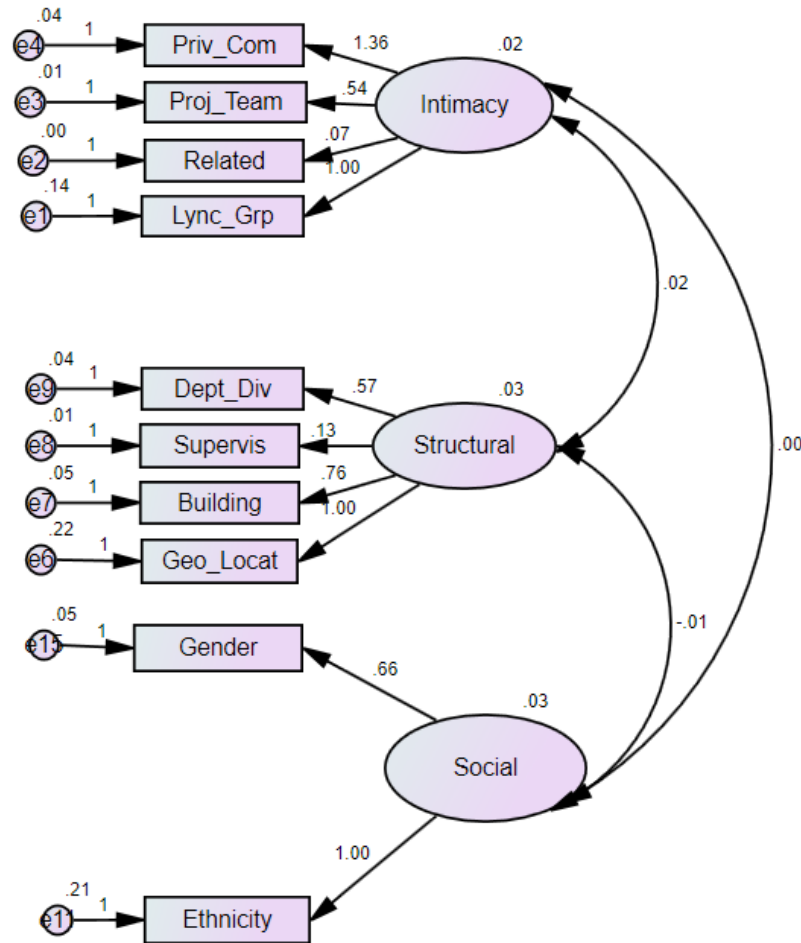


Figure 4: Modified SEM Model

For the modified model, regression estimates indicated that all of the indicator variables loaded significantly on the latent factor except for Gender, as shown in Table 18. Private Communications was significant at a regression estimate of 1.357, which remained the highest regression estimate for the Intimacy variable, as it was in the

original model. Similar to the original model, Building had the highest regression weight for the Structural variable, but the estimate increased to .761 in the revised model.

			Estimate	S.E.	C.R.	P	Label
Lync_Grp	<---	Intimacy	1.000				
Related	<---	Intimacy	.065	.011	5.860	***	
Proj_Team	<---	Intimacy	.535	.067	8.035	***	
Priv_Com	<---	Intimacy	1.357	.162	8.359	***	
Geo_Locat	<---	Structural	1.000				
Building	<---	Structural	.761	.099	7.698	***	
Supervis	<---	Structural	.133	.023	5.916	***	
Dept_Div	<---	Structural	.567	.078	7.267	***	
Ethnicity	<---	Social	1.000				
Gender	<---	Social	.659	.376	1.755	.079	

Table 18: SEM Regression Weights Default Model

The standardized regression weights were fairly low (seen in Table 19), and none of the regression weights valued greater than .70. The lowest regression weight was calculated to be .287 for the factor of Supervisor. Private Communication calculated at the highest regression weight at .694.

			Estimate
Lync_Grp	<---	Intimacy	.346
Related	<---	Intimacy	.283
Proj_Team	<---	Intimacy	.552
Priv_Com	<---	Intimacy	.694
Geo_Locat	<---	Structural	.343
Building	<---	Structural	.489
Supervis	<---	Structural	.287
Dept_Div	<---	Structural	.422
Ethnicity	<---	Social	.374
Gender	<---	Social	.488

Table 19: SEM Standardized Regression Weights

Revised Model Fit Indices

Absolute, Incremental, and Parsimony Fit Indices were tested to determine if higher levels of fit could be established based on the revised model. The revised model achieved increased fit, according to the values produced during fit tests, which can be shown in Table 20. The original model calculated RMSEA of .079, but the new model calculated RMSEA at .087, which is just above the acceptable threshold of .08 (MacCallum et al., 1996). The new model calculated GFI of .947, rather than .929 of the original model. This GFI value is below the .95 threshold, which is considered acceptable for this fit index (Miles and Shelvin, 1998). AGFI calculated a fit of .909, which is just above the acceptable level of less than .90 (Tabachnick & Fidell, 2007). RMR acceptable level is less than .05 according to Blunch (2008), and this fit index calculated at an acceptable level of .004. NFI should be over .95 to be considered acceptable according to Hu and Bentler (1999), but this index only calculated a value of .728. PGFI should have measured a value over .60 according to Blunch (2008), but this index only calculated at .551, indicating inappropriate fit. The AIC value was lower than the original model. Model fit that measured within acceptable thresholds included (GFI=.947, RMR =.004, and AIC = 309). Model fit that was not established within the expected thresholds established by the literature included (RMSEA=.087, AFGI=.909, NFI=.728, CFI=.750, and PGFI=.533), as seen in Table 20.

Fit Test	Indices
CMIN	263.656
CMIN/DF	8.239
RMSEA	.087
GFI	.947

Fit Test	Indices
AGFI	.909
RMR	.004
NFI	.728
CFI	.750
PGFI	.551
AIC	309.656

Table 20: Revised Model Fit Tests

Hypothesis Revision for MANOVA

In order to perform the MANOVA testing, it was established that Tie Strength would be treated as a single independent variable, rather than three separate independent variables based on the three tie strength indicators (intimacy, structural, and social). The single tie strength variable was created by calculating an aggregated value based on the three indicators used to establish tie strength. The aggregated tie strength independent variable was tested to determine its impact on the three dependent variables: information dissemination via instant messaging, information dissemination via chat rooms, and information dissemination via video/conferencing.

Further Cleaning

During the original data cleansing stage, the skewness statistic for tie strength was reduced to .963 and kurtosis to 1.994, which made the dataset within the normally distributed range (Tabachnick & Fidell, 2007). Prior to conducting the MANOVA, further data cleansing was performed to determine the set of proxies that best described the unified tie strength variable. Cronbach's Alpha was employed to determine the

reliability of the measurement scale and decide which variables could be removed from the study to increase its reliability to an acceptable level of 0.700 (Hair et al., 2005; Kim et al., 2015). The scale's reliability was first calculated using the remaining 14 observed variables. In this initial test, Cronbach Alpha yielded a value of 0.501, which was relatively weak and did not meet the established criteria of convergent validity. A possible explanation of the initial low reliability coefficients could be explained in the work of Petrozci et al. (2007), who received a low reliability value when measuring tie strength in an online social network using existing tie strength factors determined within the literature. Petrozci et al. (2007) explained that many of the factors available for observing tie strength pertained to friendship relationships, but through their analysis determined that the factors did not carry the same weight within a group setting that was being measured. Similarly, in the current study, several of the variables used to measure tie strength were indicators of a close relationship within a friendship network, but they may not be as effective in measuring a collaborative group.

In order to improve the quality of the reliability of the scale to an acceptable level, the items of zip code, job class, geographic location, gender, age, language status, ethnicity and occupational prestige were removed from the scale and excluded from the final analysis. A new Cronbach Alpha was calculated with the remaining observed variables, which subsequently produced a cumulative reliability of 0.700, as shown in Table 10. It was decided that seven indicators (private communication, project team, related, Lync group, department, supervisor and building) that produced a reliable Cronbach Alpha would be included in the final analysis, which can be seen in Table 21. Table 22 includes a Summary of the Item Statistics when performing the final Cronbach Alpha calculation.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.700	.775	7

Table 21: Cronbach Alpha Reliability Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Inter-Item Correlations	.329	.125	.732	.606	5.831	.017	7

Table 22: Cronbach Alpha Summary Item Statistics

Testing MANOVA Assumptions

Although it was lower than expected as shown in Table 23, Box's was still considered a concept of analysis and was calculated at $p < 0.001$. In order to test the assumption that the sample size had an effect on the Box's M results, the sample size was reduced to 61 connections by removing the participants who had zero communications. After reducing the sample size, the Box's M value was computed and yielded a value of 0.11. At this Box's M level, the multivariate tests still produced significant results of $p < 0.000$.

Box's M	566.272
F	29.608
df1	18
df2	7277.280
Sig.	.000

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + TieStrength

Table 23: Box's Test of Equality of Covariance Matrices (a)

Testing Hypothesis Using MANOVA

MANOVA was calculated on 952 connections that were remaining after the outliers were removed during the data cleaning phase. The connections included in the MANOVA analysis, separated by their tie strength, can be viewed in Table 24. The descriptive statistics for all of the dependent variables according to their corresponding tie strength can be viewed in Table 25.

	N
TieStrength 1.0	679
2.0	178
3.0	57
4.0	23
5.0	12
7.0	2
8.0	1

Table 24: MANOVA Between Subjects Factors

	TieStrength	Mean	Std. Deviation	N
Total_IM	1.0	.000	.0000	679
	2.0	.713	2.6494	178
	3.0	4.649	11.8389	57
	4.0	17.957	22.4307	23
	5.0	67.667	36.9996	12
	6.0	68.500	4.9497	2
	8.0	114.000	.	1
	Total	1.962	11.1222	952
Total_Chat	1.0	1.290	2.5119	679
	2.0	9.444	8.1435	178
	3.0	10.035	10.0231	57
	4.0	6.522	8.2013	23
	5.0	3.667	4.5394	12
	6.0	10.500	2.1213	2
	8.0	.000	.	1
	Total	3.513	6.1280	952
Total_Vid_Conf	1.0	.091	.5326	679

	TieStrength	Mean	Std. Deviation	N
	2.0	.174	.9070	178
	3.0	.386	1.5090	57
	4.0	.739	1.8394	23
	5.0	2.667	3.1718	12
	6.0	.500	.7071	2
	8.0	4.000	.	1
	Total	.178	.8910	952

Table 25: MANOVA Descriptive Statistics

MANOVA was conducted using the SPSS General Linear Model/Multivariate procedure. MANOVA revealed a significant multivariate main effect for Tie_Strength, (Pillai's Trace = 1.075, $F(18,2835) = 87.975$, $p < .001$, partial eta squared = .358), as can be viewed in Table 26. Power to detect the effect was 1.0. Thus Hypothesis 1 was confirmed. Given the significance of the overall test, the univariate main effects were examined. Significant univariate main effects for tie strength were obtained for Total_IM, ($F = 368.234$ $p < .001$, partial eta square = .700 power = 1.0); Total_Chat, ($F = 83.356$, $p < .001$, partial eta square = .346 power = 1.0); and Total_Vid_Conf, ($F = 25.147$, $p < .001$, partial eta square = .138 power = 1.0).

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^d
Intercept Pillai's Trace	.602	475.159 ^b	3.000	943.000	.000	.602	1425.477	1.000
Wilks' Lambda	.398	475.159 ^b	3.000	943.000	.000	.602	1425.477	1.000
Hotelling's Trace	1.512	475.159 ^b	3.000	943.000	.000	.602	1425.477	1.000
Roy's Largest Root	1.512	475.159 ^b	3.000	943.000	.000	.602	1425.477	1.000
TieStrength Pillai's Trace	1.075	87.975	18.000	2835.000	.000	.358	1583.547	1.000
Wilks' Lambda	.179	124.017	18.000	2667.692	.000	.436	2064.849	1.000
Hotelling's Trace	3.180	166.386	18.000	2825.000	.000	.515	2994.940	1.000

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^d
Roy's Largest Root	2.662	419.329 ^c	6.000	945.000	.000	.727	2515.976	1.000

a. Design: Intercept + TieStrength ; b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Computed using alpha = .05

Table 26: MANOVA Multivariate Tests (a)

Significant tie strength pairwise differences were obtained in instant messaging. The mean number of instant messages was 1.962, the mean number of chats was 3.513, and the mean number of video/conferences was 0.178. The analysis shows that tie strength has a significant impact on information dissemination for all three types of modalities used to diffuse information ($p < 0.001$). R^2 values identify what percentage of the variable in the dependent variable can be explained by the variation in the independent variable. It shows that $r^2 = .699$ is based on instant messaging, $r^2 = .342$ is based on chat rooms, and $r^2 = .132$ was based on video/conferencing, as shown in Table 27. This data indicates that 69.9% of the variation in the use of instant messaging is explained by the variation in tie strength. This concludes that tie strength does have the largest impact on information dissemination using instant messaging, which supports H2.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^d
Corrected Model	Total_IM	82399.145 ^a	6	13733.191	368.234	.000	.700	2209.406	1.000
	Total_Chat	12359.231 ^b	6	2059.872	83.356	.000	.346	500.136	1.000
	Total_Vid_Conf	103.949 ^c	6	17.325	25.147	.000	.138	150.882	1.000
Intercept	Total_IM	45290.292	1	45290.292	1214.389	.000	.562	1214.389	1.000
	Total_Chat	1040.736	1	1040.736	42.115	.000	.043	42.115	1.000
	Total_Vid_Conf	44.341	1	44.341	64.360	.000	.064	64.360	1.000
TieStrengt h	Total_IM	82399.145	6	13733.191	368.234	.000	.700	2209.406	1.000
	Total_Chat	12359.231	6	2059.872	83.356	.000	.346	500.136	1.000

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^d
	Total_Vid_Conf	103.949	6	17.325	25.147	.000	.138	150.882	1.000
Error	Total_IM	35243.493	945	37.295					
	Total_Chat	23352.618	945	24.712					
	Total_Vid_Conf	651.050	945	.689					
Total	Total_IM	121308.000	952						
	Total_Chat	47458.000	952						
	Total_Vid_Conf	785.000	952						
Corrected Total	Total_IM	117642.639	951						
	Total_Chat	35711.849	951						
	Total_Vid_Conf	754.999	951						

a. $R^2 = .700$ (Adjusted $R^2 = .699$)

b. $R^2 = .346$ (Adjusted $R^2 = .342$)

c. $R^2 = .138$ (Adjusted $R^2 = .132$)

d. Computed using alpha = .05

Table 27: MANOVA Tests Between Subjects Effects

Summary

Data cleansing was performed on the original model, to prepare the data for testing.

The data were cleansed by removing multivariate outliers and establishing normality.

Once the data were cleaned and validity was established, statistical models were tested to determine which were most appropriate for the type of study being performed. CFA was used as initial testing for using a SEM model. However, scale fit was not achieved, and it was determined that SEM would not be the most appropriate method for testing the hypothesis. MANOVA was then used to test the hypothesis, since this scale allowed for the testing of multiple dependent variables as were included in the study. MANOVA

revealed significant support to validate both hypotheses. The data gathered and analyzed are explained in this chapter.

Chapter 5

Conclusions, Implications, Recommendations, and Summary

Introduction

Knowledge is an essential asset to an organization, and determining methods for facilitating knowledge transfer can increase an organization's ability to maintain a competitive advantage. Organizations continue to face difficulty instituting internal collaboration and information sharing (Sayogo and Gil-Garcia, 2014). Previous studies have evaluated tie strength's influence on information dissemination within a public social network (Aral & Walker, 2014; Bakshy et al., 2012). However, studies were lacking on tie strength's influence on information dissemination within a collaborative social network that is subject to organizational constraints. The goal of this study was to determine the impact of tie strength on information diffusion within a collaborative social network.

This chapter includes a discussion of the conclusions that were reached as a result of analysis of the collected data. An overview of limitations is reviewed to offer rationale for the results obtained. Recommendations for enhancements of the study are proposed as concepts for future research. Implications for practical use of the results are then provided to offer insight about how the results can be applied to practice and future research.

Conclusions

H1 Conclusions

In order to address the research questions, data were captured from a live collaborative network to observe tie strength's effect on information that was passed between relationships. Hypothesis 1 was generated to answer the research question of, "How does tie strength influence the effects of information dissemination within a collaborative social network?" H1 hypothesized that relationships that exhibit higher levels of tie strength will disseminate significantly higher levels of information via instant messaging, chat room and video/conferencing modalities of a collaboration system. To address this hypothesis, information about each relationship was digitally captured and used to calculate tie strength, and the amount of information distributed between the connections was compared to their calculated tie strength.

The testing of H1 resulted in the need to change the measurement model. SEM and MANOVA were evaluated to determine the best measurement model for testing the proposed mode. CFA analysis examined which factor model best fit the data (Grimm & Yarnold, 1995). While factor analysis proved that loadings for the proposed model were significant for the revised model with cleansed data and variables, CFA model fit indicated that SEM was not appropriate for the study as it was designed. It was determined that MANOVA was more effective for testing this model. MANOVA testing is appropriate when the model involves one or multiple categorical independent variables (Grimm & Yarnold, 1995).

Since initial conducting of SEM indicated that MANOVA was more appropriate for testing the H1, H1 was altered to test if a single independent variable influences

information dissemination via three communication modalities, each of which would be treated as dependent variables. MANOVA testing was performed to examine tie strength as the independent variable and information dissemination via three different modalities of a collaborative system as the dependent variables. The MANOVA findings showed that tie strength had a significant impact on information dissemination for instant messaging, chat, and video/conferencing, which confirms the first hypothesis (H1).

The results support the findings of Petroczi et al. (2007), which established that people seek support via their strong ties. The data collection reported that people with high tie strength shared the most amount of information. Connections with the highest tie strength shared an average of 647 messages. The number of messages shared between connections was positively related to the relationships' tie strength.

H2 Conclusions

Hypothesis 2 was generated to answer the research question, "How is the relationship between tie strength and information dissemination affected by the type of medium being used within the collaborative network?" H2 hypothesized that relationships that exhibit higher levels of tie strength will disseminate significantly higher levels of information via the instant messaging modality. To answer the second research question, the amount of information distributed within relationships using the three different modalities (instant messaging, chat rooms and video/conferencing) was captured and compared against the tie strength for each relationship. The MANOVA results showed significant pairwise differences in instant messaging. R^2 showed the percentage of variation in the response that was explained by the model. R^2 values identified that almost 70% of the variation in the use of instant messaging was explained by the variation in tie strength. That analysis

confirmed the second hypothesis (H2) by proving that tie strength had the largest impact on information dissemination using instant messaging.

Tie Strength

The study confirmed factors that can be used to measure tie strength in a collaborative environment. The tie strength factors used as observed variables were selected from prior studies that measured tie strength within online relationships (Gilbert, 2012; Luarn & Chui, 2013). These factors had been adapted from seminal research that collected tie strength data through surveys and interviews. However, the initial CFA reported that the factors of zip code, job classification, occupational prestige and age range were not effective in measuring tie strength in this study. While the factors had been conformed to evaluate an online environment, the prior studies in which they were used observed public social networks rather than collaborative environments. Collaborative social networks pass on information that is more complex in nature, and are subject to different organizational constraints (Durugbo, 2014). As it was seen in the results from this study, several of those factors were eliminated from analysis, because they did not prove to be relevant in the collaborative environment. It is possible that the factors that were removed were better suited to measure social relationships and were not equipped for measuring relationships that were more collaborative in nature.

The intimacy and structural proxies proved to be the most effective in measuring tie strength for this study. The intimacy proxy of tie strength experienced moderate levels of factor loadings and regression weights, as did the structural proxy. The social proxy reported the lowest regression weights, and three out of the five factors were eliminated based on factor analysis. The interaction between the intimacy and structural proxies was

significant at an estimate of 0.997, while the interactions between the structural to social proxies and the intimacy to social proxies were not significant. This study confirmed the results of Mathews (1998) which concluded that intimacy was the most important factor explaining variability in tie-strength. The social proxy and the factors used to measure it should be evaluated further before they are included in future studies regarding tie strength within organizations.

Limitations

This research contained limitations that may have impacted the validity of the results. The study was limited in the manner that technological skills were required for participation. A total 763 relationship connections were removed from the study due to nonparticipation, and it is not known if technological preferences and skills hindered the amount of information disseminated, therefore affecting the results of the study. The cause of non participation is unknown but could be explained by several issues. It is possible that there were participants not comfortable using technology for communicating. It is also possible that the non-participants experienced technical difficulties when using the software. While it was assumed that these relationships did not disseminate information and were removed from the study, it is not known whether these relationships disseminated information using other methods, such as phone calls, email or physical conversation. In future studies, it may be useful to capture technical issues reported about the system.

A large amount of skewness existed in the original data, which may have been due to the real-time data collection of a random sample. Data cleansing was performed to remove extreme outliers and establish normality, which resulted in the removal of 36 relationships that accounted for 4153 instant messages, 1051 chat room messages, and 253 video/conferencing messages. While the removal of these relationships increased the reliability of the scale, they also accounted for removal of a large amount of communications that were not able to be included in the study for analysis. For example, one connection that was excluded from the study exhibited a level 6 intimacy tie strength and exchanged 674 messages. It is not known whether the connections that were removed could have provided valuable data for the study. In future research, methods to structure the study to ensure less skewness of data should be considered.

This study was limited in the manner that it was not able to distinguish between information sharing and knowledge sharing. Albino, Garavelli, and Gorgoglione (2004) explained that human cognition needs to take place for information to be turned into knowledge. Prior studies measured knowledge sharing by conducting interviews with participants to determine how the data were used. In this study, knowledge sharing could have been measured by determining if the information disseminated was then used to support decision-making. However, this study did not have a method to determine how the information was utilized after it was disseminated or whether it was useful for the decision making process. Therefore, the study was not able to determine if the actual knowledge was spread, and it was assumed that only information sharing took place.

There was a limitation in the ability to capture data disseminated using the video/conferencing feature. The content of the video/conferencing transferred between

relationships could not be monitored as thoroughly as instant messaging and chat features. The content of every message sent within individual communications was captured using the instant messaging feature. However, only the timestamp of the initiation of the conversation was captured using the video/conferencing feature. As a result, the video/conferencing modality may not have received an accurate count of information transferred as did information transferred using the instant messaging and chat modalities.

Implications

Contributions to Literature

This research furthered the studies that have begun conducting tie strength analysis within live, online environments. The results indicated that connections that exhibited the highest levels of tie strength sent the most messages, and connections that had the lowest levels of tie strength sent the least messages. These results supported the findings of Luarn and Chui (2015) who stated that individuals with strong ties share more information. It also reinforced the conclusions of Kim, Lee, and Elias (2015) that determined that the strength of ties affects information sharing. The research furthered the conclusions of Casmir et al. (2012) that showed that employees are more willing to share if there are higher levels of trust.

The chat rooms in this study were similar to an online forum in which people are contributing information that can be viewed by all. Barker (2015) tracked the use of a discussion forum to monitor information transfer and determined that knowledge sharing

on an online forum is most effective when it is supported by an expert. The current study followed Barker's (2015) methodology and inserted an expert into the chat rooms. As a result, this study supported the results of Barker (2015) by showing that chat room usage was strong when an expert is inserted.

Scholl and McCarthy (2006) compared the different modalities of a communication system and concluded that there was a significant preference to using the chat modality. The data gathered from this study showed that most communication took place utilizing the instant message modality. As such, the results of this study did not support the work of School and McCarthy (2006). However, based on the amount of messages that were exchanged through the system, it supports the research of Bharati et al. (2015) which stated that social media does facilitate knowledge management efforts in a sense that information was shared using the system.

The study determined that not all of the factors that can be used to measure tie strength within a social environment are valuable in measuring tie strength in a collaborative environment. Since previous tie strength studies had not been conducted in a collaborative system, this study helped to determine factors that impact tie strength within a collaborative network rather than a public social network. It was determined that the factors of zip code, job classification, occupation prestige and age range were not as effective in measuring tie strength in a collaborative environment and should be evaluated further if considered in future studies. The study also confirmed several of the intimacy, social and structural proxies that can be used to measure tie strength in a public social network as well as a collaborative social network. This information can be used to

select tie strength factors for future studies that are evaluating tie strength within organizational environments.

Due to the limitations of the data collection, the content of video/conferencing communications was not recorded. Therefore, the study was not able to verify the work of Biehl, Avrahami, and Dunnigan (2015) who tested the effects of video conferencing in information sharing. The knowledge transfer process requires that information be created, stored/retrieved, transferred and applied Alavi and Leidner (2001). This study was missing the ability to determine how the information was applied. Since the study was not able to distinguish between knowledge sharing and information sharing, the results were not able to support the findings of Hansen (1999) that explained that strong ties transfer more complex knowledge.

Seminal studies relied on gathering tie strength data from surveys and interviews (Friedkin, 1982; Granovetter, 1973; Hansen, 1999). Recent studies have relied on data collection from public social media system, which is more closely related to chat room communication than the one-to-one communication provided within instant messaging (Bakshy et al., 2012; Rejeb-Khachlouf et al., 2011; Wei & Bu, 2014; Zhou et al., 2010). The current study captured real-time data from a live collaboration environment without relying on subjective participant interpretation to determine the amount of information that was transmitted through the system and to determine the strength of relationship ties. The study validated a new method for observing organization transfer of information and measuring content of data shared within messages.

Practical Application

Studies have shown that transferring knowledge within an organization presents a competitive advantage (Reagans & McEvily, 2003). Since the results confirm that stronger tie strength contributes to a greater amount of information transfer, the results help an organization understand that focusing efforts on increasing the closeness of relationships can be effective in the efforts to help increase information dissemination. This suggests that encouraging stronger relationships within a collaborative setting can help an organization expand their dissemination of information.

Companies are investing in technology to share information (Bharati, Zhang & Chaudhury, 2015). In particular, social media technology is increasingly being inserted into organizations (Bughin et al., 2012). These systems promote social interaction, which is essential for promoting knowledge exchange (Bakshy, et al., 2012; Wei & Bu, 2014). The implementation of these technology platforms can result in a significant investment to a company, so it is helpful to determine their usefulness before implementation. It is important to understand the preparation that should take place to ensure effective use of the system. The results showed that the strength of relationships should be evaluated as part of the planning process for implementing these systems. Since collaborative systems have proven to be effective in distributing knowledge, it is useful to determine how organizations can make the most use of them to get the most effect. The study confirms that tie strength is an indicator of system use, and therefore can establish a measurement of when to invest in collaboration systems.

Recommendations

Recommendations for Practice

The research determined that tie strength can influence information dissemination. Evaluating the tie strength proxies that exist within an organization can be effective in measuring the success of a collaboration system. The results showed that the intimacy proxy provides a measure of system use. The usage of the system could possibly be increased if efforts are made to enhance closeness within relationships. In particular, the research showed that instant messaging was effective when the intimacy proxy of tie strength was high within relationships. Chui et al. (2014) explained that tie strength might be the cause of certain network behavior. Organizations seeking to increase information sharing through the use of a collaborative system should take measures to strengthen internal closeness of relationships.

Since the communication was only monitored through an online system, this study relied on people that were comfortable using the technology system to communicate. When evaluating the number of participants who were removed from the study due to lack of participation, it confirmed that efforts to enhance training on use of the system might be beneficial to enhance information dissemination. It is not possible to know whether lack of use of the system hindered the information dissemination that could have taken place. To accommodate for the possible lack of use due to technological constraints, the study confirmed that more training efforts should be put in place to ensure effective use of the system and decrease technical barriers.

The research demonstrated that tie strength has a positive effect on information dissemination via a collaboration system. This supports the findings Bharati et al. (2015) who explain that social media also promote higher levels of organizational knowledge quality. Organizations should engage resources to begin incorporating these systems to increase knowledge management efforts. However, the study also uncovered barriers to usage of the collaboration system, which therefore hindered their effectiveness. Efforts should be made to ensure that users are technologically skilled in using an online collaborative system, so that the full benefits can be realized.

Future Research

This study did not have the ability to distinguish between knowledge and information transfer. A future study can be conducted within a controlled environment to test subjects on the content of the information that was disseminated and determine how the information was processed by the recipient and if it was used for decision-making. A survey instrument or test can be incorporated to determine the type of information that was received through the system and establish if actual knowledge was passed. A process could also be incorporated to test the quality and usefulness of the information that was passed through the system.

Lin and Lo (2015) determined that a person's position in a network can play a factor in knowledge sharing, and someone with a higher position might have greater influence. This study did not measure how a participant's position in the hierarchy of the organization played a role in information sharing. Future studies can add this as a moderating variable to determine the influence it will have on information sharing.

In future studies, rather than only including random relationships, the study can be modified with a purposive sample that includes specific relationships with equal and varying amounts of tie strength. The skewness of the data called for many connections to be removed from the study, including connections that contained a high number of communications. A purposive sample could allow for the communication between relationships to be more evenly distributed, and could result in more relevant data collection for a richer sample. Several users were removed due to lack of participation, and it is not known if technological factors played a role in their inability to use the system. A purposive sample could include people with equal levels of technological skills to reduce the number of non-participating members. The study can also be analyzed by certain groups, such as age.

This study showed how information from training was disseminated throughout a company. It would be beneficial to revise the study to determine at what point the information stopped being spread or slowed down. This could help an organization schedule training sessions or identify how often a topic needs to be revisited through training. The study can also be revised to determine how tie strength increases over time. Data from the collaborative system can be collected to determine if the system plays a role in increasing tie strength within relationships over a period of time. The effect of organizational culture can also be analyzed.

Collaboration systems include additional modalities than those included in this study (instant messaging, chat rooms, and video conferencing/presenting), and the functionality of these technological systems continue to grow. Future research should incorporate more modalities from a collaborative system, to compare their effectiveness in information

dissemination. Conducting research that has the ability to add the cutting edge modalities can help organizations determine which new technology is worth implementing for knowledge management success.

This study was conducted internally on one single company. New collaboration systems offer the capability of being configured to communicate with external parties. Future studies can incorporate external subjects to determine how tie strength can affect information dissemination through collaborative systems between organizations and the company and their clients. This can help determine if tie strength can have an effect on information dissemination with people outside the organization that are sharing information within a collaborative and non-social setting.

The video conferencing modality did not record the conversations taking place, therefore there was a limitation in determining the effectiveness of this modality's ability to transfer information. Biehl, Avrahami and Dunnigan (2015) performed a study in which they were able to monitor participants' contributions during video conferencing. Perhaps that methodology can be applied to a future study to monitor more accurately the video portion and determine its effectiveness in transferring information and its relationship to tie strength.

Summary

Knowledge sharing within an organization adds economic and social value (Mura, 2013). However, knowledge transfer within an organization remains challenging (Peng, 2013; Wang et al., 2015). Organizations are investing in technology systems to aid in the knowledge transfer process. As organizations invest more in collaborative system

(Hharati, Zhang, & Chuaudhury, 2015), it is important to understand the factors that influence information transfer within a collaborative network.

This study aimed to answer the research questions, “How does tie strength influence the effects of information dissemination within a collaborative social network?” and “How is the relationship between tie strength and information dissemination affected by the type of medium being used within the collaborative network?” The goal of the research was to test tie strength’s effect on information dissemination and to determine which modality of a collaborative system was affected by tie strength.

A literature review was performed to examine comparative studies and determine the most appropriate method for measuring tie strength within a collaborative network. The work of Lin and Lo (2015) explained that knowledge sharing is a social process affected by social motivational factors. The seminal work of Granovetter (1973) provided a basis of measuring tie strength as a relationship factor that can be measured to determine its role in information sharing. Bakshy et al. (2012) explained that stronger ties increase the probability of information sharing. Bharati et al. (2015) determined that using social media promotes organizational efforts in knowledge management. Studies have shown that tie strength affects information dissemination in a public social network (Bakshy et al., 2012; Hansen, 1999). Social media platforms have many of the same characteristics as collaborative technology system.

The current study argued that tie strength can be a determining factor of information dissemination within a collaborative social network. It was hypothesized:

- H1: Relationships that exhibit higher levels of tie strength will disseminate significantly higher levels of information via instant messaging, chat room and video/conferencing modalities of a collaboration system.
- H2: Relationships that exhibit higher levels of tie strength will disseminate significantly higher levels of information via the instant messaging modality of a collaboration system

The hypotheses were tested by collecting data within a live organization to determine the effect of tie strength on information dissemination within a collaborative network. Current studies, including Aral and Walker (2014) and Bakshy et al. (2012) that tested tie strength in a collaborative setting were evaluated to determine methodologies for evaluating tie strength. The proxies of intimacy, social distance and structural variables were used to measure tie strength. Data were collected over a period of one year to analyze the communications of 1,749 connections gathered from 68 users. After data cleansing to remove outliers and establish normality, a total of 986 connections were included in the study, which resulted in 6,021 relevant instant messages, 4,395 chat communications, and 422 video communications. Data were also aggregated to determine the tie strength of each relationship.

Tie strength was compared with the communication data collected to analyze if tie strength affected information sharing. AMOS was first used to test the model using SEM, but analysis determined that SEM was not the appropriate method for testing the proposed model. The hypotheses were modified and MANOVA testing was successfully used to evaluate the proposed model.

The results confirmed both hypothesis through MANOVA testing, which concluded that tie strength does have a positive impact on information dissemination, and the modality of instant messaging is most affected by the level of tie strength within a relationship. The study confirmed the results of previous research that indicated that tie strength does contribute to information sharing (Casmir et al., 2012; Kim, Lee, & Elias, 2015; Luarn & Chui, 2015).

The study contributed to literature by confirming factors that can be used to measure tie strength within a collaborative environment, therefore improving the measurement instrument for tie strength. The study supported previous literature and applied it to a collaborative environment by confirming that people seek support via their strong ties, even within organizations. The study established a method for collecting tie strength data from a collaborative system without relying on the use of surveys or interviews.

The study also provided practical contributions for organizations. It confirmed that increasing tie strength efforts within an organization can be an effective in increasing information dissemination via a collaborative system. It also proposed that before investing in the implementation of a collaborative system, efforts should be made to increase closeness within relationships and provide appropriate training to increase the amount of information transferred.

The main limitation of the study was the inability to distinguish between knowledge and information sharing. Roberts (2000) explains that knowledge is the productive use of information. However, this study did not have a method of determining how or if the information was put into practice or applied.

Future studies can incorporate a purposive sample to include relationships with equal amounts of tie strength and technological skills to reduce the skewness of data collected. Methods can be incorporated to capture communication through all modalities, including video conferencing, to be able to fully determine the information being transferred through the system. A future study could incorporate follow-up with those involved in the study to determine if knowledge was transferred instead of just information. A test can be administered to determine the usefulness of the information that was transferred between relationships. This study can also be performed on other companies to determine if the results can be replicated. Future studies can incorporate external relationships to determine the effectiveness on clients and customers. The study can also be revised to determine how the collaborative systems can effect tie strength over a period of time.

Appendix A

IRB Exempt Letter

MEMORANDUM

To: **Cristelia Hinojosa**
College of Engineering and Computing

From: **Ling Wang, Ph.D.,**
Center Representative, Institutional Review Board

Date: **August 18, 2016**

Re: **IRB #: 2016-357; Title, “Organizational Information Dissemination Within Collaborative Networks Using Digital Communication Tools”**

I have reviewed the above-referenced research protocol at the center level. Based on the information provided, I have determined that this study is exempt from further IRB review under **45 CFR 46.101(b) (Exempt Category 2)**. You may proceed with your study as described to the IRB. As principal investigator, you must adhere to the following requirements:

- 1) **CONSENT:** If recruitment procedures include consent forms, they must be obtained in such a manner that they are clearly understood by the subjects and the process affords subjects the opportunity to ask questions, obtain detailed answers from those directly involved in the research, and have sufficient time to consider their participation after they have been provided this information. The subjects must be given a copy of the signed consent document, and a copy must be placed in a secure file separate from de-identified participant information. Record of informed consent must be retained for a minimum of three years from the conclusion of the study.
- 2) **ADVERSE EVENTS/UNANTICIPATED PROBLEMS:** The principal investigator is required to notify the IRB chair and me (954-262-5369 and Ling Wang, Ph.D., respectively) of any adverse reactions or unanticipated events that may develop as a result of this study. Reactions or events may include, but are not limited to, injury, depression as a result of participation in the study, life-threatening situation, death, or loss of confidentiality/anonymity of subject. Approval may be withdrawn if the problem is serious.
- 3) **AMENDMENTS:** Any changes in the study (e.g., procedures, number or types of subjects, consent forms, investigators, etc.) must be approved by the IRB prior to implementation. Please be advised that changes in a study may require further review depending on the nature of the change. Please contact me with any questions regarding amendments or changes to your study.

The NSU IRB is in compliance with the requirements for the protection of human subjects prescribed in Part 46 of Title 45 of the Code of Federal Regulations (45 CFR 46) revised June 18, 1991.

Cc: **Timothy J Ellis, Ph.D.**

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The Graduate School of Computer and Information Sciences

Certification of Authorship of Doctoral Course Directed Research Assignment

Dissertation Report

Submitted to (Professor's Name): Dr. Timothy Ellis

Student's Name: Cristelia Z. Hinojosa

Date of Submission: 3/24/2017

Purpose and Title of Submission: Dissertation Report

Certification of Authorship: I hereby certify that I am the author of this document and that any assistance I received in its preparation is fully acknowledged and disclosed in the document. I have also cited all sources from which I obtained data, ideas, or words that are copied directly or paraphrased in the document. Sources are properly credited according to accepted standards for professional publications. I also certify that this paper was prepared by me for this purpose.

Student's Signature: Cristelia Z. Hinojosa