Whom to appease and whom to circumvent: analyzing knowledge sharing with social networks

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Abstract

Purpose – In an academic and research institution of repute, where the student researcher's creative mind and innovative potentials are the kingpin factors, it is of primary interest to segregate and pool competencies at an individual level and to create dynamic synergetic effects. Knowledge about potential core competencies and own resources, facilitation of existing personal relationships and the development of new personal relations and cooperation are necessary prerequisites. This is where social network analysis (SNA) acts as a useful tool for measuring the performance of knowledge sharing.

Design/methodology/approach – The current study makes a detailed analysis of the knowledge sharing network among the student researchers. The research study estimates different parameters such as knowledge sharing in various departments, the motivation for research and research environment. This work mainly attempts to undertake a differential analysis of the knowledge sharing pattern among the research scholars with the aid of Pajek software and R programming.

Findings – A holistic knowledge sharing network for the entire set of research scholars is established and the centrality features of the network and among the departments are analyzed, leading to a road map which deliberates on whom to appease and whom to circumvent.

Research limitations/implications – Every institute or organization can use the SNA to identify the key stakeholders in the knowledge sharing environment or the kingpin actors who are prone to knowledge hiding. Such useful identification of the vital stakeholders can give information on how to eliminate the barriers in the knowledge management systems, so that enhanced level of collaboration happens.

Originality/value – This is the first comprehensive SNA to decipher the knowledge sharing pattern among researchers. This work characterizes knowledge management research literature and thereby offers to reduce redundant research by delineating the possible avenues in the area of knowledge sharing.

Keywords Knowledge management, Knowledge sharing, Social network analysis, Knowledge hiding, Degree centrality, Closeness centrality

Paper type Research paper

Introduction

The sustenance and progress of any organization or institution are directly dependent on the level of knowledge sharing within the institute (Ali *et al.*, 2014). Knowledge sharing in the service sector was underscored by critical studies in the banking industry (Swan *et al.*, 1999). The World Bank operations evaluations department had come out with a comprehensive analysis of the value and benefits of knowledge sharing. Further, the concept of example-based knowledge management was established by Huber (1991). This was later developed

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and channelized to different sections. But, the relative benefits of the same were established much later. This happened once data started piling up and research methods were set up to decipher the same. The enormous amount of knowledge available in terms of data stands redundant if the same is not documented and shared (Lee *et al.*, 2016). The very existence of an institution is categorically connected to the knowledge sharing within and outside the institute. This warrants effective knowledge management in all organizational setups (Cai *et al.*, 2014).

Naif Marouf (2007) established that in an academic research institution, where the student researcher's innovative potentials, creative mind and the critical abilities for self-standardization play a vital role, it is of kingpin interest to segregate and pool competencies at different levels and to create active synergetic effects and optimal cooperation. For underscoring this, the needs (physical needs, knowledge source needs and emotional needs) of research scholar in a research institute have to be gauged (Zuo *et al.*, 2013). Researchers need people for guiding and day-to-day problem-solving. Also, the researchers need research papers, databases for secondary data, experimental infrastructure, testing laboratories, computational infrastructure, etc., for carrying out active research (Martins, 2012). Guo and Chen (2010) underscored that for active mitigation of such need aspects, we should have a sound knowledge sharing system which enables collaboration with the research supervisor, co-supervisor, fellow research scholar, research scholars from other disciplines, technical staff and the Doctoral Committee (DC) members. These are the inevitable different stakeholders in the knowledge sharing ecosystem in a technical education and research institute.

Therefore, knowledge about potential core competencies and individual resources, facilitation of existing personal relationships and the development of new personal relations and cooperation are necessary prerequisites (Shaarawy and Abdelghaffar, 2017). This is where social network analysis (SNA) acts as a useful tool for measuring and increasing the performance of knowledge sharing (Zhang and Venkatesh, 2017). SNA helps to gain objective insights into the network structures and roles using simple patterns and arrangements of relationships (such as who interacts with whom) thoroughly based on a final single event of data collection via questionnaire, survey or interview method (Henneberg *et al.*, 2009). From the perspective of knowledge management, SNA aids in identifying basic network properties, positions of network members, cohesive sub-groups characteristics of relations and bottlenecks of knowledge flows (Siersdorfer *et al.*, 2015)

This study makes a detailed analysis of the knowledge sharing network among the student researcher community. The work includes different parameters such as knowledge sharing in various departments, motivation for research, research environment, the first point of contact, the next point of contact at the instance of a problem, the seating arrangement, time spent with guide, the guide interaction, senior and fellow researchers (even accounting the tea break interactions), communication with research scholars of other departments (inter-disciplinary interaction), etc.

Therefore, this work mainly deals with the differential analysis of the knowledge sharing pattern among the research scholars in a higher educational institution with the aid of Pajek software and R programming, whereby a holistic knowledge sharing network for the entire set of research scholars in the institution is established and the centrality features of the network and among the departments are analyzed, which categorically underscores the knowledge sharing/hiding propensities and patterns of individuals within the context of an educational institution.

Literature review

The management of knowledge is a crucial area probed by researchers in the recent past. The two vital aspects of knowledge management are embodied by the creation of

knowledge and the dissemination of knowledge (von Krogh *et al.*, 2001). Though the creation of knowledge is efficient, the dissemination of the same is not so effective, as there may be cases of broken knowledge sharing links (Hwang *et al.*, 2018) or propensities to hide knowledge (Connelly *et al.*, 2012; Issac and Baral, 2018). Studies on active knowledge management networks have categorically enabled both academicians and practitioners to delineate the benefits of knowledge management and to prevent any knowledge hiding tendencies (Issac and Thomas, 2017). Chin Wei *et al.* (2012) attempts to understand the outcomes of such knowledge-sharing patterns of undergraduate students in public and private universities. Academics are expected to play a vital role in helping their students to share knowledge, emphasizing collaborative learning to reduce competition among students (Phelps *et al.*, 2012). The management of universities can promote knowledge sharing by understanding the critical barriers and motivators of knowledge sharing.

Ali *et al.* (2014) attempt to identify and understand the determinants of knowledge sharing culture, research trends, theories and future research opportunities for knowledge sharing in higher education institutions (HEIs). The study concludes that knowledge sharing culture studies in HEIs is still minimal. An attempt to contribute to this limited research on knowledge sharing in universities, by profiling the attitudes of and intentions toward knowledge sharing of UK academics, was done by Fullwood *et al.* (2013). The study established that the respondents had a positive attitude toward knowledge sharing and their intentions in this area were also good. They have a low level of affiliation to their university, perceptions of a high degree of autonomy and high level of association to their discipline.

Such similar initiatives were taken up by Henttonen *et al.* (2013). Sharma (2012) applied the construct in the Indian context by underscoring the perception of knowledge management orientation in Indian private engineering colleges. The results indicate that five attributes – i.e. knowledge acquisition, knowledge dissemination, leadership, culture and technology – are essential dimensions of knowledge management orientation in engineering institutions. On a similar line, Rangachari (2009) attempted to develop a theoretical framework for understanding the structure of active knowledge sharing networks in professional organizations. The study concluded that knowledge sharing networks in professional complex systems might be more abundant in the hierarchy than in density. Wu and Zhu (2012) attempt to create a related integrated theoretical model for determinants of knowledge sharing behaviors which recognizes knowledge sharing as a positive force for the survival of the organization.

Knowledge sharing was more critically analyzed by Mohammed Fathi *et al.* (2011), who studied the critical determinants of knowledge sharing in the electronics manufacturing industry in Malaysia. The findings underscore that collectivism, social network, social trust, incentive systems, shared goal and self-efficacy emerged significantly except for individualism. An integrated theoretical model on knowledge sharing behaviors in a related link to the above study was developed by Young *et al.* (2012). Interestingly, the study by Henttonen *et al.* (2013) tries to investigate how a team's social-network relationships affect its performance. The study reveals that both dense and fragmented instrumental-network structures affect work team performance. Social networks have indeed turned out to be a useful tool in analyzing the knowledge sharing pattern (Liu *et al.*, 2013). However, fragmentation in expressive networks has a negative impact.

The academic co-authorship networks of European researchers based on publications in leading journals were established by Behara *et al.* (2014). The centrality positions of the leading authors indicated their importance and influence in co-authorship within the operations management (OM) research networks. High total degree centrality places the UK as a leader in the European OM research. Martins (2012) made a study on the analytical

dimensions of knowledge transfer to the subsidiaries. The research was conducted to provide useful insights for multinational corporations that intend to transfer knowledge to their subsidiaries situated in Mozambique. Keeping a related approach Marra *et al.* (2011) took out the study in the context of the supply chain. A list of such knowledge sharing events in such cases has also been studied by Ceballos *et al.* (2017).

Burke (2011) in his study on knowledge sharing in emerging economies comes out with complex and varied findings which ultimately show that there is evident energy, enthusiasm and commitment to knowledge sharing to ensure the success of the business. Knowledge sharing only takes place when there is mutual trust and shared feelings of ownership. Emerging economies are ever dynamic; therefore, this work forms a snapshot of their activities at a particular moment. A related study was done by Gill (2009) on knowledge management initiatives at a small university. The research culture observed there was much shaky. The study followed both technocratic and ecological approaches to develop a sustainable knowledge management platform. Another typical research was carried out by Brown *et al.* (2016), which investigated the human factor in the North American Carbon Programme (NACP) research. Similar to Behara *et al.* (2014), this study uses the SNA of co-authorship ties. The SNA reveals that NACP has formed a tightly connected community with many social links through which knowledge may flow and that it has also expanded its network of institutions involved in carbon cycle research over the past seven years.

The potential of SNA in underlining the effectiveness of the knowledge management system was established by Alamsyah and Peranginangin (2013). An attempt was made by Naif Marouf (2007) to determine the connection between the different types of ties along with the sharing of different kinds of knowledge (Thomas and Issac, 2018). The paper concluded that the strength of both social and business relationships contributed most significantly to the sharing of public and private knowledge in this organization. While closeness predicted the sharing of most kinds of knowledge, it did not predict the sharing of private codified knowledge. This finding suggests that large parts of human knowledge, such as skills, techniques and know-how (i.e. private non-codified knowledge) cannot be easily articulated or communicated in codified forms. Knowledge of this kind is experience-based, and it can be revealed only through practice in a particular context (Chang *et al.*, 2015).

Knowledge management systems used in many organizations have benefitted these organizations immensely. The different studies conducted mainly in the American and European continents stand as evidence for the same (Bodendorf and Kaiser, 2009). Many studies have primarily focused on the effectiveness and efficiency of the knowledge sharing system and the striking advantages of the same (Orman, 1991). The review of the literature identifies two critical grey areas. First, the studies focusing on knowledge sharing in academic institutions are minimal. Research in most of the countries across the globe is spearheaded by the research scholars in academic and technical research institutes. There are categorically minimal studies which focus on the knowledge sharing interactions of these scholars. A critical understanding of the knowledge sharing pattern of these individuals may give insights into the value knowledge sharing has on research outcomes. Second, though SNA is identified as a critical instrument in deciphering the knowledge sharing pattern across organizations, it is sparsely used. This gives the authors the motivation to undertake a dedicated SNA among research scholars in a reputed research institute to establish the level of knowledge sharing among them.

Objectives of the study

The detailed literature review guides us to frame key objectives for this study. This study aims to address the knowledge sharing among the research scholars with the aid of SNA.

This is to be obtained by eliciting two key factors. First, the critical members of a knowledge sharing system in a research institute are identified. Second, the interaction of these identified critical members is established in divergent situations with the aid of centrality measures in SNA. In other words, this study aids in understanding the key individuals who cannot be ignored and the gullible ones who are always overlooked. This understanding may enable the researchers to make the knowledge management network more robust and efficient and can inevitably bring a framework in specific networks to stay away from the menace of knowledge hiding.

Methodology

This research study is undertaken in a reputed techno-management institution and is known for its intellectual capital constituted mainly by its faculty and students. The institute has made a name for itself in the past several decades by imparting quality training in different branches of engineering, architecture and lately management. The institute gives key priority to research activities, which is evident by following aspects:

- a large pool of researchers ranging from faculty members, research scholars, research associates, technical staff and start-up companies;
- a significant recipient of research grants from different agencies of the government and other private or international agencies; and
- a tremendous diversity in research focus which results in both sector-specific and interdisciplinary research findings as evident from the large quantum of research papers published on a year-to-year basis.

The major departments or schools where the research activities are carried out are architecture; biotechnology; chemical engineering; chemistry; civil engineering; computer science and engineering; electrical engineering; electronics and communications engineering (ECE); mathematics; mechanical engineering; school of nanoscience and technology; school of management studies; and physics. Considering all these factors, we conclude that the institute under consideration is the right place to research on knowledge sharing network of student researchers by using SNA.

The subjects in this study are the full-time research scholars having their physical presence in the institute campus. The part-time PhD scholars are excluded from the study subject pool for the fact that a more significant number of interactions with the institute's academic staff (be it physical or virtual nature) exists with the full-time scholars because of their continuous physical presence in the campus. The past studies on knowledge management give a detailed insight into the knowledge sharing in various situation and entities. However, there are minimal studies on knowledge sharing network among student researchers in a publicly funded technical institute. Taking this into consideration, the current research is an attempt to model and investigate the knowledge sharing network among student researchers in such a context.

This study is executed as a survey research conducted within the aforementioned national institute. The questionnaire was developed by adapting items and concepts from prior studies and contextual understandings. A stratified sampling method was used to select participants for this study. The analysis was based on 140 valid responses.

The knowledge source in knowledge management can be classified as:

- *human capital* – guide, co-guide and fellow researchers; and
- *structural capital* – e.g. Google, research papers and databases.

Knowledge source can be either people or knowledge assets. Therefore, the study has categorically included both people and knowledge assets in our network.

Study period and sampling

The study was carried for one semester [six months] among the research scholars. The study defines a research scholar as one who undertakes dedicated research work for more than two years. The study has considered only PhD scholars as subjects. The social network is an outcome of some of the questions asked in the questionnaire relating to the interactions of study subjects with their peers and other academic staff. The social networks were constructed using Pajek and the network analyses were further done using R statistical programs. As mentioned above, the defined population of the study mainly consists of all the available research scholars of the institute during the study duration. The population from which the sample is picked constitutes a heterogeneous group with pockets of homogeneity in between. Stratified sampling technique was applied to collect a representative sample.

The entire sampling plan is also exciting mainly because of the snowball technique used to get the samples. The snowball technique was used because of the vast campus and the mismatch of the schedules between the scholars. It was challenging to spot research scholars of various departments across the institute because of different seating arrangements. Hence, one scholar would direct the researcher to another scholar, thus facilitating the sample identification and saving time. The effective sampling size taken is 140, as shown in Table I; this would allow efficient analysis and evaluation, rightly addressing the underlined objective of the entire study. Such a number will also ensure the removal of any biases that may otherwise creep in owing to the too small or too large sample size. Also, this sample size, because of the stratified sampling technique used, gives an equal opportunity to the research scholars of different departments and removes related biases.

Research instrument and analysis

The study used a semi-structured survey questionnaire to elicit the different scenarios for SNA. The survey was designed in a manner such that the different contexts for SNA described in later sections were effectively captured. The questionnaire mainly had three sections, which are:

Department	Samples
Civil	23
ECE	12
Mechanical	14
Chemical	15
Biotechnology	16
Electrical	16
Chemistry	7
Physics	7
Mathematics	8
CSE	14
SNST	3
SOMS	4
Architecture	1
Total	140

Notes: SNST: School of Materials Science and Engineering; CSE: Computer Science and Engineering; SOMS: School of Management Studies; ECE: Electronics & Communication Engineering

Table I.
Department-wise classification of the sample

(1) *prelude*: demographics, department, specialization and type of research work;
(2) *research in the institute*: motivation, research environment, primary point of contact and research scholar–guide interaction; and
(3) *knowledge sharing*: social interactions, time, place, workshops, online course wares, access to papers and understanding the barriers.

Network construction

This study uses sparse networks. Generally, we can define a sparse network as a "fully connected graph" in which a certain number of connections possess zero weights. The vertices of the graph represent individual interaction between a student researcher and other members in the network, each pair (i,j) of vertices possess an edge between them if there exists an interaction as evident from the questionnaire data. One can describe the sparse network by its adjacency matrix $A_{i,j}$. The adjacent matrix A for this network is essentially represented by:

$$A_{i,j} = \begin{cases} 1 \text{ if i and j are interacting as evident from the questionnaire} \\ \overrightarrow{0} \text{ otherwise} \end{cases}$$

The values in A_{ij} represent whether an edge connects two vertices i and j, and $i, j = 1 \ldots N$. The variable N refers to the size of the network. All interactions were given equal weightage. The critical interactions that have been used for the construction of social networks are:

- The first point of contact at the instance of a problem
- Next point of contact
- Whom do you go out with, in conferences?
- Who suggests the journal for submission of a manuscript?
- If you get stuck in a topic where your guide does not have expertise whom do you meet?
- DC queries – Who do you approach?

The Pajek file was exported into the .net format and was imported into R programming using RStudio and pre-installed igraph. Following network measures were computed for each graph:

- hub nodes for each network with the highest number of degrees;
- degree distribution of the network; and
- power law coefficients.

Results and findings

Though the majority of the research scholars came from departments of civil, mechanical, electrical, ECE, computer science engineering and school of biotechnology, proportionate representation was also given to other streams of engineering and schools as noted in Table I. The positive aspect of this study is that it leaves out no particular stream and focuses on a comprehensive work. The sample turned out to be an almost right mix of both

the female–male population. The female population contributes around 47 per cent of the total sample which ensures proper representation and weight for both the genders.

A lot of factors influencing the knowledge sharing depend upon the type of research work the scholars are carrying out. Hence, this study was keen on identifying the number of research scholars who were involved in different types of research work, namely, experimental, computational, analytical and survey-based. Being primarily an engineering institute, the scholars engaged in computational and analytical work were more than the experimental or survey-based work. Apart from the SNA, as mentioned earlier, an opinion-based survey about the research environment of the institute was also included.

More than 55 per cent of the sample suggested that there exists a supportive environment for research activities. This is vital because the more supportive the research environment, the greater is the possibility of knowledge sharing. Further studies very well prove this contention. But, around 30 per cent pointed out that there are a lot of stringent regulations which dampen the spirit and motivation for research. Approximately 15 per cent had also suggested the existence of high academic rigor within the institute.

Social network analysis (SNA)

The SNA is initiated by capturing the network arrangements for six different situations. These divergent contexts create a platform from which the interactions of the network elements may be analyzed. Each of these networks is plotted according to these contexts and the parameters of these networks such as degree, degree centrality and closeness centrality, which enables further analysis of these networks as given in Table II. The six divergent contexts generating the six networks are as follows:

The social network for the "variable" – first point of contact at the instance of any query – is given in Figure 1. This variable encompasses the real spirit of knowledge sharing to the extent that it can be concluded as the best possible construction of the knowledge sharing model. From the network analysis of this variable as given in Table II, we observe that the interactions are effectively dominated by guide with a degree measure of 58 and corresponding normalized degree centrality value of 0.414286.

Network 1: the first point of contact at the instance of any query

Such dominance inevitably shows that at the instance of any doubt in the mind of research scholar the chances are that scholar approaches the guide or research supervisor first. The subsequent degree centrality measures are in favor of Google, research paper, fellow researchers, senior researchers and co-guide, in that order. The network shows a scale-free behavior and inconspicuously the guide acts as the hub node. As explained earlier closeness centrality gauges the closeness of the research scholars with the authorities (nodes) facilitating knowledge sharing. The closeness centrality follows a similar pattern as the degree centrality; with the highest measure for the guide, followed by Google, research papers and fellow researchers. Interestingly nodes which were very poor in the degree count, such as co-guide, books and Research Gate, come out with decent values of closeness centrality suggesting that there is no direct correlation between the degree and closeness centrality as in the case of degree centrality, but it mainly rests on the fact that these nodes are approachable for the research scholars even though many do not prefer to do the same.

The Network 1 as illustrated in Figure 1 is the collated network of all the survey subjects. A differential departmental analysis may yield different networks as shown in Figure 2. The density of the network explains the interaction pattern in the various departments such as civil engineering, ECE and mechanical engineering. The networks once again are analogous to the parent network in Figure 1, dominated by guide with a degree measure of 10, 5 and 8

Parameters	Guide	Co-guide	Senior researcher	Fellow researcher	Google	Research paper	Books	Research Gate
Network 1								
Degree	58	2	25	26	37	27	4	1
Degree centrality	0.414	0.014	0.178	0.185	0.264	0.192	0.028	0.007
Closeness centrality	0.462	0.308	0.376	0.34	0.406	0.348	0.295	0.241
Network 1A								
Degree	10	2	4	6	8	3	1	1
Degree centrality	0.434	0.086	0.173	0.261	0.347	0.13	0.04	0.04
Closeness centrality	0.461	0.329	0.379	0.361	0.434	0.337	0.24	0.24
Network 1B								
Degree	5	0	0	1	4	3	0	0
Degree centrality	0.385	0	0	0.07	0.307	0.23	0	0
Closeness centrality	0.352	0	0	0.117	0.294	0.235	0	0
Network 1C								
Degree	8	0	1	0	3	3	1	0
Degree centrality	0.5	0	0.0625	0	0.1875	0.1875	0.0625	0
Closeness centrality	0.428	0	0.0952	0	0.19	0.19	0.0952	0
Network 2								
Degree	62	3	29	31	35	7	3	1
Degree centrality	0.443	0.021	0.204	0.221	0.25	0.05	0.0214	0.007
Closeness centrality	0.391	0.027	0.328	0.344	0.37	0.225	0.212	0.013
Network 3								
Degree	7	0	18	66	0	0	0	0
Degree centrality	0.078	0	0.196	0.692	0	0	0	0
Closeness centrality	0.25	0	0.178	0.59	0	0	0	0
Network 4								
Degree	0	9	40	19	41	47	15	14
Degree centrality	0	0.064	0.286	0.135	0.292	0.335	0.107	0.1
Closeness centrality	0	0.283	0.398	0.308	0.41	0.381	0.317	0.306
Network 5								
Degree	7	9	35	13	26	59	25	5
Degree centrality	0.05	0.064	0.25	0.092	0.185	0.421	0.178	0.035
Closeness centrality	0.54	0.276	0.345	0.341	0.366	0.428	0.316	0.288
Network 6								
Degree	91	0	0	44	25	0	0	0
Degree centrality	0.65	0	0	0.314	0.178	0	0	0
Closeness centrality	0.586	0	0	0.418	0.378	0	0	0

Table II.
SNA parameters of various networks

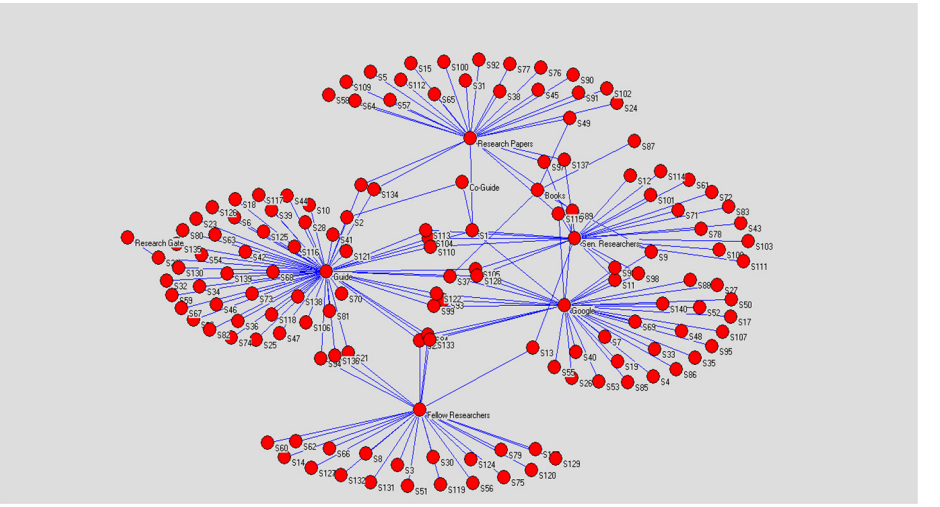

Figure 1.
First point of contact (Network 1)

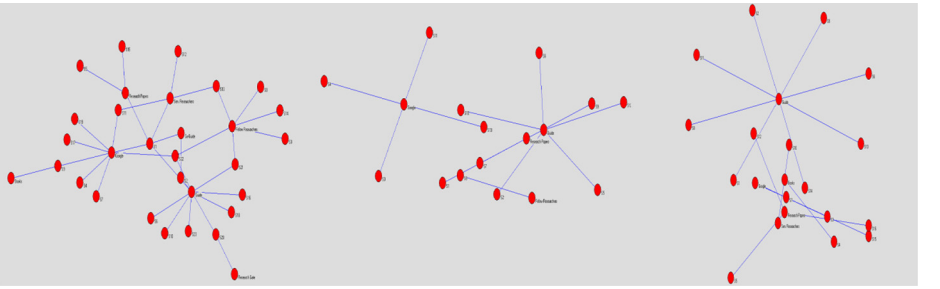

Figure 2.
Representative network of first point of contact for civil engineering, ECE and mechanical engineering departments

for civil, electronics and mechanical engineering, respectively. The corresponding normalized degree centrality values are 0.4348, 0.3846 and 0.5, respectively. Such dominance inevitably shows that at the instance of any doubt in the mind of research scholar the chances are that the scholars approach their research supervisor first. The subsequent degree centrality measure is in favor of Google, fellow researcher and senior researcher for civil engineering. For, ECE, Google and research paper contributes to the degree measure with virtually no contribution from other stakeholders (nodes).

It is interesting to note that scholars associated with the mechanical engineering department also follow a similar pattern. These networks also show scale-free behavior and inevitably in all these networks the primary research supervisor acts as the hub node. As explained earlier closeness centrality gauges the closeness of the research scholars with the authorities (nodes) facilitating knowledge sharing. The closeness centrality follows a similar pattern as in the case of the parent network where it is difficult to conclude a positive correlation of the measure with the degree figure observed. This is reinforced by the fact that nodes which were very poor in the degree count, such as co-guide, books and Research Gate, came out with decent values of closeness centrality. Hence, it enables us to conclude

that these nodes are approachable for the research scholars even though many do not prefer to do the same.

Network 2: next point of contact

The social network of "next point of contact" is given in Figure 3. In this network, we observe that the guide is the hub node with degree measure of 62 and centrality of 0.442857 as shown in Table II. Google, fellow researchers and senior researchers follow the measure with decent figures of centrality. The closeness centrality figure shows the affinity of the research scholars to guide, followed by Google and fellow researchers. This network concludes that as a secondary point of contact, scholars who had opted for research supervisor in the first case go ahead and seek help from Google and fellow researchers. Therefore, these two emerge as the key reference points for scholars after their immediate point of contact – the research supervisor. The individuals who had described the likes of fellow researchers, senior researchers and Google as the primary reference in Network 1 fall back to the guide as the primary option for contact in this network.

Network 3: interaction at tea break

The social network of "interaction at tea break" is illustrated in Figure 4. This network showcases the interactions happening during the tea break of those research scholars who have explicitly mentioned that they would be accompanied by their counterparts or other "point of contacts" when they are out for the break. We observe in this network that it is distinct from the other networks because the peer dominates interaction during tea breaks and such leisurely hours to peer interaction. Therefore, the degree values which are 66 and 18 are categorically higher for fellow researchers and senior researchers than with the otherwise ubiquitous guide. The closeness centrality figure also maintains a similar picture with a slight deviation in the case of senior researchers as observed in Table II for Network 3. The SNA establishes fellow researcher as the hub node.

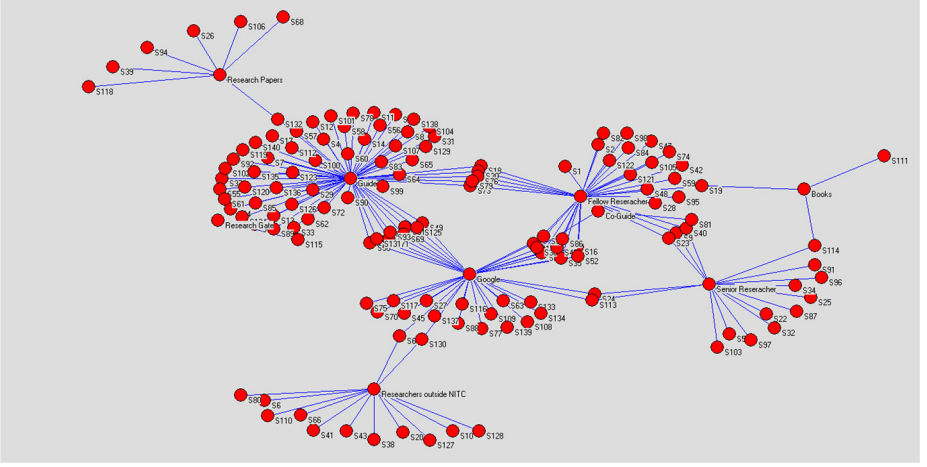

Figure 3.
Next point of contact (Network 2)

Network 4: If you get stuck in a topic where the guide has no expertise, whom do you meet?

The social network of "If you get stuck in a topic where the guide has no expertise, who do you meet?" is given in Figure 5. This network describes the possibility of interaction and knowledge sharing where the research scholar has to look into topics which are not the guide's forte. Such a network explains where the immediate focus of the research scholar lies in the absence of the guide. The main priority goes to a research paper, followed by Google

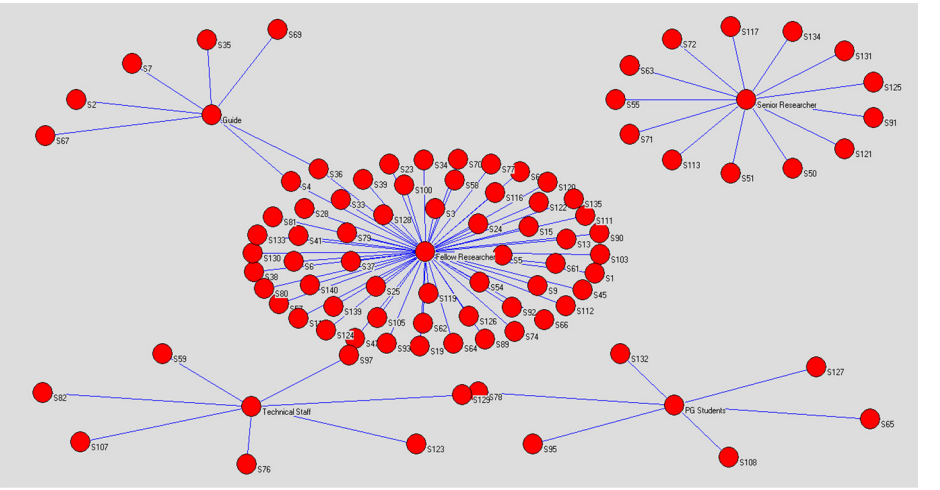

Figure 4.
Interaction at tea break (Network 3)

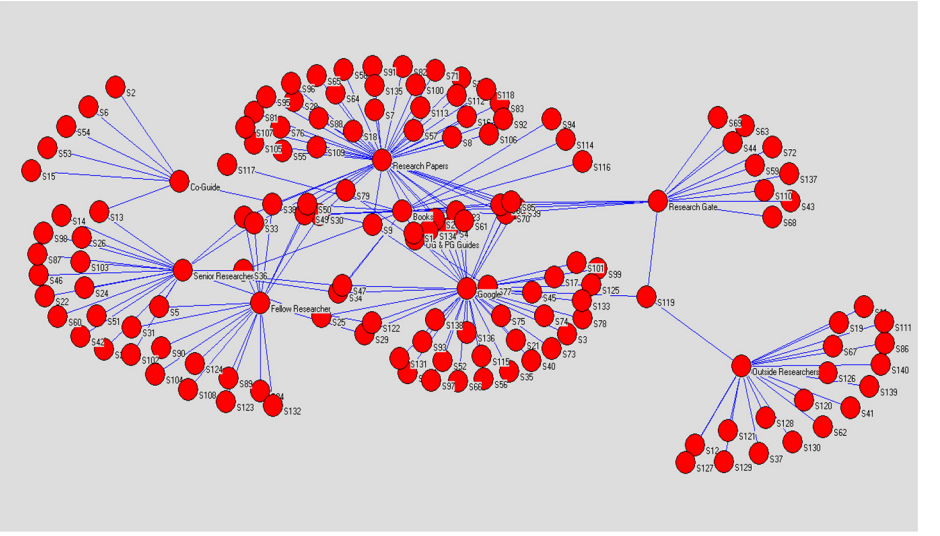

Figure 5.
If you get stuck in a topic where the guide has no expertise, whom do you meet? (Network 4)

and fellow researchers, as indicated by the degree value and corresponding degree centrality in Table II for the Network 4. This is almost consistent with the values of closeness centrality figures though the primacy goes to Google instead of research paper. In this network, the research paper acts as the hub node.

Network 5: After the Doctoral Committee, whom do you approach?

For a doctoral research scholar, the DC meetings are specific milestones where their research work executed till date is presented and a panel of experts examines the progress of the research. In the context of the institute under consideration, the DC meetings happen before the beginning of each semester where a panel of experts from the researcher's parent department and related department examines the research work progress and suggests his future course of direction in the next semester. Any queries emerging out of such meetings always stay as a conundrum.

The researcher attempts various means to find answers to the questions raised against him in the DC meetings. The avenues that the researcher uses to find solutions are depicted in the form of the network as shown in Figure 6. In the network, we can observe that the research papers dominate it and subsequently followed by the senior and fellow researcher. The centrality values clinically reflect this. The degree centrality is highest for the research paper followed by senior researcher, as noted in Table II. It is also surprising to see that the position of the guide is far below in terms of the magnitude of degree and degree centrality. This might be because the questions which are asked may or may not be known to the guide. Interestingly, the value of closeness centrality is highest for the guide. This is an unexpected outcome and is one of the key findings of this study which will be explained in the later sections in greater detail.

Network 6: Who suggests the journal for submission of manuscript?

This network in Figure 7 showcases the submission of a manuscript for a journal and the reference person for the concerted activity. The network is similar to initial networks where the field is governed by the guide, who is the hub node in this network as well. Fellow

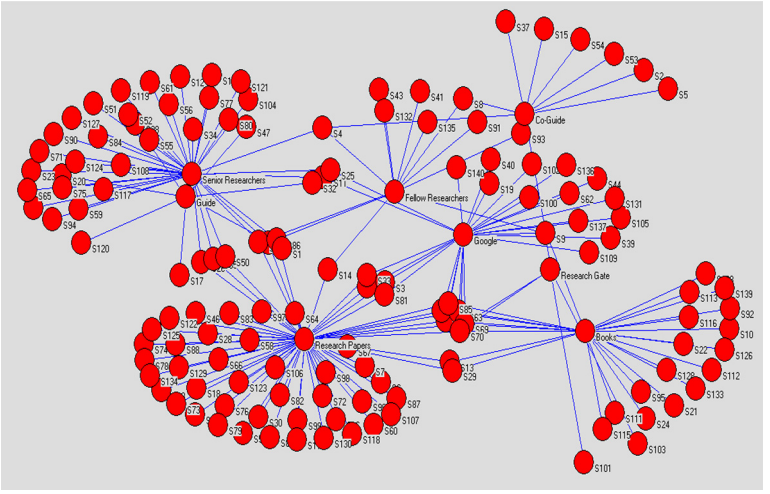

Figure 6.
After DC, whom do you approach? (Network 5)

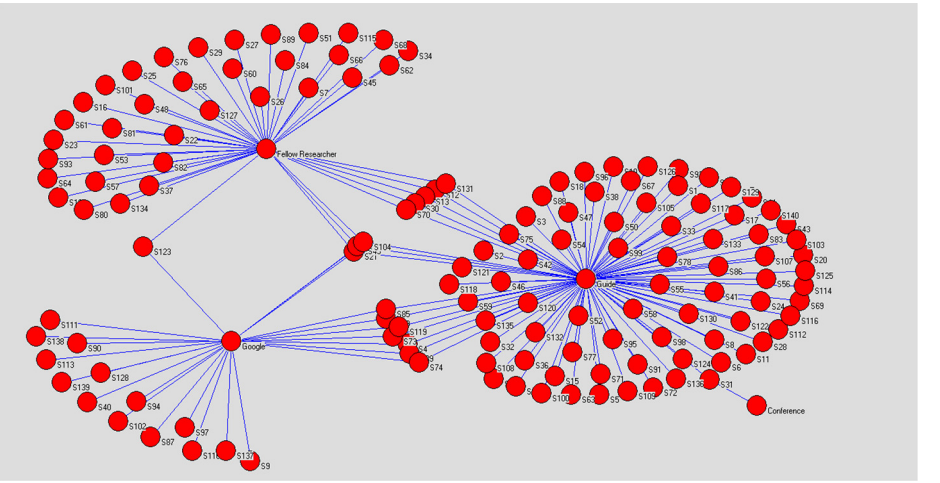

Figure 7.
Who suggests the journal for submission of manuscript? (Network 6)

researcher and Google follow this as evident by the degree measures. This network also supports a scale-free behavior. Table II illustrates that the closeness centrality value is 0.586 for the research supervisor followed by 0.418 and 0.378 for fellow researcher and Google respectively. Table II emphatically concludes that in this network, the closeness centrality replicates the pattern of the degree centrality which again underscores the critical position of the research supervisor in suggesting a journal for submission.

Degree distribution of the network

The plot of the degree distribution of the complete network is illustrated in Figure 8, which underscores that categorically one node (guide) has high levels of degree and is estimated to be 58. This distribution follows power law behavior which underlines the fact that a change in one thing can lead to a large change in other, regardless of the initial magnitude and arrangement. Consequently, this is in agreement with the findings of the SNA conducted above.

Discussion: implications for theory and practice

The SNA brings out a lucid picture of the knowledge sharing existing in the institute with the aid of the six contexts as mentioned above. The research which is anchored on SNA gives an idea about the hub nodes and the relatively important power centers, namely, the knowledge sharing. The Network 1 effectively establishes the research supervisor as the hub node which means that this study underlines the critical importance of the research supervisor for a research scholar. The specific department wise analysis reassures the importance of these key factors in the knowledge management framework. The Network 1 shows that both the measures of degree centrality and closeness centrality are following each other, which undoubtedly explains the generic importance of a supervisor in a research environment.

Though the value of closeness centrality shows the relative closeness of scholars with Google, the degree centrality value underscores the importance of peer learning in the research environment. Therefore, even when there are avenues for self-investigation, the

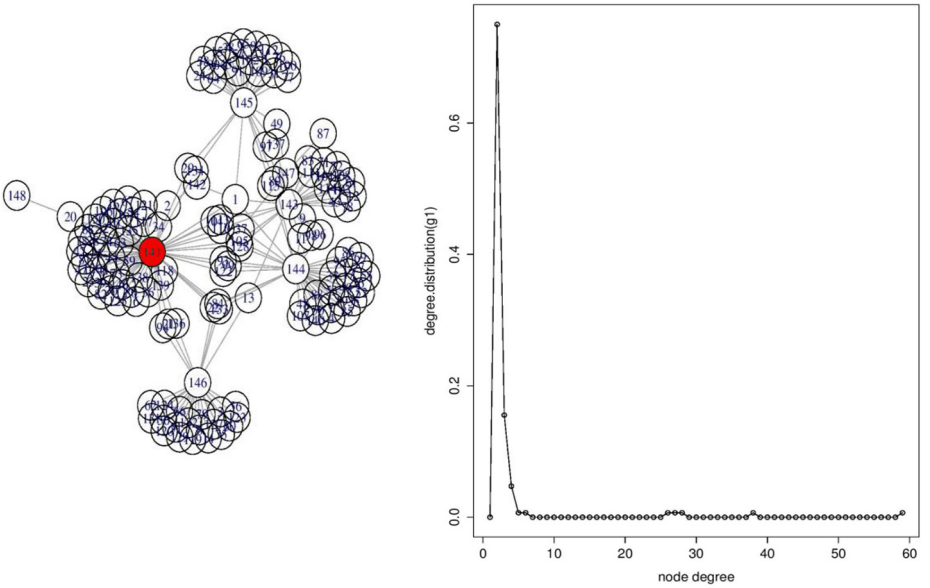

Figure 8.
Degree distribution of the network

scholar prefers to seek help from the fellow and senior researchers. The department-specific differential analysis also corroborates the above finding, i.e. the first point of contact undoubtedly is the research supervisor. Fellow researchers and Google are inevitably the next best associates of the scholars. This is reinforced by Network 2. Though the closeness centrality is in support of research literature, the degree centrality establishes the understanding that researchers value the guidance of the peers more than the external literature.

Effective knowledge sharing can happen even at the most informal meetups which is evident with Network 3. The factors that lead to knowledge hiding are relatively less in this context. The SNA again underscores the importance of fellow researchers. The closeness centrality figures show that even though the research supervisor is quite close to the scholar, still the scholars prefer to share knowledge with the fellow researchers. Therefore, more than the positional authority the credibility and the relatability of the knowledge seeker are more relevant. The critical knowledge is held back from the supervisor owing to the concern of power and psychological ownership over the quantum of knowledge. This builds up the knowledge hiding propensities within the institution.

This outcome can typically be generalized for all higher educational institutions where the authority is undermined and knowledge hiding becomes a norm. The same principles can be effectively extrapolated to organizations, in general, to keep a check on knowledge hiding where it is increasingly becoming a menace. The past three networks and their associated contexts are different from the previous ones in terms of the greater freedom associated with decision-making. In these situations, the selection is more leaning toward outward help such as Google search and research papers. This brings out the relevance of two critical aspects of higher educational institutions. One, the required academic freedom which can aid the scholars to think on their feet and to

bring out innovative solutions by personal efforts. The hand-holding in most of the trivial cases as evident in the initial networks will not make a researcher productive and successful.

Though "easy-help" is very close to the scholars, they prefer to learn and acquire the knowledge on their own by going a mile extra. Learning through experience may be critical for scholars as research is mostly a lone journey. This also has implications in an organizational context. The individuals entering into organizations may be asked to explore and learn on themselves which may add value and ownership to the knowledge acquired. The organizations can categorically facilitate knowledge sharing platforms and portals for the same. Nevertheless, it is clear from the study that the workplace should be made accessible to facilitate productive discussion. The SNA, in general, motivates the scholars to have consistent interaction with their supervisors in higher educational institutions.

The institute should document such interactions which can impart greater discipline to the system and effectively make the research works more productive by capturing the tacit knowledge. This can add up to the knowledge reservoir and make it a repository of institutional memory. The institute should take special care to augment the research rigor and the aforementioned inter-departmental collaborations which can inevitably increase the knowledge sharing propensity of the researchers and can add value to the institutional memory. Every institute or organization can use the SNA to identify the key stakeholders in knowledge sharing or the kingpin actors who are prone to knowledge hiding. Such useful identification of the vital stakeholders can give information on how to eliminate the barriers in the knowledge management systems, so that enhanced level of collaboration happens.

The SNA in this study is mainly undertaken by the estimation of the degrees and centrality measures. Identifying the key points where the node degree is low will help in making strategies to strengthen those points. For example, if the Research Gate score is reflected as low, it indicates that awareness about Research Gate is not there. Hence, awareness sessions may be undertaken as an initiative to correct the knowledge sharing network. If these inputs are well routed and the identified concerns effectively mitigated, the research environment in any research or higher educational institute can be made more vibrant and productive. Increased knowledge sharing will act as a force multiplier where individuals can come together and their potential synergies can be used to ace ahead in the rejuvenating world of research.

Limitations and future research

The research study has tried to cover the entire ambit of knowledge sharing among the research scholars in an academic institution of repute. That said, the study is not devoid of limitations. The research focuses on one particular academic semester. The results may differ with the change in subjects and semester, considering a lot of other factors ranging from physical to psychological. Longitudinal studies spread across different semesters may enhance the validity of such novel approaches such as SNA. Also, the study has not attempted to factor in the research output in terms of the number of papers published. This creates an opportunity for future research incorporating a relational study of knowledge sharing with the research output in terms of articles published. Also, the consistency of these networks on an inter-departmental basis can be analyzed to make such SNA more generic.

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