Effects of Networks on Learning during Emergency Events

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Abstract

Purpose - This paper aims to explore the relationship between learning and the social networks employed within the context of emergency management. We hypothesize using social network theory as a framework for analysis, that changes to interconnectedness between actors are implicated in the potential for those actors to learn and improvise in dynamically changing and emergent conditions.

Design/methodology/approach - To test our hypotheses, we investigate survey data which was collected as part of a research study with the support of the Australian Bushfire Co-operative Research Centre (CRC). This survey was completed by experienced personnel reflecting on a number of indicators in an emergency event.

Findings - Results show that increases in actors' involvement within the social emergency management network influences the ability of those actors to engage in learning-related work activity. We infer that by developing learning related resources within the context of their social interactions these emergency personnel are better able to adapt and improvise in complex emergency events.

Research limitations/implications –As an area of further research, it would be useful to apply the existing theoretical model to the context of another domain, preferably one that shares characteristics of uncertainty and unstable environments.

Originality/value – Most existing studies of learning theory in human networks have focused on learning in situations requiring stable working relationships with no environmental uncertainties. In this paper, we argue that the designs of existing models are useful as a building block, yet flawed for application within the context of disaster management. By presenting a model of learning-related work activity, as an ongoing aspect of network connectedness, personnel within emergency services organizations can strengthen their capacity to be flexible and adaptable.

Keywords Social Networks; Learning; Adaptability; Emergency Management; Bushfire

Introduction

Social network theorists have explored the significance of social communication and network structures on learning at individual and group levels (Granovetter, 1973; Powell *et al.*, 1996; Kraatz, 1998; Knight and Pye, 2004). However, most network studies have focused on networks in very routine and stable situations. Indeed, few studies have been conducted in a dynamic environmental context where agents must adapt to new situations and overcome possibly unpredictable problems, such as emergency events. Catastrophic emergencies are best described by surprising and remarkable interruptions to the communication and decision-making capabilities of the emergency response system itself, and a failure in coordination and communication (Kapucu and Van Wart, 2006). Overwhelming emergencies are qualitatively and quantitatively different from routine emergencies, and they are more than simply a "very large scale traffic accident" (Quarantelli, 2005). The context of routine emergencies is usually based on stable working relationships with limited environmental uncertainties. Therefore, in this paper we will only consider complex emergency events because we contend that these events represent a more dynamic environmental emergency management context. Understanding these contexts is therefore important to improve emergency management systems to mitigate the vulnerability of local communities to extreme risk.

Emergency management organizations are expected to react to emergencies by reducing the impact of the incident on communities. One of the crucial mechanisms through which organizations can enhance their effectiveness in response is through learning so that adaptation can occur in the context of uncertainty and unpredictability which enable managers and their organisations to respond to feedback from the environment (Carley and Harrald, 1997; Berkes *et al.*, 2003). However, the challenge of learning in the context of an emergency event as it unfolds is not easy (Comfort *et al.*, 2009). Members of organizations engaged in the emergency must therefore improve on their ability to learn during incidents in order to reduce the frequency and severity of errors (Blanco *et al.*, 1996).

In this paper, we investigate the emergency management response to some of Australian bushfire incidents from social networks perspective. Bushfire is a general term, uniquely used by Australians, and includes grass fires, forest fires and scrub fires, i.e. any fire outside the built-up urban environment. In the United States, it is called a wildfire and in Europe and Asia, it is usually called a "forest fire" (Bento-Gonçalves et al., 2012). The paper addresses

the following research questions: How do the network relationships among emergency management groups affect their learning? What is the relationship between use of emergency management social networks and the capacity for learning during response? Do the relationships of actors (i.e., personnel involved in mitigating the emergency event) have implications for the potential to learn as an event unfolds?

Literature Review

Two sources of literature are employed to provide the theoretical development for this paper. - Theories of workplace learning and Social Networks Theory.

Learning Theory Applied to Workplace Organizations

A substantial body of research (Zuboff, 1988; Watkins and Marsick, 1993; Weick and Roberts, 1993; Engeström and Middleton, 1998; Weick and Sutliffe, 2001) within high reliability environments -which includes emergency management work- has suggested that under dynamic and uncertain conditions learning must become integral to the work itself (Owen, 2009). That is, learning must become embedded in the everyday practice of work activity. This has led some experts working within high-reliability environments to examine closely the flow of information within organizations and to advocate for the creation of "generative" organizations where people can think and communicate effectively. Here learning is regarded as a continuous process which becomes important particularly when such work relies on interpersonal communication within and between work groups. In this paper the term *learning-related work activity* is defined as occurring when individuals and groups are engaged in deliberate and constant processes of reflection and conceptualization on experience to generate alternatives courses of action. This includes sharing ideas and observations; clarifying assumptions and courses of action, monitoring and providing feedback on performance (Owen, 2009). Learning-related work activity then enables

individuals and groups to work collectively to adapt and deal with the challenges posed by hazardous events.

For the purposes of this paper, we contend that learning-related work activity is particularly important in domains where there is high uncertainty and where conditions are dynamic and need personnel to act in ways that are coordinated and adaptive. Therefore, in our study of emergency management, we intend to investigate the connection between enabling the practice of learning-related work activity through engagement in social networks.

Networks and Learning

Social networks have attracted considerable attention in recent years. This is because they operate on many levels, from families up to the level of nations, and play an important role in finding the way organizations are run, problems are solved and the way new ideas and practices are spread (Abbasi *et al.*, 2010). A social network consists of a finite set of actors or nodes (e.g. individuals, teams) and the relations or ties (e.g. financial exchange, friends or trade) defined between those set of actors (Wasserman and Faust, 1994). Networks have become a major way forward for organizations that do not have the knowledge, expertise or financial resources to move into new marketplaces sufficiently quickly (Richardson, 1994). Using social network approach in social sciences is helpful in studying social interactions and may provide a means to understand how members of organisations design decisions and how information flows within the organisation which can be critical to effective collaboration (Cross *et al.*, 2002).

Social networks are analysed using different methods and algorithms which can provide us with measures that are useful to understand the hidden pattern within the networks. Social network measures such as centrality and strength of ties was first applied to human communication by Bavelas (1950) in the late 1950s. All the experiments done by Bavelas and his research team concluded that network measures were related to group efficiency in problem-solving, perception of leadership and the personal satisfaction of participants. Their key finding was that centralization in a network structure, which can be measured using social network analysis, leads to enhanced performance in the process of solving simple tasks because appropriate information can be transferred and synthesized to a few individuals who can make a decision and take action. Since then, the notion of centrality, ties, density and centralization were considered as one of the key network measures used for studying

network effects on individual and group outcomes such as task efficiency, productivity, knowledge transfer, employee job satisfaction, information seeking, learning and improved performance (Pfeffer, 1980; Mullen *et al.*, 1991; Faust, 1997; Cross *et al.*, 2002; Ahuja *et al.*, 2003; Borgatti and Cross, 2003; Cross and Cummings, 2004; Inkpen and Tsang, 2005; Hossain *et al.*, 2006; Abbasi *et al.*, 2011). The use of social network measures presented by most of these studies examined group behaviours based on small groups in a stable environment; however, few studies have been conducted in a dynamic environment context such as emergencies. This study adopts the view of networks of learning in a dynamic environment context.

Previous research suggests that interactions between nodes in the network resulted in important opportunities for learning (Granovetter, 1973; Kraatz, 1998). The most seminal work in social networks and its effect on learning and innovation almost always begins with Granovetter's (1973) theory on the strength of weak ties. "The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (Granovetter, 1973, p.1361). A given tie is strong, weak or absent. The mark of strong ties is connections with high intensity of emotional closeness and frequent communication (Granovetter, 1973; Burt, 1992). Granovetter (1973) argues that individuals obtain new and novel information from weak ties rather than strong ties within the individual's group structure. That is, networks, where strong ties tend to bond similar people to each other, are closed networks and according to Granovetter are not well receptive of new information. The implications of Granovetter's theory suggests that the influx of new and novel information must therefore come from weak ties (hence, the theory of the strength of weak ties), which serves as a bridge to a different cluster of people from where the new information originates.

However, other research work done by Kraatz (1998) shows that stronger ties between the nodes of the network will provide better opportunities to learn for those nodes. This study further suggests that organizations in smaller networks, more homogenous networks and older networks will be more likely to adapt their core features in response to environmental change. The view of learning presented by Granovetter (1973) and Kraatz (1998) is valid in stable environments, but this concept in studying and identifying social networks may not be adequate for research in non-routine situations, such as emergency incident management where a key feature of the work is dynamic change and uncertainty. Therefore, in our study of emergency management, we intend to investigate learning through engagement in social

networks in a dynamic environment of emergency management. In light of these arguments, we expect a significant association between team members' ties strength and their learning in dynamic environment.

Networks of Learning in Emergency Events

Researchers suggest that interactions between work groups result in important opportunities for learning during complex emergency events (Kapucu, 2006). During these events, emergency management operations take place in settings of networked actors who necessarily depend on each other. Building networks of effective action is particularly challenging in those environments, which can also be regarded as unstable. Collaborative decision making is needed in those situations because it is an essential element of networks (Berkes et al., 2003). Social networks are not only useful in a functional way but also in a supportive way during complex emergency events. The role of social networks is vital in providing social support and promoting better response through stress management. The individual's need for social connectedness is probably never greater than in times of crisis (Reich, 2006). Social networking was found to be critical in providing alternative support in times of crisis. It provides invaluable support in times of crisis and allows disaster victims to rely on neighbours, friends and relatives for support in terms of resources (Gaillard et al., 2008). However, our research only examines how social network coordinate resources to deal with functional challenges of the response.

In order to meet the challenges raised during emergency events, the need of new systems of governance and knowledge management to deal with increasing unpredictability and complexity has resulted in the creation of a variety of related concepts, such as *adaptive management* and *adaptive resource management* (Holling, 1978; Berkes *et al.*, 2003). The idea is that, in order to manage with the complexity of emergency events, organisational systems and related administration arrangements should include different actors from different areas of society. At these times of emergencies the capacity for learning and innovation is crucial to enduring resilience and the sustainability of basic features of the system. Knowledge of social–ecological systems in their full complexity is needed in order to monitor resource availability, make decisions about allocation, and respond to feedback from the ecosystem at several scales (Berkes et al., 2003). Because of this complexity, it is difficult for any one team or group to acquire the full range of knowledge needed to manage resources. Therefore, effective network coordination between different teams and groups will

be critical for enhanced response to emergencies. Through this new network, the processes of double-loop, generative learning are continued and extended (Berkes et al., 2003). Nevertheless, it is interesting to note that research into how networks are employed to enable acting effectively in such situations is surprisingly limited.

There has been a rise on the research on social network theories and its importance during complex emergency events after the events of September 11 (Kapucu, 2005; Petrescu-Prahova and Butts, 2005; Kapucu, 2006; Carter *et al.*, 2007; Butts, 2009). For example, Kapucu (2006) has demonstrated the importance of networking and learning in disasters during the events on September 11 and in the days and weeks that followed in New York City's massive destruction and social disruption. Assisted by emergency workers, occupants of the (World Trade Center) WTC and people in the surrounding area helped one another to safety, even at great risk to themselves. Prior experience with the 1993 WTC bombing had led to significant learning among organizational tenants and occupants of the Twin Towers, and planning and training contributed to their ability to respond in an adaptive fashion to highly ambiguous and threatening conditions (Kapucu, 2006). In other example about September 11 social network theory, Petrescu-Prahova and Butts (2005) investigated coordination within responder radio communications during the World Trade Centre disaster and found that, regardless of organizational type, the great majority of coordinators do not occupy formal coordinative roles. All those studies have applied social network theories in disaster. However, very few studies have evaluated the relationship between networks and learning in dynamic complex environment. Therefore, in our study of emergency management, we intend to investigate the connection between enabling the practice of learning-related work activity through engagement in social networks.

Our Proposed Model

Based on the review of literature, our proposed model is developed. Unlike previous models which were based on stable environments, the framework of our proposed model, as illustrated in Figure 1, is intended to assess the capacity of personnel to engage learning-related work activity in dynamic emergency management environments. There is a gap in literature addressing the relationship between networks and learning in a dynamic complex environment. The aim of our model is to fill this gap and evaluate the connection between networks and learning in dynamic emergency management environments. In developing the measures of social network and those of learning in dynamic environment, two sources of

data were used. These were: (1) observations on field, experience and subject matter experts, and (2) an analysis of the literature (Dekker and Hansen, 2004; Corbacioglu and Kapucu, 2006). The attributes we are measuring are the degree to which doing so enhances flexibility and satisfaction with the quality of information flow by personnel engaged in emergency management in order to optimize emergency management network performance in unstable environments. The model is constructed with a view to assess the current state of learning-related work activity which we argue is a product of attributes of network relations.
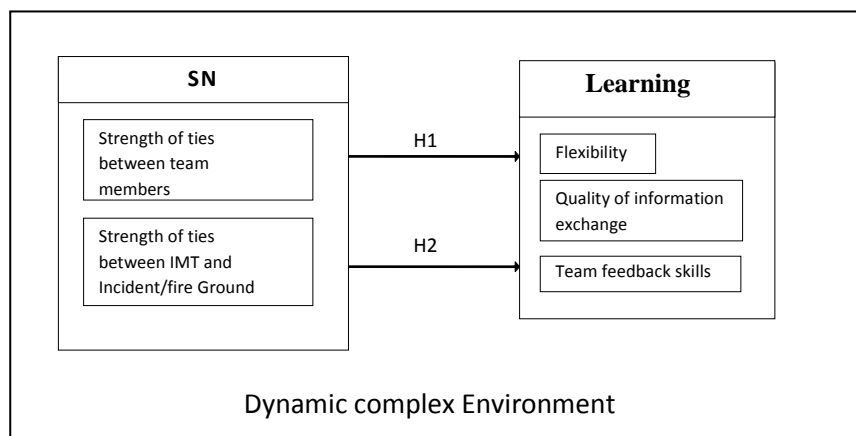

Figure 1: The relationship between social networks and learning in emergency management

In order to measure network relations in the model, the strength of ties between team members and the strength of ties between the Incident Management Team (IMT) and Incident/fire Ground are used as independent variables as shown in the left side of the model in figure 1. These are measured as indicators in order to assess network relationship against learning behaviour. The learning behaviour measures (i.e. flexibility, quality of information exchange and team feedback skills) are used as dependent variables as shown in the right side of our model in figure 1.

Construct Definition

In this section, the definition of the constructs in the model is presented. The description of the final set of scale items that measure the construct is shown later in the method section.

Learning Indicators (Dependent Variables)

Flexibility. Flexibility refers to the ability and willingness to adapt performance strategies quickly and appropriately to changing task demands (Corbacioglu and Kapucu, 2006). In this study flexibility is demonstrated in teamwork where team members are open to adaptation and to changes in strategies based on feedback from others. It has been found that teams need to maintain flexibility in order to respond to unanticipated events (Mendonca *et al.*, 2001). When these situations arise, flexibility will help emergency teams to be better prepared and improvise to fit the requirements of the current situation. The capacity to adjust to rapidly changing emergency condition is an important capability for reducing the vulnerability of local communities. Corbacioglu and Kapucu (2006) showed that in order to help teams to learn and adapt to shifting conditions in their environments, sufficient flexibility for processing information will be needed. Therefore, an analysis of the perceived "flexibility" is used to indicate openness of an actor's to learning from team members.

Quality of information exchange. Previous research has shown that the major influence to work-related learning activity is the quality of information exchange which involves passing relevant data to team members who need it, in a timely manner, including transmitting and receiving (Dekker and Hansen, 2004). Researchers suggest that dissemination of knowledge is an important behavioural aspect of learning (Dekker and Hansen, 2004). Sharing lessons within an organization or a larger inter-organizational field obviously leads to more broad-based learning (Huber, 1991). Researchers also highlight that adequate organizational structures for information acquisition, dissemination, storage and interpretation can help members of organizations to learn and adapt to shifting conditions in their environments rapidly (Corbacioglu and Kapucu, 2006). Therefore, an analysis of the perceived "quality of information exchange" is used to indicate the resources available for learning.

Team feedback skills. Previous studies have characterized learning as dependent on attention to feedback (Schon, 1983). Feedback skills is defined as the ability to enable team members to communicate their observations, concerns, suggestions and requests in a clear and direct manner without becoming hostile and defensive. Learning has been conceptualized at the group level of analysis as an on-going process of reflection and action, characterized by asking questions, seeking feed-back, experimenting, reflecting on results, and discussing errors or unexpected outcomes of actions (Edmondson, 1999). It was also found that there were differential effects of feedback on learning and team performance in crisis situations

(Rouse *et al.*, 1992). Therefore, we include indicators of perceived "team feedback skills" to determine the interpersonal conditions to support learning.

Social Network Indicators (Independent Variables)

Strength of ties between team members. The construct of strength of ties is defined earlier in literature review as (Granovetter, 1973) "The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie". The notion of strength of ties were considered as one of the key network measures used for studying network effects on individual and group outcomes such as learning and performance (Granovetter, 1973; Kraatz, 1998). Therefore, we investigate the strength of ties between team members within a team whether this team is at an operational level or at the IMT level and use it as a social network indicator.

Strength of ties between IMT and Incident/fire Ground. In an emergency management organizational response, information flows between first responders (e.g. those on the fire or incident ground) and those charged with the responsibility of managing the emergency (the IMT) and this part of the overall network is crucial. In previous research, information flow between these two components in an incident management structure has been found to be the first to breakdown (Dwyer and Owen, 2009). Given the importance of the relationships between those on the fire or incident ground and those on the IMT, our study will investigate the link between them.

Based on the review of literature and in alignment with the model, the following hypotheses are proposed:

H1 (within team communication, or inter-team communication): There is a significant relationship between strength of ties between team members and the learning-related work activity of an actor.

To assess this hypothesis, three sub-hypotheses are presented to evaluate and test the proposed theoretical model based on the perceptions of actors in the data collected. They are:

• (H1a) Strength of ties between team members will be significantly associated with perceived flexibility

• (H1b) Strength of ties between team members will be significantly associated with perceived quality of information exchange

• (H1c) Strength of ties between team members will be significantly associated with perceived team feedback skills

H2 (across teams' communication or intra-team communication): There is a significant relationship between strength of ties between IMT and Incident/fire Ground and the learning-related work activity of an actor.

To assess this hypothesis, three sub-hypotheses are presented to evaluate and test the proposed theoretical model based on the perceptions of actors in the data collected. They are:

• (H2a) Strength of ties between IMT and Incident/fire Ground will be significantly associated with perceived flexibility

• (H2b) Strength of ties between IMT and Incident/fire Ground will be significantly associated with perceived quality of information exchange

• (H2c) Strength of ties between IMT and Incident/fire Ground will be significantly associated with perceived team feedback skills

Method

Data

The data used in this analysis comes from primary research collected from a research team supported by the Bushfire CRC[1] and led by one of the authors. The analysis reported here is thus a secondary analysis conducted as part of a subsequent collaboration. To collect the primary data, a questionnaire was distributed to 25 agencies in Australia aiming to assess how information flowed between emergency incident management personnel at different layers of the Australian and New Zealand incident control system, and what enabled and constrained coordination between those personnel. Emergency management in Australia is based on what is called the Australasian Inter-service Incident Management System (AIIMS)

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1 The Bushfire Co-operative Research Centre is a nationally funded research centre [For more information, see - http://www.bushfirecrc.com/]

which in turn was based on the American model of National Incident Management system (NIMS) (AFAC, 2005).

Work is organized in distributed work teams, with personnel working on the fire- or incident ground, within a locally-based IMT and supported through coordination practices at regional and state levels. Decisions about managing the incident are made at the IMT level and communication between the IMT and the fire-or incident ground is critical to the success of the operation.

Respondents were asked to give their perceptions on a range of indicators of information flow and teamwork within the AIIMS system. They were asked to think about one incident and to identify the characteristics of that incident, e.g. whether they received a briefing or incident action plan, whether particular risk management and assessment tools were in use and whether particular teamwork indicators were in use.

Throughout the questionnaire (depending on the type of question), respondents were asked either to tick a box or boxes, or give a rating via 7-point Likert Scales (De Vaus, 2002). Personnel from Fire and Emergency Services agencies were targeted from a range of emergency incident management roles which included those who worked on the fire or incident ground; those who worked in IMTs and those who worked in regional or state centres of coordination (Dwyer and Owen, 2009). The questionnaire was completed by 543 people in different layers within the AIIMS structure – 109 (19%) worked directly on the fire or other incident, 375 (65%) were in (IMT), and 59 (10%) were engaged in regional or state-level coordination. The details of the demographic details of respondents are shown in Table 1. The participation rate for males who completed the survey is 73% and for females is 12.5% while there were 14.5% who did not respond to this question. Table 1 also shows the age distribution of respondents. It can be seen that the majority of respondents are over 40 years of age (35.6% of respondents were between 50 and 59 and 6.3% over 60). In addition, Table 1 shows the average number of years respondents had performed in their respective roles (9 to 13 years). The role of coordination, particularly at a regional level is one that has only recently developed and this is indicated in the proportion of respondents who had less than 5 years experience in their role (44%), and in the average number of incidents (5) attended in that role. Table 1 also shows Incident Controllers/Deputy Incident Controllers (ICs/DICs) had the most experience (13 incidents).

Table 1. Demographic Details of Respondents

Age	%	Gender	%
20-29	3	Male	73
30-39	16.2	Female	12.5
40-49	38.9	Unidentified	14.5
50-59	35.6		
60+	6.3		

Position	Detailed Position	N	%	Mean years exp in role	% <5 years exp in role	Ave N of incidents attended in role
Incident Ground	Fire Ground	109	18.8	11	26.3	13
Incident Management Team	IC/DIC	112	19.3	13	24.3	15
	Operations	96	16.6	13	29.6	12
	Planning	107	18.5	8	38.4	11
	Logistics	60	10.4	9	44	8
Coordination	Coordination	59	10.2	N/A	42.9	5
	Total	543	93.8			

Data Limitations

There are two main limitations that can be identified in this research. First, the sample might not reflect the entire population of personnel involved in incident management even though the questionnaire includes a sizeable proportion of the emergency management population across Australia and New Zealand. Second, as in most self-completion surveys, the responses might be biased through memory and the motivations of people who took the time to complete it. From this point of view it is important to review the results cautiously and to consider the directions they might indicate for further research validation.

Exploring the data

For the purpose of this paper the analysis has been narrowed to focus only on complex emergency events for the reasons discussed before. We have considered only incidents which are on ICS (Incident Control System) level 3. A level 3 incident is defined as one that is sufficiently complex to involve the full deployment of an ICS. We examined incidents where: the perceived complexity level is high; the number of people involved at peak of incident is above 100; the number of agencies involved at peak of incident is more than 7; and the number of threats is more than 6 and have affected the infrastructure. Thus, for our analysis, the number of cases has been reduced to 69.

Analysis of the dataset for the purposes of this paper first involved a thorough exploration of the survey instrument to identify possible questions that would provide relational data to assess the respondents' social network, or questions relevant to learning measures as proposed in the model. As can be seen from Table 2, there were six items assessing the strength of ties between team members and five items assessing the strength of ties between IMT and ground/ fire incident for social network measures. For learning measures, three survey items were included to assess perceptions of team flexibility, five items for the information exchange and four items for team feedback skills.

The learning measures were derived and validated from the human factors literature. For each learning indicator item, the exact wording of the item and a reference to the literature discussing the construct/item can be found in Owen and Dwyer (2009). For the social network indicators, the scale items are drawn from the social network literature (Granovetter, 1973; Kraatz, 1998). Tests using Cronbach's alpha coefficient were conducted to assess the internal reliability of the items. The Cronbach's alpha coefficients surpass the 0.7 threshold recommended by Cronbach (1951) and Nunnally (1978) to be satisfactory. So, all our measures are considered reliable. The details of the statistics are shown in Table 3. For any key indicator, the scores of the items are combined to form the respondent's degree of that indicator. In these sections the data reported are predominantly at an ordinal level of measurement and initial review showed that the spread of scores did not represent a normal distribution. Therefore, nonparametric statistical tests are applied to test hypotheses, as defined in the research model.

Table 2: Survey Item relevant to network and learning measures

Variable	Survey Items

Strength of ties between team members	3.2.5 Team members effectively monitored each other's performance
	3.2.6 Team members exhibited a strong 'we are in this together' attitude
	3.2.14 Team members anticipated the needs of others
	3.2.18 Team members trusted each other
	3.2.19 New team members were quickly integrated into the team
	3.2.23 Comfortable approaching members of the team for help when Needed
Strength of ties between IMT and incident/fire ground	4.1.4 IMT and Fire/Incident Ground personnel effectively monitored each other's performance.
	4.1.5 IMT and Fire/Incident Ground personnel exhibited a strong 'we are in this together' attitude.
	4.1.11 IMT and Fire/Incident Ground personnel were able to state and maintain opinions openly with each other.
	4.1.14 IMT and Fire/Incident Ground personnel anticipated the needs of others.
	4.1.18 IMT and Fire/Incident Ground personnel trusted each other.
Flexibility	3.2.13 Strategies were adjusted in a timely manner as the incident unfolded
	3.2.15 Roles were effectively re-allocated as the situation changed
	3.2.22 When problems occurred the team was able to recover quickly and get on with the job
Information exchange	3.2.1 Team members exchanged information clearly
	3.2.2 Team members exchanged information accurately
	3.2.8 Team members kept one another well informed about work-related issues
	3.2.9 There were genuine attempts to share information
	3.2.16 Team members interacted effectively with stakeholders outside their own team
Team feedback skills	3.2.3 Team members provided helpful advice to each other
	3.2.4 Team members provided constructive feedback to each other
	3.2.10 Team members shared their individual knowledge to gain a better understanding of the situation at hand
	3.2.21 Team members received clear direction in relation to the tasks at hand (from the supervisor or officer in charge)

Table 3: Reliability Statistics

Variable	Cronbach's Alpha	N of Items
Strength of ties between team members	0.971	6
Strength of ties between IMT and incident/fire ground	0.923	5
Flexibility	0.812	3
Information exchange	0.906	5
Team feedback skills	0.875	4

Results and discussion

A Spearman correlation test was carried out to test all the hypotheses and to determine if there is a relationship between the independent network relationship variables (i.e. tie strength between the team members and ties strength between IMT and ground/ fire incident) with the dependent learning variables (i.e. flexibility, quality of information exchange and team feedback skills). The result of Spearman test in Table 4 indicates that there is a positive correlation between each independent variable and all dependent variables.

Table 4: Results of Spearman Correlation test

	Variable	Mean	Standard Deviation	1	2	3	4	5
1	Strength Of Ties Team	5.64	.92	1.00				
2	Strength Of Ties IMT Ground	5.34	1.06	.78**	1.00			
3	Flexibility	5.57	.99	.81**	.72**	1.00		
4	Information Exchange	5.62	.93	.87**	.75**	.76**	1.00	
5	Team Feedback Skills	5.66	1.00	.88**	.74**	.76**	.89**	1.00

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The results of Spearman correlation test indicate that an increase in the tie strength between the team members is associated with an increase in the flexibility, quality of information exchange and team feedback skills; the results are all significant at the 0.01 level. The same finding applies for the other network relationships variable of tie strength between members of the IMT and those working on the fire- or incident-ground. In conclusion, the analysis shows that all hypotheses holds true.

Using the framework of the research study, the results show support for Hypotheses 1a and 2a that stronger ties (both intra- and inter-team) is significantly associated with team flexibility. Based on that, it can be argued that more investment in existing social relationships (both intra- and inter-team) will enable individuals and teams to know each other roles and widen their knowledge of the work. This will enhance the ability of individual

and teams to adapt changing strategies which in time could improve their flexibility. Effective flexibility allows a team to deal successfully with the unexpected and maintain regularly safe and effective service. As a result of this, individuals and teams will be more able to recover quickly and get on with the job when problems occur during emergency events because of better networked relationships. As the situation changes during emergency events, improved working relationships may also lead to roles to be effectively re-allocated and strategies to be adjusted in timely manner which lead to better performance.

In addition, the results show support for Hypotheses 1b and 2b stronger ties (both intra- and inter-team) will provide an ideal atmosphere for team members to exchange information effectively. This indicates improved access to information that is of better quality which enables personnel within emergency services organizations to perform their role better because of the information sharing that is occurring. The better networked relationships (both intra- and inter-team) also lead to improved access of resources which would permit individual and teams to exchange information accurately, clearly and in a timely manner. Effective information exchange helps team members to build and maintain their own situation awareness as well as contribute to the teams understanding of the big picture. We can say based on our results that better networked relationships will motivate individuals and teams to share information and keep others informed about work-related issues which will cause for more attempts to share information and facilitate further learning.

Findings from this study also show statistical support for the hypotheses 1c and 2c that stronger ties (both intra- and inter-team) will provide an ideal atmosphere for team members to provide helpful advice and constructive feedback to each other. Investing in existing social relationships can build trust and common shared knowledge which encourage personnel within emergency services organizations to provide constructive feedback to each other and to receive clearer direction in relations to the task in hands from the supervisor or officer in charge which can facilitate team support learning-related work activity. With effective team feedback skills the team can correct and prevent errors, resolve conflict and continuously improve performance. In addition, better networked relationships allow members to foresee the information needs of others, support one another during extreme stress periods and avoid frustration and conflicts. Thus, it can be argued that when personnel and teams in an emergency network invest in existing relationships to strengthen the bond, inter-organizational dependency is supported through the development practices that support

learning-related work activity. Therefore, the data discussed supports our main hypotheses that improved working relationships may then have a positive effect on sharing, which may facilitate further learning and the perceived state of readiness to interact with other personnel involved in emergency management.

We can also conclude from our study that the lack of direct relationships and extensive communication among personnel within emergency services organizations is considered to be an impeding factor for the success of knowledge sharing and hence learning within the context of emergency management organizations. Close and frequent interactions between teams and across teams within emergency management organizations are therefore seen as a perquisite for the timely integration of knowledge across organizational boundaries that lead to an effective response to emergency events. We suggest that learning initiatives within emergency management organizations require a certain amount of coercion by top management or the development of a culture that allow change instigated by individuals or teams in order to produce an environment for learning at the individual and team level.

Moreover, we can suggest based on our results that social networks can help organizations to share or pool knowledge which is considered vital for facilitating effective knowledge sharing. Therefore, encouraging socialization as a mean to knowledge sharing is also seen as critical for facilitating learning in organizations. In particular, we conclude that continuous learning occurs when an organization is able to accommodate the development of informal networks through their existing legitimate network structure. These informal networks which are based on relationships of trust, advice, past working relationships, or team membership are to a greater extent valuable contributor to performance (Cross *et al.*, 2002; Cross and Parker, 2004). Rapid activation of appropriate social networks including local participation and the transfer, use, and quality of shared information is critical to effective learning during emergency events. Existing theories of social networks do not address these issues adequately. We argue that the use of social network helps building a collaborative, sharing and learning culture in organizations. This would help build trust among individuals so that a higher level of collaboration and learning may be achieved.

Conclusion

Social networks theories and its affect on learning have been successfully used in many different areas of business and government where the environment is stable. In this paper, we

have shown that social networks can be applied to complex and dynamic environment in emergency scenarios and situations. The value of this is to expose the value of learning behaviours in chaotic and often dangerous situations. The results provide greater support for the above-mentioned hypotheses. The learning measure was positively correlated with both strength of ties between team members and strength of ties between members of the IMT and personnel working on the incident- or fire-ground. It can be concluded that successful learning depends not only on formal and planned organizational implementation activities but also on the capabilities of the existing and emergent social networks. Improved communication within teams enhances effectiveness of perceived emergency management performance.

It can also be argued that the communication across teams is as important as communication within teams. Emergency managers should invest in existing relationships across teams to strengthen the bonds. These better networked relationships enhance flexibility and satisfaction with the quality of information flow by personnel engaged in emergency management which optimize emergency management network performance in unstable environments. Investing in existing social relationships can build trust and common shared knowledge which support learning-related work activity and the perceived state of readiness to interact with other personnel involved in emergency management.

As an area of further research, it would be useful to conduct more research to investigate networks within emergency services from a social networks perspective. Further whole network analysis conceptual tools such as centrality analyses can then be conducted and could be introduced as new independent variables in our model which would provide a richer picture in terms of understanding network, learning and performance patterns during emergency events. Another valuable task for further research would be to apply the existing theoretical model to the context of another domain, preferably one that shares characteristics of uncertainty and unstable environments. For example, the model could be applied to a range of other crisis and emergency events (e.g. floods) to understand what factors of social network may affect learning and performance.

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