DISCONTINUITY IN ORGANIZATIONS: KNOWLEDGE FLOW BEHAVIORS IN SEQUENTIAL WORKFLOW PROCESSES

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3.1 ABSTRACT

Maintaining product feasibility and managing knowledge flows are difficult if an organization has to operate in an equivocal environment. We build upon an ethnographic study and computational organization theory (COT) modeling to study how knowledge flow—defined as allocation and retrieval of information—occur in two sequential workflow processes in a discontinuous membership organization. Using a knowledge mapping instrument, we collected information about knowledge retrieval, knowledge allocation and perceived expertise during various project phases from 19 participants of an affordable housing project. We conclude that experts who are continuous members of a discontinuous organization facilitate the flow of knowledge in that organization. We also find that functional experts are self-sufficient in explicit-dominant knowledge areas. However, in tacit-dominant knowledge areas, the presence of the experts is critical for

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knowledge flow. We propose new propositions for communication to retrieve and allocate information for facility development organizations. The study highlights the need to consider knowledge flows to be based on its knowledge type when designing organizations operating in dynamic and complex environment.

Key Words: Discontinuous membership, knowledge flows, knowledge network analysis, functional information-processing, transactive memory, and organization design.

3.2 INTRODUCTION

After nine months of negotiations, a facility project obtained its development permit that enabled its owner to apply for permanent financing. While the owner worked with its finance team on the financing aspects, the architect requested that the owner expand the design team to include new team members to help prepare the building documents for obtaining the project's building permit. Among the new members were a mechanical engineer, an electrical engineer, and a concrete structural specialist. The new design team successfully submitted the project's building permit application after three months of working together.

After two months of waiting, the building department informed the architect that the building permit application was rejected because the project had ignored the oak grove conservation requirement at one corner of the property. Apparently, the mechanical engineer had routed a water pipe through the oak grove because it was the shortest route from the major water main to the project. The city authority had earlier stipulated the conservation as one of the development permit's conditions, but that knowledge seemed missing within the design team. There was no other alternative but to amend the building documents, but among the effects of this missed implementation included the owner postponing its financing application, delaying its bidding process, incurring additional financing charges, and most importantly delaying its return on investment. This case demonstrates that a facility developer may have difficulty maintaining a project's feasibility while it maintains knowledge flows of information during multiple processes.

Previous theory and research have addressed information retrieval and allocation patterns among employees. Wegner's (1987) transactive memory theory poses that individuals will retrieve information from and allocate information to those who they perceive to be experts in that information area. However, previous research on transactive memory and knowledge management fail to address the problem of discontinuous membership illustrated above. *Discontinuous membership* in an organization occurs where a position in an organizational structure is added or deleted while the process is on-going. It differs from *turnover*, which occurs where the incumbent of a position in an organizational structure is replaced with another incumbent to fulfill the *same position's role* while the process is on-going. More specifically in this case, the team members and leaders vary during the phases of the facility development process. *Discontinuous organization* refers to a group of workers who experience structural organizational changes due to discontinuous membership of one or more of its members while the process progresses. Organizational managers often utilize discontinuous members because different skill sets are needed in order to complete the tasks in different phases of a single workflow process.

We define *knowledge* as a set of commitments and beliefs of its holder that enables the holder to undertake certain action (Nonaka, 1994). The criterion for using the term 'knowledge' in this paper is its *enabling action* property that allows the holder of a knowledge entity to undertake certain actions. *Explicit knowledge* is the selected and applicable group of facts that is transmittable in a formal systematic language that enables its holder to take some action to complete a task; and *tacit knowledge* is the entity of "knowing how" that an individual or an enterprise possesses in selecting and applying a group of facts that enables action to complete a task (Polanyi, 1971; Nonaka, 1994). On the other hand, *information* is the selective collection or group of facts that an agent *can use* to perform a task, while *data* are facts that an individual or enterprise *can use* to compose the information used to analyze or make a decision.

An earlier ethnographic study by Ibrahim and Paulson (2005), results described in Section 3.3.4, found that a facility development process has multiple sequential and concurrent phases. Each phase requires a different skill set because it has a different goal (ibid.). The purpose of this article is to determine whether or not there are any differences in the knowledge flow behaviors—i.e., communication to retrieve information (CRI) and communication to allocate information (CAI)—within the facility development life cycle due to organizational discontinuous membership. We first introduce the literature on knowledge flows and transactive memory theory (Wegner, 1987) in organization theory. Then we introduce the discontinuous membership patterns on the facility management project we examined. In the remainder of this article, we report the method, results and implications of this study.

3.3 LITERATURE REVIEW

3.3.1 Organization Theory

We reviewed literature on organization, but found much of it concentrates on organization formation and behavior (March and Simon, 1958; Cyert and March, 1963; Galbraith, 1974; Mintzberg, 1992; Scott, 1998; Burton and Obel, 2003). Most researchers focus upon hierarchy as the basic structure for organizing complex social activity where cooperation among members is achieved through vertically imposed bureaucratic processes (Grant, 1996). March and Simon (1958) identify the use of rules or program to coordinate behavior between interdependent subtasks. Galbraith's *information-processing* model is an extension of Lawrence's and Lorsch's (1967 in Scott, 1998) *contingency theory* where the efficiency of an organization depends upon it adapting to its environmental context. The *information-processing* model of organization (Galbraith, 1974) proposes that decision-makers need to process information well during exception-handling for the organization to perform well. Galbraith argues that the greater the task uncertainty, the greater the amount of information that participants in an organization must process. As an organization faces greater uncertainty, its members face situations for which they have no rules. At this point, the hierarchy is employed on an exception basis (ibid., p. 86) where lower-ranked staff would seek guidance or information from their supervisors. Built upon Galbraith's *information-processing* model of organization, Burton and Obel (2003) extended the *contingency theory* and developed six *contingency factors* for *contingency fit* during the design of organizations. They are *management style*, *climate*, *size/ownership*, *environment*, *technology*, and *strategy*.

3.3.2 Knowledge Management and Dynamic Knowledge Flows Theories

Knowledge management is an increasing concern in the design of organizations. In knowledge management literature, Alavi and Leidner (2001) note abundance of literature on knowledge creation, knowledge storage, and knowledge retrieval. However, the literature concerning knowledge transfer is scarce (ibid.) and the study of knowledge flow dynamics is recent (Nonaka, 1994). Similarly, Carlile and Rebentisch (2003) highlight that most approaches to knowledge management in organizations emphasize storage and retrieval processes. Based on Kogut and Zander's (1992) knowledge of the firm theory, Nonaka (1994) supports that knowledge resides within individuals. Therefore, he argues that organizational membership plays a critical role in articulating and amplifying that knowledge. Kogut and Zander (1992) posit that firms are more successful in transferring knowledge within organizations than between organizations. Central to their argument is that although knowledge is held by individuals, it is also expressed in regularities by which members cooperate in a social community. Nonaka (1994) proposes four modes of knowledge transfer mechanism—*socialization*, *externalization, combination, and internalization* (SECI)—in a dynamic spiral epistemological relationship between tacit and explicit knowledge as it extends its ontological reach from individual to inter-organizational.

Nissen (2002) extends Nonaka's dynamics of knowledge flow theory by integrating the life cycle process of knowledge flow through the enterprise: 1) creation, 2) organization, 3) formalization, 4) distribution, 5) application, and 6) evolution. This six-step knowledge life cycle was an amalgamation of earlier views of knowledge life cycle, which were proposed by Davenport and Prusak (1998), and Depress and Chauvel (1999).

Von Hippel (1994) coined the term 'stickiness' on how needed info can 'stick' with the problem-solving capabilities in a different location. Stickiness connotes the difficulty experienced in the process in which an organization recreates and maintain a complex, causally ambiguous set of routines in a new setting (Szulanski, 2000). In Nissen's later work (under review), he states that new organizational forms may obtain and even dominate through a focus on dynamic knowledge flows. Nissen's work provides discrete qualitative categories for potential operationalization of knowledge flow in enterprise. His four knowledge flow dimensions are *type* of knowledge (tacit versus explicit), *level of socialization* associated with the knowledge (individual, group, organization, and inter-organization), activities of *knowledge work* (create, share, apply, etc.), and *flow time*.

In order to understand knowledge creation by individuals, Grant (1996) conceptualizes that the firm is an institution for integrating knowledge at the next organization level. Grant attempts to devise mechanisms for integrating individuals' specialized knowledge. He proposes four mechanisms to coordinate the integration of knowledge within an enterprise: (a) having rules and directives to enable the conversion of tacit knowledge to explicit knowledge; (b) sequencing of the workflow process that minimizes communication, but ensures the input of expert in a different time slot; (c) creating routines to support complex patterns of interactions between individuals in the absence of rules, directives, or even significant verbal communication; and (d) establishing group problem solving and decision making. The resulting knowledge-based firm theory has implications for the basis of organizational capability, the principles of organization design (in particular, the analysis of hierarchy and the distribution of decision-making authority), and the determinants of the horizontal and vertical boundaries of the firm. Grant's knowledge-based view of the firm encourages us to perceive interdependence as an element of organizational design and the subject of managerial choice rather than exogenously driven by the prevailing production technology. Grant emphasizes knowledge application and the role of the individual as the primary actor in knowledge creation and the principal repository of knowledge. However, he points to further research need on knowledge-based theory of the firm that will embrace knowledge creation and application.

An emerging trend among knowledge flows research is the utilization of computational models to simulate knowledge flows (Levitt & Nissen, 2002). Prior Computational Organizational Theory (COT) research has examined the work processes and information flows associated with project- or task-based organizations (Carley and Prietula, 1994; Levitt et al., 1994). The advantage of utilizing such computational simulation assistance is that it can provide hypothetical data to analyze a unique operating environment that is hard to test in real life. A study by Schreiber and Carley (2003) encourages this research when they acknowledge that among barriers to knowledge transfer in an organization are: 1) not knowing which members have the desired knowledge, 2) not knowing whether they exist, and 3) not knowing what knowledge they hold. They found that 53 percent of received answers by information seekers contained referral information using information technology. Their study identified two data types—task and referential—and determine how they are different. They described task data as a purely technical process wherein a member queries the database and obtains the results. On the other hand, referential data is obtained through a social process facilitated by technology. While Nonaka (1994) argues that many employees tend to seek knowledge from individual experts on a personal basis (i.e., socialization to transform tacit knowledge to explicit knowledge among individuals), the organizations in Schreiber and Carley's (2003) study use information technology to facilitate knowledge transfer. However, neither study integrates the transfer of individual's or repository's knowledge based on the work process in which the employees are involved, but Schreiber and Carley (2003) do highlight the need to understand task complexities that an organization faces. It is in this light that we seek to utilize a knowledge network analysis tool—common in the sociological communication field—to examine the differences, if any, between knowledge flow behaviors in different facility development life cycle phases.

Since organization theory has emphasized vertical information-processing structure in organization design, horizontal (or non-hierarchical) information-processing structure for decision-making is of particular interest to us. Recent scholars such as Lambert and Shaw (2003) have turned to Wegner's (1987) transactive memory theory to explain the existence of this non-hierarchical information-processing structure in organizations. We define knowledge flow as communication to retrieve or allocate information between individuals in an organization. We define the communication to retrieve and allocate information as *knowledge flow* because the flow of selected information would 'enable' action by either the source or recipient. We would like to explore whether transactive memory theory plays a role in knowledge flows in discontinuous organization.

3.3.3 Transactive Memory Theory

Wegner (1987) describes transactive memory as a shared system for encoding, storing, and retrieving information. The three key processes of a transactive memory system are (a) directory updating, where people learn what others are likely to know; (b) information allocation, where new information is communicated to the person whose expertise will facilitate its storage; and (c) retrieval coordination, which is a plan for retrieving needed information on any topic based on knowledge of the relative expertise of the individuals in the memory system.

Wegner (1987) and later Moreland (1999) posed that organizational teams may act like a large brain, where individuals store information to be combined with others' information. When individuals in that team need information they go to the "expert node" or expert member. When individuals gain new information related to a particular expert area, they allocate it to an "expert node". As individuals gain new information through experiences about the expertise of the others in their "brain", they update their individual directory of where information should be and is stored. Although the purpose of this project is to examine the knowledge flow processes in discontinuous membership teams, we expect to uncover similar patterns posed by transactive memory theory.

(H1): In discontinuous membership organizations, less expert group members tend to retrieve information from perceived experts in their group.

(H2): In discontinuous membership organizations, less expert group members will allocate information to perceived experts in their group.

A number of communication scholars, such as Monge and Contractor (2004); Contractor, et al. (in review); and Yu Yuan, et al. (2005) examine the social influence on development of knowledge networks among individuals. Other contemporary scholars (such as Lambert and Shaw, 2002; Hollingshead, 1998) have examined whether or not hierarchical decision-making process is applicable in today's fast-track project delivery environment. Lambert and Shaw (2002) merge *transactive memory* theory (Wegner, 1987) with information-processing views of organizational work processes (Galbraith, 1974). Lambert and Shaw argue that in current high-technology environments where participants have equal access to information, organizations can minimize the need to perform hierarchical decision-making processes if participants know from whom to seek information. While Lambert and Shaw focus on "who knows what", Hollingshead's (1998) study focuses on the function of communication behaviors. Lambert and Shaw, and Hollingshead do not consider the aggregate level of knowledge the enterprise possesses. In addition, Ibrahim and Nissen (2005) point to the need to include non-hierarchical information-processing in dynamic knowledge flows within an organization if scholars want to study performance in contemporary organizations.

Transactive memory systems may operate more effectively in teams where individuals have higher interdependence and have developed a more convergent cognitive map of task-person-expertise relationships (Brandon & Hollingshead, 2005). The knowledge of "who knows what" enables peers to consult independent team members in order to complete their own tasks, especially when their supervisor lacks the level of expert knowledge needed. In a temporal organization, in particular, the supervisor primarily acts as a bridge spanner or chief coordinator. Thus, other experts in the team may have more specialized expertise than the supervisor. A product development team, specifically the facility development organization, reflects a norm of discontinuous membership while the team works on the workflow process. In this instance, the knowledge flows may be governed by two additional mechanisms. The first mechanism is seeking information from a mediator when one's directory of expertise is incomplete. Wegner (1995) describes this process as seeking information from "who knows who knows what." For example, the remaining team members would know "who knows what" and can provide the resource to newly joined team members when they seek information. A second mechanism particular to discontinuous membership teams may be to seek information from those who were in the previous phase of the project and to allocate information to those who will continue in the next phase of the project. In this mechanism, it is not *proper embedding of knowledge in experts,* but *continuing the life of the knowledge* that is the key factor governing knowledge flow patterns.

An effective transactive memory system has several advantages for a group process. Foremost is the expansion of an individual's expertise when the individual gains access to others' domains of expertise. Another is that an individual also gains access to new knowledge that is created through integrations occurring within the transactive process. Integration affirms the need to have a group in the first place, showing all members the utility of coming together to remember because the group exerts a strong directive pressure on what is to be encoded, stored, and retrieved and places a special premium on integrative transactions (Wegner, p. 197). The third advantage is the possibility of others processing the knowledge and making decisions even when the individual is not available. Finally, Mooreland (1999) finds that groups that develop effective transactive memory systems can complete tasks more efficiently. It is unknown if these advantages of effective transactive memory systems in continuous membership organizations will apply equally to discontinuous membership organization.

3.3.4 Results from Ethnographic Study

A previous ethnographic study of an affordable housing development project was conducted to examine knowledge flows (Ibrahim and Paulson, 2005). The purpose of this earlier study was to understand why knowledge flow problems occur despite the developers having invested in information technology tools for knowledge management. They found several unique environmental characteristics regarding the facility development life cycle that may cause interruptions in knowledge flow.

Ibrahim and Paulson (2005) listed the major characteristics as 1) having multiple concurrent and sequential workflows, 2) having discontinuous membership, 3) having multiple task interdependencies, and 4) displaying different knowledge form (i.e., tacit- or explicit-dominant knowledge areas). These characteristics were further refined using a computational organization theory tool, i.e., SimVision®, to model three constructs (Ibrahim and Nissen 2005). They are *work complexity*, *team knowledge transaction*, and *knowledge flow.* The refined constructs explained the complexity of the facility development process in general, and revealed that the affordable housing development process is even more complex due to the financial and regulatory constraints imposed by state and federal programs on their development and operations (Ibrahim & Paulson, 2005).

Earlier work by Ibrahim (2001) illustrates the division of the sequential phases of the facility development process into five phases: 1) *feasibility*, 2) *entitlements*, 3) *building permit*, 4) *constructio*n, and 5) *property management phases*. Ibrahim and Paulson (2005) later combined the two early phases into *feasibility-entitlements* phase for better clarity. Given the discontinuous nature of this type of organization, it is unknown what additional mechanisms will govern knowledge flow. However, as discussed previously, it is possible that both "who knows who know what" and concern for the remembrance of knowledge may impact discontinuous membership organizations differently than continuous membership organizations. Therefore, we pose:

> (H3): In discontinuous membership organization, members will turn to continuous members to augment their knowledge of "who knows what."

The facility development life cycle displays multiple task interdependencies between the concurrent phases. The final major unique characteristics found different forms of knowledge dominate during different facility development life cycle phases. Specifically, tacit knowledge dominates during the early *feasibility-entitlements* phase, while explicit knowledge is dominant during the later *building permit*, *construction*, and *property management* phases. Tacit knowledge is rooted deeply in action, commitment, and involvement in a specific context (Polanyi, 1967). As such it can be very difficult to articulate and share. Explicit knowledge is transmittable in formal, systematic language. As such it can be articulated and shared via plans, drawings, documents and databases. Facility developers obtain tacit knowledge by socializing and internalizing the actions and sayings of the local elected officials and the public that supports them. The nature of knowledge that dominates each phase may impact knowledge flows as well. Therefore, we ask:

> (RQ1) How does the tacitness versus explicitness of knowledge affect knowledge flows within a workflow process?

3.4 RESEARCH METHOD

The Discontinuous Organization

The discontinuous organization is an affordable housing project team, and the complex process we selected is the project's pre-construction process. We divided the process into three phases (Ibrahim and Paulson 2005): *feasibility-entitlements*, *building permit*, and *project financing*. The *feasibility-entitlements* and *building permit* phases form a sequential process, while *project financing* is a concurrent phase to that sequential process. We assumed the cumulative data from all three phases as belonging to a discontinuous organization. However, for the purpose of our study, we limit our study to data from two sequential phases, which are feasibility-entitlements and building permit, to study knowledge flow behaviors due to tacit- and explicit-dominant knowledge type in each phase. Figure 3-1 illustrates how Ibrahim and Paulson (2005) divide the facility life cycle into its concurrent and sequential phases. Please refer to Appendix 1-2 for a larger representation for a typical affordable housing project.

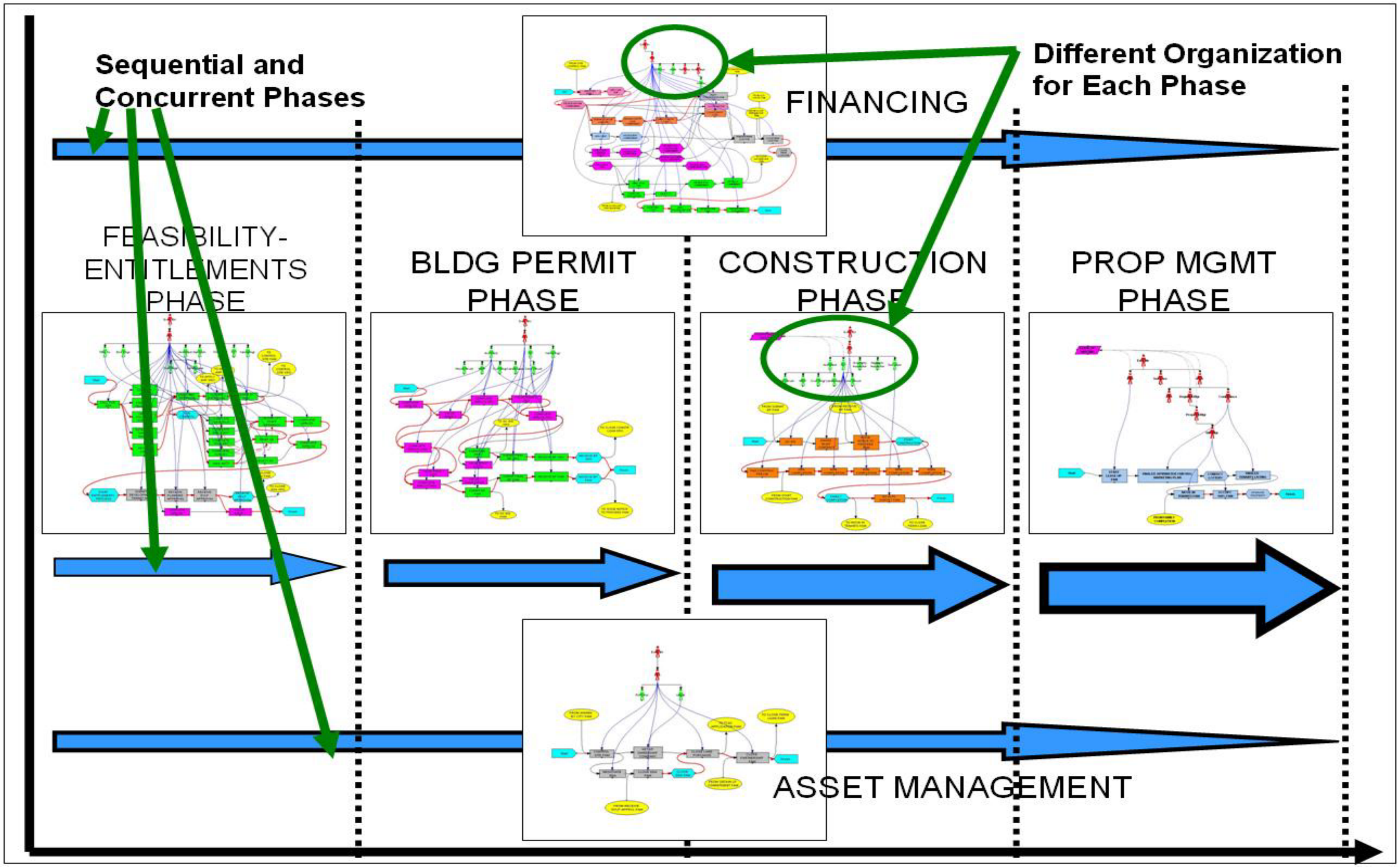

Figure 3-1. Multiple concurrent and sequential phases in a typical facility development life cycle with a different organization in each phase (Adapted from Ibrahim and Paulson (2005), Fig. 2-2).

Participants

The participants in the current research were all part of an affordable housing project team in the San Francisco Bay Area. The project is a housing project with 148 single resident occupancy units belonging to a non-profit housing developer, who is one of the three largest affordable housing developers in that region. There were 19 members of this project that worked in three of the five life cycle phases. Four of the members were staff of the non-profit housing developer, while the others were appointed external consultants in various capacities.

KAME Procedure

Data were collected using an online survey and Knowledge Asset Mapping Exercise or KAME (Contractor, et al., in review; Yuan, et al., in review). The KAME instrument was customized for each team based on a detailed protocol completed by the team leader, i.e., the project manager. (The pre-KAME interview protocol is appended in Appendix 3-1). Responses to the protocol provided information regarding the key knowledge areas, key tasks, and the assignment of various team members during the phases of the project. The major knowledge areas for the feasibility-entitlements phase are *architectural-engineering-construction* (AEC), *development project finance* (DPF), *and regulatory and authority requirements* (RAR).

In the building permit phase, the major knowledge areas are *AEC documentation process* and *bidding process. AEC issues* and *regulatory and authority requirements* are major knowledge areas for the *project financing* phase. The KAME included questions regarding perceived expertise, information allocation, information retrieval, and task assignments. Network data in the KAME were collected using interactive Java applets that allowed participants to indicate their network ties by clicking on images. Eighteen of the nineteen members completed the knowledge mapping exercise (95 % response rate).

Measures

Perceived Expertise. Participants were asked to rate the amount of expertise each team member possessed in the specified knowledge areas for the team. The response set for this question included “expert,” “intermediate,” “beginner,” and “none.” Expert was defined as “one of the team’s most knowledgeable people on the topic.” Intermediate was defined as “a clear understanding of the topic.” Beginner was defined as “a basic understanding of the topic” and none was defined as “not familiar with this topic.” Perceived expertise was the project manager’s ranking of each of the members of the team. This measure was utilized in order to compare results with data on members’ knowledge levels that had been collected for an earlier computational model of the same team processes (Ibrahim and Nissen 2003, 2004).

Continuous versus discontinuous membership. Continuous membership was defined as being present in the previous and successive phases of the sequential process. For instance, if a member is in the initial feasibility-entitlements phase and will be present in the succeeding building permit phase, she or he is rated as continuous. Otherwise, she or he is rated discontinuous. Similarly if a member is present in the later phase and was present in the previous phase, she or he has a continuous attribute. If the member was not present in the previous phase, then she or he has a discontinuous attribute. Individuals’ assignment to project phases was indicated by the project manager. Continuous membership was coded as a binary variable where one equaled continuous membership and zero equaled discontinuous membership.

Information Retrieval and Information Allocation. Information Retrieval (IR) was defined as a matrix of information retrieved for each team for each knowledge area. Information retrieval was also measured via an online applet for each knowledge area by which individuals were asked, “Please indicate how frequently you have retrieved information about <Knowledge Area> from your colleagues during this project.” The response set was a five-point Likert scale where one through five represented “none,” “seldom,” “sometimes,” “often,” and “very often,” respectively.

Information Allocation (IA) was defined as a matrix of information allocation for each team for each knowledge area. In these items individuals were asked, “In your work, you may receive or create information about <Knowledge Area>. Using the adjacent screen, please indicate how often you have provided unsolicited information (i.e., information that you distributed that was not requested from others) about <Knowledge Area> to your colleagues during this project.” The same response sets were used, substituting allocation for retrieval in the response.

Analysis

In order to test the hypotheses, *betweeness*, *indegree* and *outdegree centrality* measures were computed for each information retrieval and information allocation network. Betweeness centrality is defined as “the probability that a distinct actor, *i*, is “involved” (i.e., on the chosen geodesic path) in the communication between two actors” (Wasserman and Faust 1994, p. 190). Indegree centrality is defined as the number of communication links directed toward a single node. Outdegree centrality is defined as the number of communication links directed away from a particular node. After each node’s centrality score was calculated, a multiple regression analysis was conducted where continuous membership and perceived level of expertise were utilized to predict the betweeness, indegree and outdegree centrality respectively. These results were utilized to test the hypotheses H1 to H3.

Additionally, a multiple regression quadratic assignment procedure (MRQAP), a network analytic technique, was used to examine the research question in this project (Krackhardt, 1988). MRQAP is similar to multiple regression analysis in traditional multivariate statistics. Like multiple regression, multiple independent variables simultaneously predict a single dependent variable. However, in MRQAP, both the independent variables and dependent variables are networks of relations. Additionally, the significance of beta weights are calculated differently in MRQAP (for more on the differences, please see Krackhardt, 1988). MRQAPs were run for allocation and retrieval networks in each knowledge area in both the *feasibility-entitlements* and the *building permit* phases. In these MRQAPs, presence in a previous phase for building permit and continuous presence in the feasibility-entitlements phase was entered as an independent variable. Additionally, the agent's expertise as rated by the team manager was entered as an independent variable. Finally, the individual's presence in the examined phase was entered as a control variable.

3.5 RESULTS

Knowledge flows in discontinuous membership organizations seem to be impacted not only by the distribution of expertise but also by members' continuous vs. discontinuous participation. Hypothesis 1 and 2 posed that discontinuous membership organizations would seek information from and allocate information to those who were experts. Hypothesis 3 posed that members would turn to continuous members to augment their knowledge of "who knows what". Table 3-1 shows the comparison of standard coefficients of independent variables *being continuous* and *perceived expertise* against the dependent variable for *information retrieval and information allocation* using the *betweeness, indegree,* and *outdegree* measures for all three phases in the discontinuous organization.

Table 3-1. Comparison of Standard Coefficients of Being Continuous and Having Perceived Expertise on Betweeness, Indegree, and Outdegree Centrality for Feasibility-Entitlements and Building Permit Phases

Variables	Retrieval (K-Inflow)			Allocation (K-Outflow)		
	Betweeness	In-degree	Out-degree	Betweeness	In-degree	Out-degree
Constant	[illegible]2	16.431	16.097	4.971	15.428	16.736
Being Continuous	.373 **	.527 ***	.464***	.386 ***	.522***	.449 ***
Perceived Expertise	.123	.320***	.446***	.186	.331***	.413***
R-Squared	.196	.536	.605	.250	.541	.544
F-score	10.992***	51.922***	69.013***	14.98***	53.14***	53.69***

NOTE: *N* = 95, *df* = 2
* $p < 0.05$ *(two-tailed)*
** $p < 0.01$ *(two-tailed)*
*** $p < 0.001$ (*two-tailed*)

Hypothesis 1 posed that individuals would retrieve information from more expert members of the group. Indeed, individuals who were perceived as having higher expertise did have higher indegree centrality (β = 0.320, p < 0.001). Therefore, H1 is supported. However, a unique phenomenon was also discovered in these measures. Expert members also tended to retrieve information from other members at a greater level than non-expert members (β = 0.446, p < 0.001). The knowledge retrieval results illustrate that in a discontinuous organization, while expert members would tend to wait for lesser expert members to retrieve knowledge from them, they would also tend to seek information from other members.

Hypothesis 2 posed that individuals would allocate information to more expert members of the group. Again, consistent with transactive memory theory, individuals did tend to allocate information to those with higher expertise ($\beta = 0.331$, $p < 0.001$). Therefore, hypothesis 2 was supported. However, again we found an interesting additional knowledge allocation pattern. Experts in this discontinuous organization also tended to allocate information to others more than their less expert counterparts ($\beta = 0.413$, $p < 0.001$).

Hypothesis 3 posed that in a discontinuous membership organization, members will turn to continuous members to augment their knowledge of "who knows what." Individuals who were continuous members did have higher betweeness centrality in both the knowledge retrieval ($\beta = 0.373$, $p < 0.01$) and knowledge allocation ($\beta = 0.386$ $p < 0.001$) networks. Both the knowledge retrieval and allocation behaviors show that both continuous and expert members do turn to other members in their network to augment their knowledge of "who knows what" when their cognitive knowledge networks are incomplete. Therefore hypothesis three was strongly supported.

The research sought to discover whether knowledge type (i.e., tacit or explicit) \ could provide some additional insight into the knowledge flow patterns in discontinuous organizations. Particularly, we were interested in the above finding that experts tended to allocate and retrieve information more often than did their non-expert counterparts. We conducted several MRQAPs for each identified knowledge areas within two independent sequential phases. During the first feasibility-entitlements phase (see Table 3-2), the knowledge areas are *architectural-engineering-construction* (AEC)*, development project financing,* and *regulatory and authority requirements.* This phase displays tacit-dominant knowledge areas.

Table 3-2. Comparison of MRQAP Coefficients Predicting Knowledge Networks in the Feasibility-Entitlements Phase (Phase 1)

Variables	Retrieval (K-Inflow)			Allocation (K-Outflow)		
	AEC	Dvlp. Project Finance	Reg./Auth. Requirements	AEC	Dvlp. Project Finance	Reg./Auth. Requirements
Constant	.716	.553	.891	.631	.653	.176
Agent will be present in Phase 2	-0.042	.237*	.322	.214	.170	-0.082
Agent is in current phase	.114	.212*	.271**	.153	.237*	.240*
Perceived Expertise	.186	.111	-0.074	.214*	.091	.407
R-Squared	.048	.151	.153	.127	.125	.180

NOTE: $N = 342$, $df = 3$
* $p < 0.05$ *(two-tailed)*
** $p < 0.01$ *(two-tailed)*
*** $p < 0.001$ (*two-tailed*)

Ibrahim and Paulson (2005) found that the developer project managers obtained tacit knowledge by socializing and internalizing the actions and sayings of the local elected officials and the public that supports them, while they ensured transfer of explicit knowledge among the team members during the design and financing application processes. Their study found that these experienced project managers are very comfortable in their social and political operating environment. This enables them to maneuver socially, politically, and financially during the complex process to ‘smoothen’ the sequence of the architectural-engineering-construction process. The study observed a number of remarks such as, "…I'll call so-and-so at the city hall to find out what's going on," or "….Please arrange a lunch meeting with so-and-so so (that) I can clarify the details…."

In the feasibility-entitlement phase, team members did not tend to allocate information to or retrieve information from those who have expertise. The only exception to this is the AEC knowledge area, the only explicit-dominant knowledge area in this phase. Explicit knowledge flows are represented by the sharing of documents each team member passes on to others to complete their tasks. For instance, the structural engineer would wait for the architect's documents before designing the structural system for the housing project. In that knowledge area, expert members tend to contribute significantly in knowledge allocation, but not in its knowledge retrieval. In the building permit phase (see Table 3-3), which Ibrahim and Paulson (2005) identified as mainly consisting of explicit-dominant knowledge areas, the agents' expertise was consistently predictive of information allocation and retrieval patterns. Results show that having perceived expertise facilitates knowledge retrieval and allocation.

Addressing RQ1, knowledge flow is influenced by the discontinuous nature of the organization. In tacit-dominant knowledge areas such as the *development project financing* and *regulatory and authority requirements,* neither expertise nor being continuous predicted the information retrieval and allocation patterns. In explicit-dominant knowledge areas, such as *AEC documentation process* and *bidding process*, knowledge flow behaviors are supported by expert members.

Table 3-3. Comparison of MRQAP Coefficients Predicting Knowledge Networks in the Building Permit Phase (Phase 2)

Variables	Retrieval (K-Inflow)		Allocation (K-Outflow)	
	AEC Documentation Process	Bidding Process	AEC Documentation Process	Bidding Process
Constant	.332	.795	.502	.685
Agent is present in Phase 2	.057	-0.069	-0.008	-0.122
Agent was present in Phase 1	.025	.010	-0.003	-0.036
Perceived Expertise	.366**	.249*	.358***	.363**
R-Squared	.130	.066	.129	.132

NOTE: $N = 342$, $df = 3$
* $p < 0.05$ *(two-tailed)*
** $p < 0.01$ *(two-tailed)*
*** $p < 0.001$ (*two-tailed*)

3.6 DISCUSSION

Knowledge flow behaviors could impact the efficiency of knowledge transfer in complex process. There are two major findings from our study. First, is that knowledge flow behaviors in a discontinuous organization are qualitatively different from those of a stable organization depending on the “expertise” and “continuous” nature of the members. Second, knowledge flow behaviors depend on the knowledge type—tacit- or explicit-dominant—of the knowledge areas in a workflow process. In the first finding, expert members would tend to wait for lesser expert members to retrieve knowledge from them, while they would also tend to seek knowledge actively from other members during knowledge retrieval. Likewise, the experts would also tend to wait for lesser expert members to allocate knowledge to them, while they would also tend to provide knowledge to other members during knowledge allocation. These knowledge flow behaviors support Wegner's transactive memory theory; and they extend Wegner's theory for knowledge retrieval and knowledge allocation by identifying these unique behaviors for discontinuous organization.

We revisited Ibrahim and Paulson's (2005) ethnographic study to seek explanation for this new observation during knowledge retrieval. The construction industry is known to be a high risk industry where the success rate for development projects to be completed through construction can be as low as three percent and as high as fourteen percent. The need to support every member of the group by each independent member is thus strong for the sake of the whole group. The external consultants' incentive is always towards earning bigger consultancy fees should the project progress towards construction. By the time construction starts, the consultants are entitled to seventy percent of their professional fees; whereas they would only obtain about fifteen percent of their fees during the feasibility phase. Given this incentive, we are not surprised by this outcome.

Transactive memory explains that there are two sources of information people use to decide who is to be the acknowledged location of a set of labeled knowledge in the group (Wegner, 1987). First this is based on the individual's *personal expertise.* Second, it is determined through the *circumstantial knowledge responsibility* that accrues as a result of how the knowledge has been encountered by the group. We find both to be true in the facility development organization. For example, the architectural information is encoded under the *architecture* label among the building submission documents. External encoding, however, requires that the *location* be encoded internally with the label, but the *item* itself need not even be known (ibid.). For instance, the mechanical engineer in the design team would only need to label the location of the architectural design information under the *architecture* label, but he does not need to know what the details are about. When the mechanical engineer requires the building plan, she or he would easily retrieve this knowledge using the 'architecture' label. This knowledge retrieving behavior by the experts is encouraged by the fact that all members are at least trained experts in their fields, so they know "who knows what" for information they require to complete their task.

Using the same arguments, we could explain how experts would tend to allocate knowledge more to continuous members in the discontinuous organization. Supporting the organization's survival for the long term benefit of the individual (Ibrahim and Paulson, 2005), expert members willingly allocate any knowledge they feel could benefit other members in the team. Using transactive memory's encoding process, we pose that expert members would decide that certain knowledge is better stored by other experts, who may retrieve and use that knowledge to benefit their professional tasks. The incentive to do so is driven by the long term benefit to the individual experts if the group survives. Therefore, the knowledge flow behaviors in discontinuous organization support and extend Wegner's transactive memory theory.

The study finds continuous members do play a role in knowledge retrieval and knowledge allocation in a discontinuous organization. Results show that members tend to turn to both expert and continuous members in their network to augment their knowledge of "who knows what" when their cognitive knowledge networks are incomplete. Based on the ethnographic study by Ibrahim and Paulson (2005), we similarly argue that the early members have big incentives to help the development project progress towards construction. Hence, they are willingly available for knowledge retrieval, and in addition, willingly share knowledge with new members of the organization since they want to see that the project survives.

It is also possible that continuity elevates the status of a member in a discontinuous organization (Thomas-Hunt, Ogden, and Neale, 2003) through the value they add in carrying the organization's knowledge (Cohen and Levinthal, 1990) and meta-knowledge (of who knows what) into future life cycle phases. Thomas-Hunt, Ogden, and Neale's (2003) study suggests that social status can promote the differential emphasis of shared, own, and other unique knowledge, but at the same time also the biased evaluations of member's knowledge and contribution. Given that discontinuity could spur knowledge transfer through interruptions (Zellmer-Bruhn, 2003) caused by organizational changes, we posit that the absorptive capacity of continuous members actually enables the firm to 'carry' earlier knowledge where this added value of the continuous member helps promote the prominence of continuous members as enablers of knowledge flows in discontinuous organization. Further study is recommended to measure the relationship of continuity to the prominence of a discontinuous member.

The second major finding is that knowledge flow behaviors depend on the knowledge type—i.e., tacit- or explicit-dominant—of that the knowledge areas in a workflow process. The feasibility-entitlements phase is tacit-dominant while the building permit phase is explicit-dominant. We show that team members in a tacit-dominant knowledge area did not tend to allocate information to or retrieve information from those who have expertise (refer Table 3-2). The only exception to this is the AEC knowledge area, the one explicit-dominant knowledge area in the feasibility-entitlements phase. The building permit phase, which has mainly explicit-dominant knowledge areas, reflects similar functional expertise knowledge flow behaviors. Here, expertise consistently predicts information allocation and retrieval patterns. Our results show that transactive memory does not predict knowledge flows in tacit-dominant knowledge areas.

We revert to Nonaka's (1994) dynamic knowledge flows theory, which explains that the transfer of tacit knowledge occurs mainly through socialization and internalization of the "know how" by members of the organization. For knowledge to flow well, team members have to be within the same physical location or within the communication infrastructure of that organization (Palazollo, in review). This is empirically supported by the significant results that both knowledge retrieval and knowledge allocation for development project finance, and regulatory and authority requirements occurred when "agent is in the current phase" during feasibility-entitlements phase. Hence, we claim that knowledge type does influence knowledge flow behaviors in stable organization, and transactive memory cannot support knowledge flow in discontinuous organization in this regard. If this effect is obvious in a stable tacit-dominant organization, the need to consider knowledge type in any knowledge management design and system is even more pertinent for discontinuous organizations with mixed knowledge types. We recommend knowledge type inclusion in future studies on organization design and knowledge management.

There are several implications for research on dynamic knowledge flow behaviors in organizations based on results of this study. Firstly, a complex product development process—e.g., housing development—requires additional considerations to improve its current knowledge management system. Zellmer-Bruhn (2003) who studied how interruptive events affect team knowledge acquisition provided several suggestions. We equate "interruptive events" to an equivocal and uncertain environment from Burton and

Obel's (2004) contingency theory. She identified that some types of interruptions may influence knowledge acquisition effort where teams experiencing redirection and high performance reported higher knowledge transfer effort. Redirection involves formal planning and incorporating new members, and as such may focus teams on their practices—to consider whether they are in need to change (ibid.). High performance may invoke the opportunity for slack search, or it may be that high-performing teams are compelled to actively examine their routines so they can identify what is working to codify it for potential transfer to teams with performance problems (ibid.). In other words, structural changes positively influenced acquisition. Based on this reason, Zellmur-Bruhn supports the usefulness of distinguishing distinct knowledge processes that would enhance team's performance if the organization changed. Hence, we also recommend identifying the dominant knowledge type for all knowledge areas within a complex life cycle process.

This study illustrates that knowledge type (Nissen, in review; Ibrahim and Nissen, 2005) influences team members information allocation and retrieval behaviors. We found that in functional knowledge areas (such as architectural-engineering-construction) where explicit knowledge dominates; knowledge flows are facilitated by experts within the team, and having continuous membership does not influence information allocation and retrieval behaviors. On the other hand, we found that generally in tacit-dominant knowledge areas (such as development project financing, and regulatory and authority requirements) there are additional factors to consider. Being a continuous member and being present in that particular phase do seem to play some roles in information allocation or retrieval, in addition to perceived expertise. Nissen (in review) suggests the possibility that an organization could be designed based on its knowledge flows. Our finding that transactive memory does not promote knowledge flow in tacit-dominant organization supports this future area of research.

We also recommend that future research consider the product development process together with the changing organization for each life cycle phase. Zellmer-Bruhn (2003) indirectly points to this need when she recommends future research to examine *timing* during the process to improve knowledge acquisition. We further recommend that researchers take the opportunity during this process examination to further identify potential knowledge loss locations during the process and/or the team member responsible for critical task in these locations.

Secondly, future knowledge management systems and incentive programs for organizational members must consider the knowledge flow behaviors caused by the combination of different knowledge area's dominant knowledge type in a single life cycle process. The combination of tacit- or explicit-knowledge type depends on which knowledge area is required to perform the task. We have shown that different dominant knowledge types have different knowledge flow characteristics. Our study does not include organizational learning (Levinthal, 1991; Levitt and March, 1988). Further study is recommended to determine the impact of knowledge type on organizational learning processes and outcomes.

The third implication is that information-processing within an organization must include non-hierarchical information-processing to accurately represent knowledge flows. This finding points to the need to revisit Galbraith's (1977) information-processing theory of the organization, in which the vertical structural hierarchy still dominates in the exception handling and decision-making process. Our study found non-hierarchical communications made by agents present within the same workflow process. We believe this non-hierarchical knowledge flow does affect organizational performance as proven by different knowledge flow behaviors in two independent phases. Hence, we propose the development of new hypotheses and propositions that integrate the non-hierarchical knowledge flow with Galbraith's (1977) information-processing theory.

This study establishes how environmental characteristics of a workflow process influence team members' knowledge flow behaviors via communicating to retrieve or allocate information within an organization with discontinuous membership. We will seek to obtain further validation of our findings by the development of a computational organizational modeling tool to model and measure this new found discontinuous membership factor and how it would impact organizational performance. We also recommend further studies to develop organization theories to cater to the design of dynamic organizations that include knowledge flows and discontinuous membership.

3.7 CONCLUSIONS

This study is the first to utilize a social network analysis tool (i.e., KAME) to study knowledge flow behaviors as a means to understand the knowledge loss phenomenon in the construction industry. We sought to find if there were differences in knowledge flow behaviors of a stable versus discontinuous organization. We found that knowledge flow behaviors in a discontinuous organization are different from those of a stable organization depending on the "expertise" and "continuous" nature of the organization's members. Moreover, the knowledge flow behaviors depend on the knowledge type—i.e., tacit- or explicit-dominant—of that knowledge area in a workflow process. The study found that the prominence of a team member depends on the *continuity* attribute of that person. Our study establishes how environmental characteristics of knowledge flow behaviors can impact how agents facilitate knowledge retrieval and knowledge allocation within the organization. The different methodologies of knowledge transfer due to different knowledge types affect the efficiency of knowledge transfer in complex product development process. These findings lend further support to the hypothesis that discontinuity in organizations is a factor contributing to the knowledge loss phenomenon inherent in complex processes, and highlight the need to consider knowledge flow in organization design.

3.8 ACKNOWLEDGEMENTS

This paper is part of the first author's doctoral research at Stanford University, which is sponsored by the Ministry of Science, Technology, and Innovation of Malaysia in affiliation with Universiti Putra Malaysia. Additional support was provided by the UPS Foundation Endowment at Stanford University. We acknowledge the contributions of Professors Boyd C. Paulson of Stanford University, Palo Alto, California; and Mark E. Nissen of Naval Postgraduate School, Monterey, California. We extend a special appreciation to Fran Wagstaff, Anna Kramer, Kevin Brown, Mara Blitzer, and Chunke Su for their assistance throughout this study.

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