BEHAVIORAL FACTORS INFLUENCING LEAN INFORMATION FLOW IN COMPLEX PROJECTS

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ABSTRACT

As construction projects become increasingly complex, the success of these projects depends increasingly on effective information flow. Based on a three-year ethnographic study of the project team responsible for two capital healthcare projects, this paper presents a model of the interrelation of trust, commitment, learning, and understanding within project teams and how these constructs are vital to effective information flow. This model was developed through analysis of project team behaviors, behavioral trends, and triggers that prompted changes in behavioral trends. The model has implications regarding the competencies required of managers on complex projects, tools and processes that improve information flow, and the importance of information flow planning.

KEYWORDS

Information flow, trust, learning, commitment, knowledge management.

INTRODUCTION

In their seminal study Lawrence and Lorsch (1967) found that as organizations become increasingly complex, they require greater specialization. However, they also found that increased specialization, in turn, requires greater integration in order to fully capitalize on their available information and knowledge. As the Architecture, Engineering, and Construction (AEC) industry undertakes increasingly complex projects, the challenges of effective integration and information flow management have become two of the most critical challenges facing the industry (Davidson 2004).

The recent boom in healthcare construction projects has provided valuable illustrations of the challenges facing complex projects. Despite having this information readily available to projects, much of it still fails to become effectively incorporated into the project due to poor information management (e.g., Loftness et al., 1999). There has been significant research related to understanding how various tools, techniques, and organizational structures influence information flow and overall performance within project teams and AEC firms. However, a more comprehensive understanding of the structure of information flow and the mechanisms that influence flow are needed for the AEC industry to address the challenges of the 21st century.

LITERATURE REVIEW

Studies have shown that effective information and knowledge management are vital to firms and project teams for several reasons. Specifically, it allows the AEC

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industry to: 1) capture valuable tacit experiential knowledge, 2) effectively implement innovative ideas, 3) improve project cost, schedule, and quality metrics, and 4) promote the evolution and growth of the industry (Chinowsky and Molenar 2005).

Research related to technical factors has primarily focused on the development of processes and computational tools that more effectively capture and organize information. Austin et al. (2002) used a combination of process modeling and design structure matrix (DSM) analysis to plan design tasks and minimize unnecessary iterative cycles. Similarly, Lapinski et al. (2006) applied lean production management principles and comprehensive process mapping to reduce waste and improve the value in the delivery of sustainable building projects. Technologies such as Virtual Design and Construction (VCD) and Building Information Modeling (BIM) that have been shown to increasing participation of project team members, reduced risk, improved cost and schedule control, and increased responsiveness (Gilligan & Kunz 2007). Jin and Levitt (1996) developed Virtual Design Team (VDT), a computational organizational analysis tool that combines aspects of CPM (critical path method), PERT (program evaluation and review technique) modeling, and DSM to understand the way that communication and coordination affect work processes.

Finally, in recent years there has been increasing research focused on understanding the role of interpersonal factors related to information sharing and acceptance of new information. Loosemore (1999) observed the phenomenon related to the collapse of trust and constructive cooperation between project team members when problems arise. Ding et al. (2007) indentified factors influencing trust and willingness to share information within project teams. There have also been several studies relating project goals, participation, and conflict to project team member commitment and satisfaction (e.g., Leung and Chan 2007).

RESEARCH METHODS

Due to the socio-technical nature of information flow, this three-year study of capitol healthcare project made use of ethnographic methods for data collection and a grounded theory approach for analysis (Phelps and Horman 2009). Although these methods have a well-established history in the social sciences, they have not traditionally been used in construction research. Some exceptions include AEC studies related to barriers to innovation (Seymour & Rooke 2001), challenges in cross-cultural collaborations (Mahalingam & Levitt 2004), and the role of familiarity in reducing complexity (Shields & West 2003).

Ethnographic methods involve the study and systematic recording of a specific "society" (e.g., construction project teams) in their natural setting through participant observation (Denzin, 1978). In order to observe the natural behaviors of individuals, these studies require longer observation periods (i.e., months or years), in part, to minimize the externally imposed variation caused by having an observer present.

In order to provide a comprehensive analysis of the information flow within the project team, data was collected from several sources and through direct observation, analysis of artifacts, and ethnographic interview and analyzed using a grounded theory approach. Preliminary data were used to identify themes and develop initial theoretical constructs through a process of open coding. Additional data from more focused observation, contextual interviews with field study participants, and

microanalysis of meeting notes were used to refine the initial themes and identify patterns, hierarchies, critical questions needed to link them into generalizable conceptual models through axial coding. The conceptual models were then validated by testing their applicability to various observed scenarios, soliciting feedback from study participants and other industry members, and reviews of supporting literature.

RESULTS

Preliminary findings found that although information was being shared during project team interactions, the shared information did not always add value to the project. Depending on numerous factors, new information was either accepted, ignored, or rejected. The critical question that emerged from these initial findings was why certain information accepted, rejected, or ignored. This paper strives to address this question by providing understanding of the behaviors, patterns, and triggers that influence information flow within project teams.

Behavioral Trends and Cycles

Through observing interactions between project team members, there were certain behaviours that contributed to positive experiences while others created a more negative experience.   Similarly, some behaviors appeared to improve the understanding and acceptance of new information while others had a detrimental influence. There were two general trends that emerged: 1) behaviors that gradually resulted in decreased information flow and deteriorating team performance (i.e. vicious cycles); and 2) behaviors that resulted in continuous improvement of information flow and increased team effectiveness (i.e. virtuous cycles). Each of these trends had unique characteristics, qualitative descriptors, and outcomes.

In general, the teams that experienced deteriorating information flow (i.e. vicious cycles) throughout subsequent interactions demonstrated the following characteristics: 1) Focus on reiterating old information without any new supporting information; 2) Avoidance of complex issues; and 3) Emphasis on the individual. These behaviors resulted in greater tensions and increasingly extreme behaviors during subsequent interactions. The following vignette illustrates one of these cycles:

Even after the 75% construction drawing set had been released, there were still several components of the building envelope design that were missing critical information related to constructability and performance. The owner's representative (owner) was disappointed with the lack of useful information in the drawings and made his opinion well known to the architect. Since he had some significant design and construction experience, the owner conducted an informal internal review of the envelope design, created a spreadsheet of his comments, and shared them with the architect. At each meeting, the owner would ask the architect if they had addressed the building envelope issues to which the architect would give a reason why they had not. Gradually, the owner became even more adamant that they needed to address these issues and would push even harder for results (e.g., through more aggressive language, then he brought in an outside consultant to review the design, and eventually he added mock-up and in-situ performance testing requirements to make sure that the design would perform adequately). During this time, the architect only became more defensive and withdrawn in the project team interactions. The issues

still remained unaddressed and because of the contentiousness of the issue, the architect began avoiding any conversations about the envelope systems. Finally, the owner brought on board the key subcontractors to assist the architect figure out the design. This only worsened the relationship between the owner and architect and the architect stopped attending meetings and sharing any non-essential information. Communication between the owner and architect essentially came to a halt and this tension began to negatively affect relationships between other project team members.

In this vignette, the interactions between the owner and architect created a vicious cycle of confrontation and avoidance. The overlap of the owner's architecture knowledge and the architect's knowledge created a condition for conflict. Although this could have been constructive conflict, the combination of the owner's intimidating personality and the architect avoidance of complex issues created a destructive situation. The architect could have taken the opportunity to understand the issues through asking for clarification or hiring their own consultant, but instead felt too threatened to exhibit anything that could be perceived as ignorance. For the owner's part, he felt that the architects were ignoring his concerns. The combination of distrust, avoidance of learning, and other misunderstandings caused the owner to push even harder for his priorities and the made the architect become more defensive. Each became more extreme in their differing perspectives and goals instead of developing a common understanding. This decreased their commitment to the project and subsequently only reinforced the cycle.

The confrontation/avoidance cycle was one of the most prevalent negative cycles within the project. Another common cycle was the confrontation/misdirection cycle where individuals that were confronted with a challenging question would dismiss the question by either providing an overly ambiguous answer or by talking about another topic that they did could speak about more confidently. Another more subtle vicious cycle was that of disrespect and withdrawal (i.e. the gradual withdrawal of individuals that either did not feel comfortable contributing information or whose prior information contributions were ignored). When asked for their thoughts regarding these vicious cycles, project team repeatedly referenced the themes related to insecurity, ignorance, frustration, anger, opportunism, risk adversity, and lack of motivation.

There were also several interactions that resulting in increasingly effective information flow (i.e. virtuous cycles). In general, these interactions were characterized by: 1) Open discussions, e.g., soliciting input from others, providing constructive criticism, and freely sharing new information and ideas; 2) A willingness to discuss and work towards solving complex issues; and 3) Consideration of the goals, concerns, and knowledge bases of others. These behaviors enabled project team members to develop a better understanding of the perspectives of the other team members and use that understanding to contribute new information that was meaningful and relevant to them. This, in turn, resulted in more openness in sharing information and greater productivity and satisfaction within the team. The following vignette is a continuation of the earlier vignette, but instead provides an example of a virtuous cycle:

Because of the deadlock that resulted from the interaction between the owner and architect regarding the building envelope design, the construction manager to

brought in an independent building envelope to try to revive the coordination process. This consultant had several years of experience as an architect and contractor prior to becoming a building envelope consultant. He reviewed the drawings and issuing a report with his comments and suggestions just as the owner and the owner's consultant had done earlier. However, this consultant also facilitated a series of coordination meetings to discuss his comments. In the first meeting, he started off by explaining his technical background. Then he began to explain his comments. When he talked to the architect, he referred to things in architectural terms and asked them several questions to make sure that he understood their concerns and goals. He did the same when engaging the subcontractors and the owner. In addition to asking for clarification until he understood each party's concerns and goals, he also used his questions to linked their comments to earlier comments made by others and explained how their concerns influenced the concerns of the others. For example, during one exchange, he asked the architect "What is the architectural intent that you are going for here? Then he asked the glazing subcontractor "How were you planning to build this condition? Followed by an open question: "How does that (construction sequence) influence the architectural intent? He also drew critical details in 3D to clarify complex issues, when the discussion warranted it. Gradually, the team shared information more openly and began to work productively together to collectively develop solutions that they all could comfortably commit to.

The dynamic of the team in this vignette was significantly different from their previous interactions. First, the consultant was able to build trust by demonstrating that he understood and valued the opinions of the others by bringing up issues related to their concerns, using familiar language, and reinforcing their roles as experts by asking them questions. As a result, the team became more comfortable with sharing information. The consultant explained specific issues or illustrated them with isometric sketches so that everyone could develop the same understanding of the issues. By asking questions, he pulled valuable information from one person and then translated and linked that information to the goals and concern of others. This enabled the team to develop common understanding, interdependence, and a shared sense of responsibility for the outcome of their interactions. Because of these behaviors, he set in motion a virtuous cycle, where he gained the trust and understanding of the various team members and then transferred them to the rest of the team by building enough of a common understanding between the others.

This vignette illustrates several cycles that were prevalent in other aspects of the project. For example, the link/build cycle and clarify/build cycle both build common understanding by either linking information from one person to another or by clarifying ambiguity. These cycles allowed individuals to have more substantive discussions and continue to link and clarify new and more detailed information. There was also a cycle that occurred regarding inclusivity and commitment, i.e. when individuals were asked for input or otherwise involved constructively, they feel a greater commitment to the results and shared better information and became more active members of the team. When asked about these positive interactions, project team members mentioned themes related to openness, adaptability, trust, respect, and genuine liking of each other.

DISCUSSION

Through the analysis of these behavioral trends, there were four underlying themes that emerged: 1) Trust; 2) Commitment; 3) Learning; and 4) Understanding. These themes provide a basis for understanding the relationship between how information is shared and the outcome of that information within a project team.

The first two themes, trust and commitment, are closely related to each other and are heavily linked to emotion. Trust involves having positive expectations about another's future actions when an individual is vulnerable to those actions (Rousseau et al., 1998, p. 395). Commitment is the strength of an individual's identification with and involvement in a particular organization and influences the willingness of an individual to exert effort toward common goals. Trust and commitment were most often linked to a person's values regarding the project, such as: 1) how they view others in the project team, 2) how they view their own role in the project, 3) how much effort they are willing to put toward other member's goals and the project goals, and 4) their sense of association and interest in the project.

Similarly, learning and understanding are closely related, but heavily linked to more cognitive processes. Learning occurs when the processing of new information changes an individual's understanding and range of potential behaviors. Understanding is an internal process that occurs when individuals can apply the knowledge in their existing mental model (i.e. the basis for how individuals understand information) to new and novel situation specific to the project. Mental models determine how a person: 1) evaluates new information, 2) links new information to their existing knowledge, and 3) categorizes and orders information.

In both cases, there are several parallels. First, the development of trust and learning are influenced by interaction; specifically, the characteristics of the information shared and the means by which that information is shared. Secondly, trust and learning facilitate convergence among project team members; trust results in convergence in values while learning results in convergence of mental models. Third, convergence of values results in shared commitment and convergence of mental models results in common understanding which subsequently influence what information individuals choose to share and how it is shared in future interactions.

These finding suggest that there are two simultaneous cycles that continuously shape and are shaped by the type of information shared and the way that it is shared. These two cycles are: 1) a trust/commitment cycle that is based on an individual's valuation of the experience, and 2) a learning/understanding cycle that is based on an individual valuation of the information.

Valuation of the Experience: The Trust/Commitment Cycle

The valuation of the experience depends on how the individual felt during the interaction. Some of the critical factors of an experience include: 1) how the individual was received by the rest of the group; 2) the individual's perception of others in the group; and 3) the changes in trust and commitment that resulted. Based on the experience of each interaction, there can be a shift in an individual's values related to the project (i.e. their level of commitment to the project and project team members). An individual's commitment to the project affects the quality and amount of information that an individual will share with the rest of the team as well as the type of reaction the individual will have to information shared by others (Figure 3).

In positive iterations of this cycle, individuals feel that: 1) their contributions are
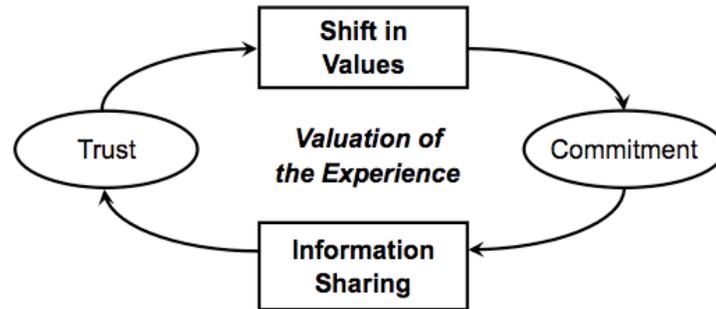

Figure 3: Valuation of the Experience and the Trust/Commitment Cycle

valued; 2) they are being treated fairly; 3) they and others are being given responsibility but also held accountable for those responsibilities; 4) their expectations are being met; and 5) other project team members share their commitment to team goals. In these cases, individuals feel a greater identification with the team and stronger commitment to the team outcome (i.e. a shift in values). In negative iterations, individuals feel the opposite and therefore hold more tightly to their own values and remain committed only to their individual goals. Subsequently, an individual's level of commitment influences the quality and relevance (to others) of their information contributions. It also affects their willingness to understand and learn from information provided by others. These behaviors influence future interactions and create either increasingly positive or increasingly negative experiences that further perpetuate the cycle.

Valuation of the Information: The Learning/Understanding Cycle

The perceived value of shared information also affects its outcome. The value that an individual places on the information is what triggers learning. One's propensity to learn depends on: 1) their willingness to learn; 2) the clarity of the information; 3) the relevance of the shared information to their existing mental model; and 4) an individual's trust of the person providing the information and the others present (i.e. psychological stability). When individuals engage in learning, they link new information to a part of their existing mental model that is related to the new information (i.e. association). This process subsequently broadens or modifies their mental model. As mental models converge, individuals develop a greater awareness of how their knowledge relates to others and to the project in general (i.e. common understanding). This awareness results in sharing of information that is more relevant to the needs of others and the project in general (Figure 4).

In positive iterations of this cycle, information is shared in a way that it is deemed
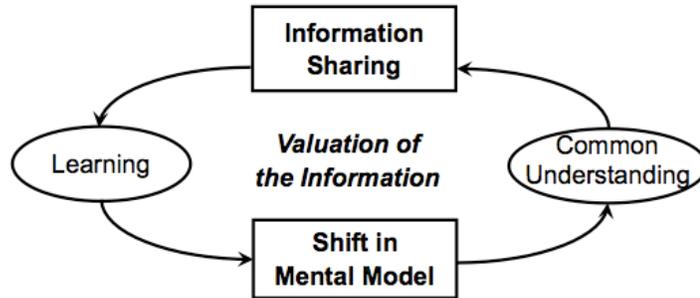

Figure4: Valuation of the Information and the Learning/Understanding Cycle

valuable by others. Because of its perceived value, it is linked to their existing mental model and shifts their understanding and interpretation of the situation so that it is more aligned with what others feel is valuable. In subsequent interactions, individuals will build on that common understanding by providing information that is relevant. Relevant information is more easily accepted and learned resulting in further convergence of mental models. In negative iterations, individuals do not value or trust new information, ignore or reject it, and avoid learning. As a result, individuals retain their existing mental models and continue to contribute the same information as they did in past interactions without understanding how to make it more valuable to others. This only builds frustration among the team members and decreases their willingness to share new information and learn.

Interdependence of the Trust and Learning Cycles

Although the trust/commitment cycle is responsible for convergence of values and the learning/understanding cycle for convergence of mental model, neither can happen in isolation from the other. In fact, they are intimately dependent upon each other. Trust and commitment can only be strengthened when: 1) others provide information that is helpful and supportive to an individual, or 2) when an individual feels that they are providing information that is valued by others. Both of these conditions only happen through greater common understanding. Similarly, learning can only occur in psychologically safe environments where individuals trust the information provided by others and are committed enough to the project to engage in learning. Because of these interdependencies, factors that affect one aspect of the interaction model influence all aspects (Figure 5). Collectively, both of the cycles influence the likelihood that information will be made available and accepted by the project team.
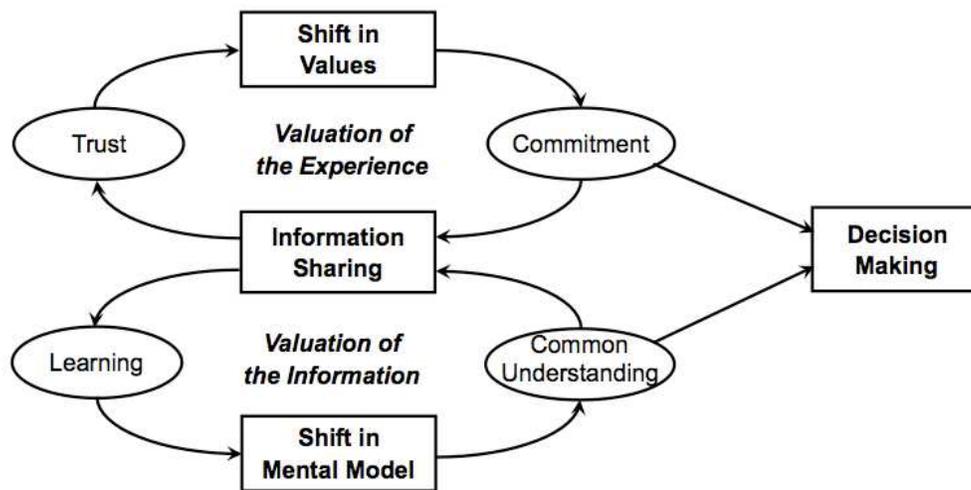
Figure 5: The Interrelation of Trust and Learning Cycles

CONCLUSION

As the AEC industry becomes increasingly information-intensive, the success of project teams and the firms that make up those teams depends on their ability to effectively find, process, and incorporate new information. These challenges cannot be addressed through technological advances alone. They require complementary advances in the understanding of social phenomena related to individuals and collaborative information processing.

This study illustrates the important the social and technical factors affecting information flow; more specifically, that increased trust and learning within project teams generated higher levels of commitment and understanding that greater information flow effectiveness. Teams that created environments characterized by high levels of trust and learning had members that provided more useful information and as a team were more effective and translating the available information into value for the project. The observation and analysis of these teams provided valuable insights as to the competencies, tools, and process that AEC industry firms needs to develop in order to survive and excel in an ever increasing complex information age.

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