

Culture and Shared Understanding in Distributed Requirements Engineering

Yvonne Hsieh
University of British Columbia
yvonneh@ece.ubc.ca

Abstract

Developing requirements for large software systems requires continuous and effective coordination of tasks, resources, and people. Research in team cognition suggests that the traditional Input-Process-Output model is insufficient for the level of coordination needed in the development of such large systems. Coordination in these projects is greatly affected by human and behavioural factors, relying on developers having a shared understanding of both the system and the project. In globally distributed projects cultural diversity poses interesting challenges to the team's ability to form a shared understanding since developers from different cultures have disparate problem-solving and communication processes. This paper discusses an ongoing study on how culture affects the efforts through which requirements engineers, along with other members of the development team, acquire a shared understanding of both the system requirements and other issues such as project organization and progress. This paper explains the study's theoretical framework and outlines the more specific questions explored.

1. Introduction

As today's IT industry witnesses the growing trend towards global software development, the challenge of requirements engineering is compounded by the various boundaries inherent in distributed projects, be they geographical, temporal, organizational, or cultural. A number of researchers have started to examine the intricate interplay of these boundaries and its effect [1, 2]. Most of the effort has been devoted to elicitation and facilitation techniques, focusing on the interactions between the requirements engineering team and the stakeholders. The need for improved collaborative tools has also been discussed [3, 4] whereas little research has been done on the group processes and management *within* the requirements engineering team.

Requirements engineering is a problem of *coordination*. Developing requirements for a large-scale system is seldom a one-person job. Rather, it involves coordination among application domains; contradictory requirements and priorities; and interdependent modules, tasks, and people. While prior literature in coordination has primarily revolved around the traditional Input-Process-Output (IPO) model, recent research suggests that coordination is achieved through the team's cognitive and social ability such as developing shared mental models [5]. In other words, team members coordinate their actions by having a collective understanding of the work; the organization and its goals; and the other players involved. Research also shows that the development of a shared mental model is more difficult in the distributed team than in the collocated one. The challenge has been attributed to added delays in communication and the loss of "water fountain talk" [6]. In an ongoing research study conducted at UBC, we propose that another factor making the development of a shared understanding in the distributed team problematic is *cultural diversity*. This paper presents the theoretical framework of the study, elaborating on why and how culture may pose challenges to shared understanding in the distributed development team. The paper also outlines some of the more specific topics that will be explored.

2. Shared Understanding in the Requirements Engineering Team

2.1. Shared Mental Models

The development of a large-scale software system involves multiple stakeholder groups (with possibly contradicting needs) and requires knowledge from many domains [7]. Negotiating these needs and acquiring, exchanging, and integrating knowledge from multiple domains is a challenging endeavour entailing more work than that can be handled by one person, no matter how talented [7, 8]. Moreover, with a complex system, it is unlikely that parts of the requirements specification can be generated without having

interdependencies with other parts. As the size of the requirements engineering team grows and the interdependencies among modules and tasks increases, the coordination processes enacted among the requirements engineers and developers become extremely complex and troublesome. Failures in coordination create “breakdowns” [9] in which the requirements engineers lose sight of the team’s goals, work and progress as a whole, diminishing their contributions to the project. To address these obstacles in coordination, researchers have proposed various approaches for identifying and managing tasks and requirements dependencies [5, 7, 10].

Still, coordination in software development projects is more than a dependency-management issue that can be readily solved with IPO model-based mechanisms. Recent research in team cognition suggests that coordination is very much a social and behavioural accomplishment relying on members of the team having collective, organized, yet cognitive *knowledgeability* about “tasks, each other, goals, and strategies” [11]. As such, for a software development team to operate effectively and efficiently, all members must have a shared understanding of the system, the work, the organization, and the other players involved.

The concept of shared understanding is explored in the discussion of shared mental models [11], which are defined as “knowledge structures held by members of a group that enable them to form accurate explanations and expectations for the task and in turn, to coordinate their actions and adapt their behaviour to demands of the task and other group members.” When the concept is applied to study software development teams, researchers find that shared mental models lead to better team performance and that a large amount of development time is spent on forming a shared mental model in the team [9].

2.2. The Impact of Culture

Developing a shared mental model in teams is not an easy task [12]. In globally distributed projects the challenge is even more pronounced because geographical, temporal, organizational, and cultural boundaries make it difficult for the requirements engineers and developers to foster a consistent understanding of the system requirements and also a common orientation to issues such as development methodology, schedules, and goals [13].

One factor that potentially has a significant impact on the development of a shared mental model in the distributed team is *cultural diversity*. Different cultures often have drastically different values, beliefs, and approaches to communication and problem-solving. In the context of a global software project these

differences may lead to miscommunication. Developers from different cultures may also have disparate interpretations of requirements [14] and ways to perform requirements engineering. As such, cultural diversity may hinder the team from forming a shared understanding of both the system requirements and other project-related issues.

3. Theoretical Framework

Our study is informed by Orlikowski’s work on knowing in distributed organizations [13] and Weick and Robert’s theory of collective mind [15]. This section provides an overview of these concepts and how they are instrumental in studying intercultural issues in global software development teams.

3.1. Knowing in Distributed Organizations

Based upon the premise that an organization’s ability to operate effectively is founded on its members’ *collective knowledgeability* of the work and the environment, Orlikowski [13] studies the everyday practices in a global high-tech company. Specifically, she focuses on practices that address the issue of developing and sustaining knowledgeability across geographical, temporal, organizational, and cultural boundaries. The key element that distinguishes Orlikowski’s work from other literature on organizational knowledge is her emphasis on *knowing*, rather than *knowledge*. Most literature focuses on knowledge transfer and the transfer of best practices — concepts that seem to suggest knowledge as a set of static, objective entities that can be readily transferred and accepted. Orlikowski argues that knowledge should not be treated as discrete, stable pieces of information. Rather, the essence of knowledge (or knowledgeability) is the *human ability to act in a knowledgeable way* — hence the verb “knowing”. Orlikowski suggests that knowledgeability is neither external (existing in outside systems and routines) nor internal (inscribed in the human brain). Instead, knowledgeability is a social accomplishment that is continually enacted and re-enacted by the human agency, based on context and through daily practices. The enacted nature of knowledge (or knowing) suggests that knowledge is “at any given time, what the practice has made it.” Orlikowski therefore places the focus on human practices in her examination of organizational knowing.

The issue of *collective* knowing is particularly interesting in the distributed environment. The demands for collaboration in today’s organization make it necessary for an individual to know not only his/her own work and environment, but also the work and environment of others. The various boundaries in

the distributed organization, however, make the development of collective knowing problematic. In her study, Orlikowski identifies a repertoire of five practices that are instrumental in propagating knowing across boundaries: sharing identity, interacting face-to-face, aligning effort, learning by doing, and supporting participation. These practices are said to help members develop knowing of the organization, the other players, the team's coordination mechanisms, and also the ability to work and innovate in a technical organization. See [13] for details.

3.2. The Theory of Collective Mind

Weick and Robert [15] propose the theory of collective mind and use the theory to explain group performance in situations requiring exact, continuous operational reliability. Their work is based on studying aircraft carrier flight deck operations and investigates the question: *What makes the operations on a flight deck, a place with "a million accidents waiting to happen," [16] so reliable?*

Weick and Robert assert the answer is that members of an organization concerned with reliability are capable of enacting more fully developed mental processes - conceptualized as "collective mind." Such mental processes enable the members to acquire a better understanding of the complexity they face and also to respond with fewer errors and greater efficiency. In the theory, mind is defined as the "disposition to heed," [15] an individual's propensity to act in a style connoting qualities such as "noticing, taking care, attending, applying one's mind, concentrating, putting one's heart into something, thinking what one is doing, alertness, interest, intentness, studying, and trying." [15] These qualities are not separate entities that govern actions; rather, they are attributes *actualized* in patterns of actions. In organizations where high reliability is essential, it is found that the team members' performance is more *mindful* than in other organizations.

Unlike other concepts on group work, Weick and Robert do not assume a superentity (i.e., the organization) as the governing agent on individual behaviours [7]. They argue that the overall performance of the group should be studied in the actions of the individuals and, more importantly, the interconnections of these actions. In other words, group mind is manifest in the interrelation of individual actions. Weick and Robert further identify three behaviours that typify group work: contribution (an individual constructing her/his actions), representation (an individual envisaging a personal mental model of the group), and subordination (an individual relating his/her contributions to the group as envisaged). Based

on these characteristics, collective mind is described as heedful interrelating. An individual's disposition to heed is expressed in her/his actions that construct interrelating with the rest of the group. These actions (constructing, representing, and subordinating) from each individual together form the pattern of interrelating through which the collective mind of the group is manifest. Variations in heedful interrelating therefore result in variations in the degree of the collective mind and affect the overall performance of the group. When members of an organization act/interrelate heedfully (i.e., with collective mind), they understand more clearly the situations they face and the actions and expectations of others, and consequently they contribute more effectively to the group.

3.3. Discussion

The primary distinction between Orlikowski's and Weick and Robert's work can be considered as a matter of granularity. While Orlikowski examines practices and the knowing involved in practices (the what), Weick and Robert, through a more microscopic lens, explore the finer qualities attached to the practices (the how). It may also be argued that knowing, as described by Orlikowski, is the essence behind the actions of constructing, representing, and subordinating. It is knowing the technical work, the organization, the coordination, and other team members that enables an individual to effectively envisage the actions and needs of others (representation), decide on his/her own actions (constructing/contribution) while aligning with others (subordination).

These concepts provide important insights to our study. It may be argued that for an organization to operate effectively, especially in a distributed environment, knowing and mind are both of great importance. Knowing refers not only to the knowledge of the organization, the work, and the players, but also to the ability to continually reflect, adjust, and act based on that knowledge. Knowing is exhibited through the members' actions and allows the members to develop an understanding of the situation as a whole, as well as how he/she can make contributions. Mind, on the other hand, refers to the vigour and attentiveness with which the contributions are made. Given the importance of knowing and mind, the study will look for not only the practices that exhibit knowing and mind but also those that develop and sustain them. Moreover, the term "collective" must be highlighted. The study will examine knowing and mind not just in individual practices, but in the *interrelations*

of practices, focusing on differences and conflicts that arise.

4. Where Does Culture Fit In?

In an intercultural situation, the concepts of collective knowing and mind, as well as their manifestations in interrelations of practices, are complicated. Research in cultural studies suggests that intercultural factors may have a significant impact on how group knowing and mind are developed.

4.1. Layering of Culture

Spencer-Oatey [17] defines culture as “a fuzzy set of attitudes, beliefs, behavioural norms, and basic assumptions and values that are shared by a group of people, and that influence each member’s behaviour and her/his interpretations of the ‘meaning’ of other people’s behaviour.” This definition suggests that the nature of culture is *layered*. At the most rudimentary, culture can be viewed as consisting of two levels: an invisible *values* level and on top of that a visible *behaviours* and *artifacts* level (which in turn is heavily influenced by the hidden values underneath) [18]. Knowing and mind can then be considered to be part of the invisible values level whereas the practices and interrelations are part of the visible behaviours and artifacts level. In an intercultural situation, there are then two implications:

(a) Values level: Different cultures have different interpretations of knowing and mind (e.g., which is more important: subordinating to group needs or individual heroics?);

(b) Behaviours/Artifacts level: Even when they have relatively close ideas regarding the meanings of knowing and mind, different cultures may have disparate mechanisms for developing collective knowing and expressing mind (e.g., is knowing achieved through consensual discussion or command-and-control from superiors?).

When *interrelating* of actions is required, differences in both values and practices may create significant boundaries in global, intercultural development work and hinder the development of collective knowing and mind. Left unresolved, these boundaries may ultimately degrade the organization’s performance.

4.2. Structuration Theory

To analyze intercultural value differences and conflicts in the distributed development team, our study draws on Giddens’s structuration theory [19, 20]. The main goal of the theory is to provide a way to describe the nature of human actions in relation to social structures. The structuration theory is distinguished from other concepts in sociology in that

it treats human actions and social structures as being *mutually constituted*. Social structure is not viewed as some external constraint that stringently limits human actions. Rather, structure is defined as “rules and resources” that form the basis of human knowledgeability but that only exists “as memory traces” in the human mind. In other words, an individual draws on the structure to inform his/her actions and by doing so recursively produces the structure in her/his mind at the same time.

Giddens defines three dimensions of the social structure (i.e., *structural properties*): systems of meaning, forms of power relations, and sets of norms. All human actions and social structures are said to contain elements of the three structural properties and these properties distinguish one social system from another across space and time. Every social system is said to exhibit some degree of *systemness* in its systems of meaning, forms of power relations, and sets of norms, even though there always remains some degree of intrasystem variances. This aspect reveals how the structuration theory can be applied to examine intercultural interactions: while there are always factors such as individual nuances that disturb the systemness of a culture, there is enough systemness for the culture to be considered as a collective.

Another implication of the structuration theory to intercultural studies is its discussion of conflicts and contradictions. Conflicts are defined by Giddens as actual fights between actors or groups while contradictions are the structural “fault lines” between social systems that form potential bases for conflicts. Conflicts arise under the combination of two conditions: (a) the actors feel that the contradictions affect them negatively, and (b) they are motivated enough to act on the contradictions.

Walsham [21] applies the structuration theory to study intercultural interactions in a collocated software development team consisting of Jamaican and East Indian developers. He explores the cultural dispositions of both groups along the three structural properties, focusing on the contradictions and conflicts that arise. Walsham finds a number of value differences between the two cultural groups. For instance, Jamaican and Indian developers are found to differ significantly in their views of power. Jamaican developers view the Indian project leaders as too autocratic while the Indian management perceives the Jamaican staff’s consensual decision-making to be ineffective. This contradiction in the structural property of power relations, along with other differences (see [21] for details), eventually creates conflicts in the team, leading to staff turnover and delivery delays.

5. Research Question

The primary research question investigated in this study is: *What is the impact of culture on the development of a shared understanding in the global software project?* The study will focus on requirements engineering activities and look for the effects of culture in the everyday practices of the requirements engineers and developers. The efforts through which the team develops a shared understanding will be explored through collective mind and knowing. Topics investigated will include:

- (a) Knowing: Do distributed requirements engineers and developers interpret system requirements in the same way, follow the same process/practices/models, know the team process as a whole, and know where to seek (even remote) expertise?
- (b) Mind: Do distributed requirements engineers and developers display "mind" in the same form and how are vigour, motivation, and heedfulness interpreted by remote team members?

The structuration theory will inform the study in its analysis stage. Intercultural contradictions and conflicts among remote sites will be studied along the structural properties and their effects on shared understanding will be investigated. The goal of the study is to discover practices and techniques that may enable the capability of the global software development team in forming a shared, collective understanding of both the system requirements and the project.

6. References

[1] D. E. Damian and D. Zowghi, "Requirements Engineering Challenges in Multi-site Software Development Organizations," *Requirements Engineering Journal*, vol. 8, pp. 149 - 160, 2003.

[2] J. Hanisch, "Understanding the Cultural and Social Impacts on Requirements Engineering Processes - Identifying Some Problems Challenging Virtual Team Interaction with Clients," presented at The 9th European Conference on Information Systems, Bled, Slovenia, 2001.

[3] T. Wolf and A. H. Dutoit, "Supporting Traceability in Distributed Software Development Projects," presented at Workshop on Distributed Software Development, Paris, 2005.

[4] R. Evaristo, M. B. Watson-Manheim, and J. Audy, "E-Collaboration in Distributed Requirements Determination," *International Journal of e-Collaboration*, vol. 1, pp. 40-55, 2005.

[5] D. R. Ilgen, J. R. Hollenbeck, M. Johnson, and D. Jundt, "Teams in Organizations: From Input-Process-Output Models to IMOI Models," *Annual Review of Psychology*, 2005.

[6] J. A. Espinosa, R. K. Kraut, S. A. Slaughter, J. E. Lerch, J. D. Herbsleb, and A. Mockus, "Shared Mental Models, Familiarity, and Coordination: A Multi-method Study of

Distributed Software Teams," presented at 23rd International Conference on Information Systems, Louisiana, New Orleans, USA, 2002.

[7] K. Crowston and E. E. Kammerer, "Coordination and Collective Mind in Software Requirements Development," *IBM Systems Journal*, vol. 37, pp. 227 - 245, 1998.

[8] D. B. Walz, J. J. Elam, and B. Curtis, "Inside a Software Decision Team: Knowledge Acquisition, Sharing, and Integration," *Communications of ACM*, vol. 36, pp. 63-77, 1993.

[9] B. Curtis, H. Krasner, and N. Iscoe, "A Field Study of the Software Design Process for Large Systems," *Communications of ACM*, vol. 31, pp. 1268-1287, 1988.

[10] T. W. Malone and K. Crowston, "The Interdisciplinary Study of Coordination," *Computing Surveys*, vol. 26, pp. 87-119, 1994.

[11] J. A. Cannon-Bowers and E. Salas, "Reflections on Shared Cognition," *Journal of Organizational Behavior*, vol. 22, pp. 195 - 202, 2001.

[12] L. L. Levesque, J. M. Wilson, and D. R. Wholey, "Cognitive Divergence and Shared Mental Models in Software Development Project Teams," *Journal of Organizational Behavior*, vol. 22, pp. 135 - 144, 2001.

[13] W. J. Orlikowski, "Knowing in Practice: Enacting a Collective Capability in Distributed Organizing," *Organization Science*, vol. 13, pp. 249-273, 2002.

[14] T. Thanasankit and B. Corbitt, "Thai Culture and Communication of Decision Making Processes in Requirements Engineering," *Proceedings of Cultural Attitudes towards Technology and Communication*, pp. 217-242, 2000.

[15] K. E. Weick and K. H. Roberts, "Collective Mind in Organizations: Heedful Interrelating on Flight Decks," *Administrative Science Quarterly*, vol. 38, pp. 367 - 381, 1993.

[16] G. C. Wilson, *Supercarrier*. New York: Macmillan, 1986.

[17] H. Spencer-Oatey, *Culturally Speaking: Managing Rapport through Talk across Cultures*. New York: Cassel, 2000.

[18] S. Dahl, "Intercultural Research: The Current State of Knowledge," Middlesex University Business School Discussion Paper, 2004.

[19] A. Giddens, *The Constitution of Society*. Cambridge, UK: Polity Press, 1984.

[20] M. Jones, "Structuration Theory," in *Rethinking Management Information Systems: An Interdisciplinary Perspective*, W. L. Currie and B. Galliers, Eds. Oxford, UK: Oxford University Press, 1999.

[21] G. Walsham, "Cross-Cultural Software Production and Use: A Structural Analysis," *MIS Quarterly*, vol. 226, pp. 359-380, 2002.