Attitude and Usage of Collaboration Tools in GSE: A Practitioner Oriented Theory

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***Abstract*—Collaboration tools support global software engineering (GSE) by providing relevant information and work context to developers, essentially seeking to provide a local context for developers working globally. Although many collaborative tools have been developed, we have insufficient knowledge of how they are used in practice. In this paper, we review the recent empirical studies on collaboration tools for GSE. Then we theorize a conceptual framework that aims to explain how the unique contextual dimensions of GSE (e.g. culture diversity and adaptation, etc.) influence practitioners' attitudes toward, and usage of, the tools. The conceptual framework will guide our future empirical studies, and it will be refined by the empirical evidence collected in these studies.**

***Keywords*-Global Software Engineering (GSE); distributed teams; virtual teams; computer-supported cooperative work; software tools; software adoption; practitioner-oriented theory**

I. INTRODUCTION

The growth of global software engineering (GSE) has created a need to research, understand and address the challenges it presents to developers. A great deal of GSE research has focused on developing collaborative tools to support developers. Other research, from the organizational perspective, identifies key obstacles to the success in GSE, including the issues of shared identity, trust, conflict, and team performance (e.g., [1] and [2]). Still other research has reported the challenges of GSE from the developer's perspective and speculated on how collaborative tools can promote the awareness that is absent in globally distributed contexts (e.g., [3], and [4]). Despite these research efforts, not enough is known about the effectiveness of such tools from the perspective of actual practitioners working in real corporations that practice GSE. Yet, such information is crucial if there are to be real improvements of collaboration techniques and tools. Moreover, the lack of a theoretical framework leads to a situation where empirical studies are often conducted in ad hoc ways, inhibiting the meta-level analysis of the results.

To bridge these research gaps, this paper presents a review of existing research in this area, as well as a conceptual framework that theorizes how unique contextual dimensions of GSE (e.g. culture diversity and adaptation, etc.) influence developers' attitudes and usage in practice. The framework is grounded by literature review and our preliminary studies [5][6]. We also develop a work plan for empirical evaluation and refinement to the conceptual framework.

II. RESEARCH BACKGROUND

A. Collaboration Tools

Collaboration tools support GSE practices by providing a local, work context for developers located globally. Researchers have taken on two primary threads of work to date. The first is developing and evaluating visualization tools that summarize software engineering activities to promote awareness of them in the collaboration. Secondly, researchers have taken various collaboration technologies that are already part of the fabric of day-to-day Internet communications (e.g., e-mail, wikis, blogs, and feeds) and integrated them into virtual spaces with a sense of "place" where stakeholders can discuss, share, and brainstorm, as well as gain extensive awareness of development activities. An example of such a space is IBM Rational Team Concert (formally known as Jazz).

B. Studies on Attitude and Usage of Tools

Studying the attitudes and usage of collaboration tools for GSE is challenging due to a lack of access to organizational resources including time, personnel, and project information. Many companies equate sharing these resources to losses in productivity. As such, many tools are evaluated through ethnographic study, [7] laboratory study, [8] and/or survey [9].

Table 1 summarizes some recent examples of empirical studies of collaboration tools and some key findings. These examples represent different empirical study methods as well as different mechanisms implemented for supporting information behaviors in collaboration. Obviously, there are several important limitations in these studies. First, most of them are from the perspective of functionality rather than the users themselves. Second, we note that most of these studies were of collocated development teams and thus did not consider the virtual environment and the "global" software development characteristics. Furthermore, the sample size for most studies is usually relatively small and does not provide enough confidence towards the primary evaluation findings.

TABLE I. RECENT EMPIRICAL STUDIES ON COLLABORATION TOOLS

Tools	*Year*	*Approach*	*Mechanism*[a)]	*Subjects*	*Context*	*Primary Findings*
Sarma et al. [8] (Palantír)	2008	Comparative laboratory experiment (Quantitative)	Direct and indirect conflicts. (Eclipse plug-in)	Student (*N*=40; 26 for experiment 1; 14 for experiment)	90 min. lab sessions for predesigned tasks.	1. Improved ability to detect and resolve conflicts; 2. Minimal overhead; 3. Increased communication for resolving indirect conflicts.
Sarma et al. [10] (Tesseract)	2009	Laboratory experiment & Interview (Quantitative)	Linkage (Web-based Tools)	Experiment: Gnome Dev. (*N*=5) Interview: Dev. (*N*=5)	*Experiment:* 1 hour sessions for predesigned tasks. *Interview:* Feedback to some features.	1. Viewing and exploring linkages are interesting and useful; 2. Linkages are suggested by interviews for visualization.
Biehl et al. [7] (FASTDash)	2007	Observation (Qualitative)	Various kind of information (Dashboard style widget)	(*N*=5) 3 developers & 3 other project members.	170 min. pilot observation & 4-day formal observation.	1. FASTDash increased the communication and reduced the work overlap; 2. General attitudes to it are positive.
Begel et al. [11] (Codebook: Hoozizat &Deep Intellisense)	2010	Interview for Hoozizat; (Qualitative) No reported for Deep Intellisense	Developer related to code or expertise. (social media styleapplication)	Developers in Microsoft (*N*=14)	Use Hoozizat to find right people for code ownership or expertise.	1. No missing infomation, but some irrelevant results; 2. User interface is well accepted; 3. Various opinions on ranking results.
Fritz & Murphy [12] (Feeds)	2011	Interview (Qualitative)	Events in software process. (Feeds)	Developers in a large corporation (*N*=5)	Project with support of IBM RTC.	1. User's judgments on the relevance of information feeds depend on four factors; 2. Current tools support only one factor.
Dittrich & Giuffrida [13] (IM)	2011	Ethnographic study (Qualitative)	Various comm. channels (integrated to IM)	A team in three locations (USA: 1, Denmark: 5, India: 7; *N*=13)	4 months observation of using IM, and Interviews.	1. IM acts as a real time glue between different channels. 2. The communication through IM helps to build trust and social relationships
Treude & Storey [9] (IBM Jazz: Dashboard & Feeds)	2010	Mixed Approach (Quantitative & Qualitative)	Various kinds of information (Dashboard style web application)	Developers in IBM Survey: *N*=119 Team: ≈30	The process of Jazz Dashboard development.	1. Dashboard supports individual and collective process; 2. Feeds are used to track work at small scale; 3. Both evolve with the life cycle.

a) The mechanism here refers which kinds of information are provided and how information is presented.

III. CONCEPTUAL FRAMEWORK AND PROPOSITION DEVELOPMENT

A. Conceptual Framework Development

By combining preliminary results from our empirical studies of GSE and our literature review in several related research domains (e.g., software engineering, organizational study, and psychology), we built the following conceptual model (see Fig. 1). The conceptual model is novel in its focus on five unique dimensions of GSE practices and how these dimensions influence practitioners' attitudes towards collaboration tools and usage of them. The five dimensions are: *Cultural Diversity and Adaptation, Inter-team Communication and Coordination, Shared Social Identity, Geographic Distance,* and *GSE Experience*. Each dimension includes some individual factors, e.g., *attitudes* may contain *perceived usefulness*, *perceived task-tool alignment*. We focus on high-level dimensions in building conceptual framework, and will decompose them into specific factors in future empirical studies. We focus on the social and organizational dimensions rather than technical ones, which have been explored extensively by others (e.g., [11]), because the GSE is a typical social-technical system. The model in Fig. 1 depicts the five dimensions and emphasizes how both attitudes and usage behaviors are pivotal.

B. Proposition Development

Changes in attitude will directly lead to changes in behaviors according to Theory of Planned Behavior (TPB) [14]. Therefore, they are in the center of our framework. The first dimension in our theoretical framework is *Cultural Diversity and Adaptation*, which derived from our prior research on the role of culture diversity and adaptation in GSE teams [6]. We observed that where culture diversity is high, team members come from different organizations, nations, and have different professions. Our preliminary results indicate that culture difference may lead to different attitudes while cultural adaptations may encourage more usage [6].

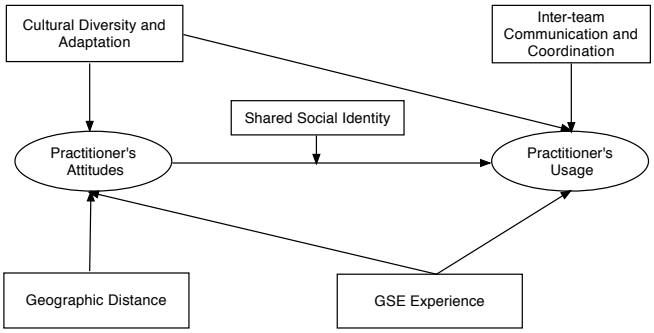

Figure 1. Theory development for practitioners' attitudes toward and usage of collaboration tools.

The second dimension is *Inter-team Communication and Coordination*. Previous studies indicate that inter-team communication and coordination are more frequent among remote teams and can directly influence the usage of collaboration tools [9]. *Shared Social Identity* is the third dimension in our preliminary theory development. Our literature review leads us to conclude that while this dimension may not only directly influence the attitude and usage, but also it may moderate the linkage between them (as shown in Fig. 1). As in any typical social-technical system, there are many social psychology factors involved in GSE practices. Specifically, software developers who work in a distributed way often lack shared social identity [2] and are more inclined to use technology to compensate [15].

Geographic Distance is the fourth dimension and assumes that such distance will influence attitudes towards tools, but not usage. GSE teams often reside in regions that have no overlap in their working time. The geographic distance and different time zone can increase people's reliance on communication technologies; hence increase the likelihood of positive attitudes towards new collaboration technology. The fifth and final dimension is that of *GSE Experience*, which is supported by literature and results of our own preliminary study [5]. Practitioners who have long exposure to GSE are more likely to have positive attitudes towards tools, and may also use them more frequently.

In terms of this model, our research centers on the following propositions:

PROPOSITION 1. *Positive attitudes towards collaboration tools will lead to more usage.*

PROPOSITION 2-a. *High culture diversity will lead to more diverse attitudes towards collaboration tools. Cultural adaptation may lead to more usage.*

PROPOSITION 2-b. *More inter-team communication and coordination will lead to more usage.*

PROPOSITION 2-c. *Shared Social Identity moderates the way in which attitudes towards collaboration tools influence usage. Specifically, with same attitude, higher shared social identity may lead to more usage.*

PROPOSITION 2-d. *Large geographic distance will lead to positive attitudes towards collaboration tools.*

PROPOSITION 2-e. *More personal experiences with GSE will lead to positive attitudes towards collaboration tools as well as more usage.*

These propositions provide high-level guidelines for framing future study. They will be refined according to the decomposition of specific factors in each dimension to draw more specific hypotheses for following studies. Here, these propositions only highlight the major concerns of our future research.

IV. Future Work Plan

Our future work consists of three highly interrelated parts: empirical field studies, theoretical development, and verification and refinement of the theory. The empirical field studies provide first-hand evidence for the theoretical framework. The empirical studies also enable us to explore rich details of each contextual dimension. In turn, the theoretical framework will guide the design of laboratory experiments with professional software development team members as subjects. The experimental results will be used for theory refinement and verification. Through this process, we can build a practitioner oriented theory with both high reality and scientific rigor.

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