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Distributed Developers and the Non-Use of Web 2.0 Technologies

A Proclivity Model

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***Abstract*—We sought to understand the role that Web 2.0 technologies play in supporting the development of trust in globally distributed development teams. We found the use of Web 2.0 technologies to be minimal, with less than 25% of our participants reporting using them and many reporting the disadvantages of adopting them. In response, we sought to understand the factors that led to the use and non-use of these technologies in distributed development teams. We adopted a mix of qualitative and quantitative methods to analyze data collected from 61 interviewees representing all common roles in systems development. We discovered six factors that influenced the use and non-use of Web 2.0 technology. We present a proclivity model to frame our findings as well as our conclusions about the interrelationships between the results of our qualitative and quantitative analyses. We also present implications for the design of collaboration tools, which could lead to greater support and usage by distributed developers.**

Keywords- Web 2.0 technology, technology adoption, virtual teams, distributed development, global engineering.

I. Introduction

Our interest in Web 2.0 technology adoption by distributed development teams emerged from a goal to understand the factors that influence trust in such teams [1][[2]. We assumed that the tools adopted by developers to support their collaboration would play a role in the development of trust, and that Web 2.0 technologies would be amongst the tools adopted. Instead, in a study of five large multi-site and multi-national organizations, we found that the use of Web 2.0 technologies (e.g. blogs and wikis, among others) was generally limited and several disadvantages were named when we interviewed developers. Thus, we could not investigate how these technologies influenced trust in distributed teams and sought to understand the use and non-use of Web 2.0 technologies.

Our initial assumptions were based on our review of previous studies. This review led us to assume that Web 2.0 technologies would be widely adopted by distributed development teams and that these technologies would play a significant role in supporting collaborations. Specifically, previous studies reported the use of Web 2.0 technology by development teams [3][4] and within organizations [5]. Others reported the significance of incorporating Web 2.0 features into software development environments [6]. We also found that organizational collaborations are highly dependent on social networks rather than teams based on organizational structure [8][9][10][11]. The growing recognition of the importance of social networks motivates the need for technologies that support the centrality of such networks within the modern workplace.

Web 2.0 technologies can provide support for social networks and yet we have a limited understanding of their use when adopted by distributed systems development (DSD) team members. As noted above, we found that these technologies are not widely adopted by development team members who participated in our study. Thus, our research questions became: *why do developers not use these technologies* and *who does use these technologies?* These research questions guided our subsequent analysis of the *use* and *non-use* of these technologies. We report our findings in this paper.

The remainder of this paper is organized as follows: Section II reviews research related to the use and non-use of Web 2.0 technologies in system development. Section III describes the research methodology adopted in our study. Section IV presents the data analysis procedures as well as the qualitative and the qualitative findings from the analysis. In section V, our proposed proclivity model of use/non-use of Web 2.0 technologies is presented. We then discuss the individual findings in relation to other work and each other in this section ,present the study limitations and our intended future work in Section VI. Implications for tool design are presented in Section VII. Section VIII concludes the paper with final remarks.

II. Background

The term *Web 2.0 technology* is often used to refer to "a platform via which individuals provide content and services in the public domain creating a network effect through which others can remix and continually update content" [5]. Such features are used to support social interactions, both personal

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and work related interactions in addition to facilitating a sense of community [10].

Studies of the *use* of Web 2.0 technology within organizations report the benefits of its adoption and also observe factors that could lead to its *non-use*. Many studies report the benefits of Web 2.0 technology adoption e.g. [10] [11][12]. We note that widespread adoption of said technology occurs when it is developed in-house and made available as a prototype [10][11]. Alternatively, successful adoption is achieved within the context of relatively small distributed development teams in small organizations [12]. The *use* of Web 2.0 technology within these contexts often led to an increase in productivity.

Web 2.0 technologies have also been incorporated into development environments and play a significant role in supporting coordination and communication within distributed development teams. IBM®'s Rational Team Concert® (formerly known as Jazz) includes dashboards and feeds that enable programmers to increase awareness by providing transparency during programming activities. Programmers share correct and current data through such mechanisms, often finding diverse uses for these features [6].

Researchers investigating the use of these technologies observed some factors that could inhibit its use or that could lead to the *non-use* of Web 2.0 technologies. The most common factor that has been reported is that such technologies were not adopted by a "critical mass" e.g. an insufficient number of team members adopt the technology. Other factors that can lead to the non-use of such technology are the time needed to explore the technology and the sense that the time spent is time wasted. Developers who adopt Web 2.0 technologies generally doubt their efforts will be rewarded given the amount of information made available through these technologies [11][12]. Thus the success of such technologies is highly dependent on the number of users reaching a "critical mass"; conversely the more people that utilize the tool the more time it will require for others to keep track of all the information made available through these technologies and avoid information overload [13]. We surmise that an inverse relationship exists between the two variables, *adoption* and *size-of-audience* since the likelihood of information overload increases with the increase of contributions.

III. Research Approach

We conducted an empirical study across five Fortune 500 multinational organizations that are considered leaders in the development of computer-based technologies. We recruited subjects through e-mails sent to a cross-section of the organizations' mailing list and word of mouth (snowball sampling). We specified that only employees who were members of a distributed development team within the last year or are members of such a team at the time of the recruitment were eligible to participate in the study.

We recruited 61 subjects: 18 female and 43 male employees. Participants had an average of 11 years' experience working in distributed teams and 12 years' experience in the organization. Overall, participants had an average of 21 years of work experience. The participants' roles in the distributed team fell into one of three broad categories: managers - 21 (e.g. project manager, portfolio manager), developers - 35 (e.g. tester, software designer, system architect, business analyst), and support staff - 5 (e.g. lawyer, quality assurance). Nearly 45 of the interviewees had been working on projects they discussed for over 6 months with the average experience in their current team calculated to be 13.5 months. Some interviewees reported that they had worked with some of their team members on other projects, and that they generally considered their current project teams stable. Interviewees were knowledgeable of Web 2.0 technologies. It is reasonable to assume that there is no restriction on selecting specific technologies due to the lack of shared common knowledge about them.

Study participants were based in one of the following locations: the United States, Brazil, Mexico, Costa Rica, Ireland, Israel, Poland, China, Taiwan, and Malaysia. We interviewed 34 participants from the U.S., 18 participants from Brazil, 2 participants from Mexico and 1 participant from each of the other remaining sites.

We note that our study participants' roles within their organizations and their geographic distribution increases the validity of results and findings. Our pool of participants is not limited to developers (often the only focus of other studies) but also includes team members who support and are involved in the development process. We sought to include the different perspectives of team members with diverse roles because distributed development teams typically consist of members who are not necessarily developers. We will refer to all study participants as "developers," in general, as they are all involved the development process in some capacity and we did not discover any correlations between our findings and a participant's "role".

The interviews were conducted face-to-face, over VOIP, and through telepresence technologies. Two researchers conducted all the interviews using the same interview protocol. Each interview lasted an average of one hour and consisted of a mixture of open-ended questions (e.g. information about participant background, team, project, and tools used), scenarios (e.g. about team selection), and requests for stories about participant experiences (e.g. cultural surprises encountered).

In each interview, the participant was asked to discuss practices within the context of a single project that was either ongoing or recently completed (i.e., within the last year). Furthermore, the project should have at least one team member located remotely. The definition of a *remote* team member was that a team member be located in a different time zone, different country, and/or a different culture. All our study participants discussed practices within a team in which two or more of these remote conditions applied to their team members. Our subsequent discussion of tool adoption and of Web 2.0 technologies was conducted within the context of this team's project.

IV. RESEARCH ANALYSIS AND FINDINGS: THE USE AND NON-USE OF TECHNOLOGIES

We identified all references to tools used in all the transcripts. We then coded and categorized these instances and performed both a qualitative and quantitative analysis of the transcripts. As discussed in the introduction, our initial impression was that Web 2.0 technologies were used far less than we expected. In fact, the interviews bore out only 24.5% of our participants indicated any usage of the technologies. The Web 2.0 technologies that they did discuss included: Facebook, Twitter, Blogs, and Wikis.

Our qualitative analysis focused on identifying the causal reasons subjects revealed for *non-use* of Web 2.0 technologies. Our analysis revealed that three factors influenced the non-use of these technologies. These factors were the non-alignment of these technologies to their work practices, the lack of support for these technologies, and their mistrust of information provided through these technologies.

Our quantitative analysis focused on eight demographic variables we identified as potentially influential during our review of the transcripts. For convenience, a short legend of the dependent variable and eight independent variables is provided in Table 1. In the appendix, in Table 2, we provide detailed definitions, measurements and basic statistics of all these variables. Also in the appendix, Table 3 presents pair-wise correlations of these variables. Utilizing IBM® SPSS 19 for Apple Macintosh OS X Leopard, we modeled the relationship of these variables in our statistical analysis through the logistic regression technique [14].

TABLE I. LEGEND OF VARIABLES

Variable	Meaning
Usage	The usage of Web 2.0 technologies
Language	Whether an interviewee can speak more than one language
Edu.	Whether an interviewee holds a postgraduate degree
Gender	An interviewee's gender
AGE	An interviewee's age
Exp@DSD	An interviewee's experience with distributed systems development
Job_M	Whether an interviewee is a manager or not.
Job_T	Whether an interviewee's job is technical-oriented or not
Communication Tech.	The number of communication technologies an interviewee has been used in their work except Web 2.0 technologies

Our quantitative analysis of our data led us to identify three factors that can influence the non-use of Web 2.0 technologies. We found that older participants are less likely to use Web 2.0 technology, yet those who had more experience in distributed development are more likely to use such technology. Furthermore, we found that developers who reported the use of diverse communication tools are more likely to use Web 2.0 technology. We discuss each of these qualitative and quantitative findings in greater detail in the following sections.

A. Qualitative Findings

Our manual coding of all instances of the *use* of Web 2.0 technology revealed that study participants often adopted one or more of these technologies to broadcast or announce team events and other news pertinent to the team members. One participant stated that using such technologies in this way allowed information sharing amongst all team members in an equitable manner. Other participants mentioned using some Web 2.0 technologies to post updates on team members' progress. We note that these participants did *not* report utilizing the dialectic features these technologies afford them.

Our qualitative analysis led us to observe that participants' *non-use* of these technologies is more prevalent and provided us with an understanding of *why* these technologies were not adopted. Our participants often mentioned constraints which inhibit their use of technologies. These constraints fell into one of three broad categories.

First, some participants stated that these *technologies are not aligned with their current everyday work practices*. These participants stated that Web 2.0 technologies were *not* like IM, e-mail and teleconferencing, which extend and support their current communications.

None of the participants mentioned that the use of Web 2.0 tools was "billable," or that the organization discouraged their use. On the contrary, some of the organization created and provided developers access to technologies such as internal wikis. However, -non-users considered adopting them as extra "paperwork". Many participants reported that they did not believe that these technologies effectively supported collaborations across sites. They maintained that face-to-face interactions amongst team members remain the only effective approach to developing trust and conduct effective collaborations.

Second, we found that while Web 2.0 technologies are supported in some organizations, they are *not available to some or all team members.* Participants reported that the technologies are not supported in some organizations and some sites. Other participants stated that the use of these technologies is prohibited by their organization.

Third, we found that a vast majority of participants doubted whether the information provided through these technologies is accurate on the one hand and whether it is useful on the other. There is a sense that such technologies enable individuals to write "anything" to "everyone." Thus, we encountered issues of *trust in information provided through these technologies.* Furthermore, the information provided through these technologies may lack focus and are often not of use to the participant.

These initial qualitative findings provided us with an understanding of *why* developers in distributed development teams adopted Web 2.0 technologies and the factors that can inhibit technology use. We sought to gain further insights by investigating the characteristics of *who* typically did or did not have a proclivity to utilize such technologies by analyzing participant demographics.

B. Quantitative Findings

We aimed to identify the influence of demographic factors' on the use of Web 2.0 technology in distributed development. Our quantitative analysis included coding and statistical analysis and then model development.

1) Data Coding and Basic Statistics

We first coded *usage* into a 0-1 variable: '0' represents the non-use and '1' means use. The usage information was extracted from the interviews, in which our respondents discussed their collaboration tool usage (Fig. 1).

We consider the *usage* variable a dependent variable in our analysis. In Fig. 1, we depict the distribution of Cumulative Frequency where the y-axis represents the cumulative number of interviewees who have already used Web 2.0 technologies and the x-axis represents each interviewee's choice. The figure illustrates the "running total" of interviewees' usage of each individual case's value as well as how total frequencies are accumulated incrementally.

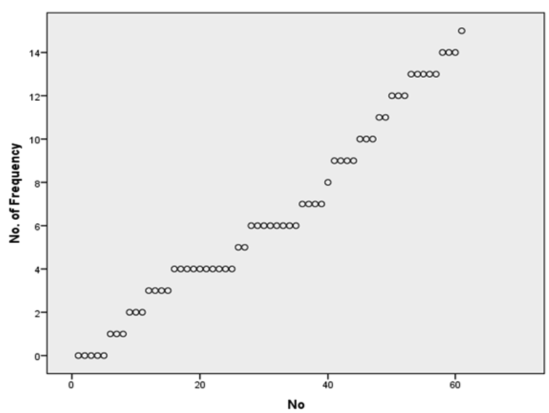

Figure 1. Cumulative frequency of 61 cases of technology use.

2) Model Building and Selection

We used logistic regression to build the quantitative regression model [14]. Logistic regression is optimal for our analysis because the dependent variable is a 0-1 variable, which cannot be estimated by the linear regression techniques. We assumed that the 61 data cases are a set of independent Bernoulli experiments. The logistic model can therefore be used to estimate the probability of each experiment with a set of influential factors (independent variables). We specify the model in the following form:

$$\theta(p) = \ln\frac{p}{1-p} = \beta_0 + \sum_{1\le k\le 8}(\beta_k \times IV_k) + \varepsilon \qquad (1)$$

It is important to note that the constant (β_0) can have a value of 0, or not have a value of 0. We therefore considered two sets of models respectively, according to its value. The models are summarized in Table 3 (β_0 != 0) and Table 4 (β_0 = 0). We started from a model with only that one constant and added other variables incrementally forming a set of nested models for model comparison. In this process, we use the "Enter" method to add each variable step by step [14].

The incremental model building process generated two sets of nested models. A careful comparison of the models presented in the Appendix in Table 3 (β_0 != 0) with those presented in Table 4 (β_0 = 0) led us to observe that the latter provides greater explanatory power. This indicates that the constant should not exist in the regression equation. Furthermore, by comparing the nested models in Table 3, we find that the model 2-8 is the best model.

Finally, while we investigated eight independent variables, we observed that only three variables (*AGE*, *Exp@DSD*, and *Communication Tech*.) appear to significantly influence the value of the whole regression equation. We will refer to these three variables collectively as *significant independent variables*, hereafter.

We went on to further explore the potential relationship of the significant independent variables and consequently built a new model which we refer to as "*Model O*" (the last column, to the right of Table 4). *Model O* is optimum for two reasons: (1) all variables significantly influence the estimation of the probability of dependent variable, and (2) this model is only 2.6% loss on explanatory power compared with the model 2-8, where there are five more variables in the regression equation (*Cox & Snell R-square: 0.348 vs. 0.374*). Hence, we conclude the following logistic regression model:

$$\theta(p) = \ln\frac{p}{1-p} = -0.123\times AGE + 0.141\times Exp@DSD + 0.900\times Communication\,Tech + \varepsilon \qquad (2)$$

We then change the form of this model to explicitly identify the influence of the independent variables:

Let:

$$\lambda = -0.123\times AGE + 0.141\times Exp@DSD + 0.900\times Communication\,Tech + \varepsilon$$

$$We\ have: \frac{p}{1-p} = e^{\lambda},\ hence,\ p = \frac{e^{\lambda}}{1+e^{\lambda}} \qquad (3)$$

We can establish that, $p = \frac{e^{\lambda}}{1+e^{\lambda}}$ is a monotonic increasing function on λ. There is linear relationship between λ and three independent variables. For the three significant independent variables in the regression equation, the coefficient of *AGE* is negative and the coefficients of *Exp@DSD* and *Communication Tech.* are both positive. This leads us to the following three conclusions:

1. *An increase of age will result, ceteris paribus, the lower probability of using Web 2.0 technologies to support distributed collaboration.*
2. *An increase of experience of distributed development will result, ceteris paribus, the higher probability of using Web 2.0 technologies to support distributed collaboration.*

3. *An increase of using other Communication Technology will result, ceteris paribus, the higher probability of using Web 2.0 technologies to support distributed collaboration.*

It is interesting to note that in Table 2, the *AGE* and *Exp@DSD* are positively correlated (β = 0.578), which means the increase of age often brings the increase of experience in distributed development as well. We thus need to consider the combined effect of *AGE* and *Exp@DSD*. The increase of *Exp@DSD* reduces the negative effect of *AGE*. When considering the coefficients of experience and age, however, we find that the increase in experience cannot fully offset the negative effect of the increase in age. Given that the subjects in this study are fairly experienced, with over 20 years average work experience, we can expect a higher rate of adoption than the less-experienced participants who were included in our sample. Moreover, it is possible that the senior developers would be forced to use Web 2.0 technologies more in a team where young people who use these Web 2.0 technologies frequently form a critical mass.

V. Discussion of Findings

Our study was conducted *in-situ* and provides us with an understanding of how Web 2.0 technologies are perceived by members of distributed development teams, within the context of current work practices. Our review of previous studies led us to observe that these studies were typically conducted through context-free questionnaires [15], have been a longitudinal study [6], or a study of general knowledge workers rather than members of a distributed development team [15]. Furthermore, previous studies of Web 2.0 technology adoption within an organization typically investigated the use and non-use of technology developed in-house [10][11][12], or in the short term with no follow up of whether they continued their use or whether employees' attitude towards the technology changes [16][17][18]. Few have investigated whether emerging technologies are actually suited to different regional cultures or investigated whether technologies were adopted across sites characterized by diverse regional culture [19]. Cultural attributes may not be consistent across sites in distributed teams that are characterized by cultural diversity.

The purpose of previous research on Web 2.0 technologies within development teams has also typically focused on the development of tools e.g., [20][21], or their evaluation within academic environments e.g., [22][23]. These observations led us to conclude that we need to gain a better understanding the use of Web 2.0 technologies within distributed development teams. Our study gave us insights into diverse team dynamics as participants discussed their role within a single team distributed across sites and/or across different organizations (e.g. with vendors). We found the reasons for non-use to be consistent across roles (e.g. support staff, developers, and managers) and across different types of different dynamics (e.g. they did not state that reason for their non-use of these tools to avoid inappropriate transparency when collaborating with vendors). And although our study did not focus in investigating different types of developer communities (e.g., custom development, open source, ERP development), we found our results were consistent even when the organization supported the use of these technologies.

In sum, our study results demonstrate that while the technology is available in some of the organizations we investigated, less than 25% of our study participants adopted these technologies and most have a negative view of these technologies. We observed that our study participants who did use the technologies typically did not utilize the dialectic features available to them and thus did not benefit from technology features which enable them to "remix and continually update content" or to create a "community" [5][10].

We also identified six factors (three quantitative and three qualitative) that influence use and non-use of Web 2.0 technologies from our analysis of 61 transcripts. We considered these factors and their implications regarding the use and non-use of Web 2.0 technologies within both the *group* and *individual* dimensions. This investigation led to the proclivity model illustrated in Fig. 2. The model takes the form used by Quinn [24], in which different orientations collectively form a domain to contextualize the outcome. We adapt Quinn's form for the purpose of our study, such that *Group* and *Individual* form the domain and the factors which influence Use/Non-Use of Web 2.0 technologies are visualized within that form.

Our model illustrates that the use and non-use of Web 2.0 technologies is influenced by the six factors we identified through our analyses. The position of each factor in Fig. 2 is determined by whether it is a *group* factor, an *individual* factor, or a combination of both. For example, *AGE*, *Exp@DSD* and trust in Web 2.0 technologies are individual attributes while we consider organizational policies on technology usage a factor within group domain. The other two factors (Tool-work alignment and Usage of other tools[1]) are factors that cross both group and individual domains.

We also use the proclivity model to visualize the interrelationships between our factors. We consider our six factors (qualitative 1-3, and quantitative 1-3) and the inter-relationship we can derive from our analysis of the 61 transcripts. We then use solid lines to represent the relationships identified within the data collected during our study. First we consider quantitative 1 and 2, which both belong to individual level. Our analysis led us to conclude that these findings are interrelated, as our findings imply that the increase of *Exp@DSD* reduces the negative effect of *AGE* (discussed in Section IV).

We then consider qualitative 1 and 3, together with quantitative 3. Our participants indicated that e-mail, IM and videoconference are all collaboration tools high in work-technology alignment (qualitative 1 and quantitative 3). Participants also show high trust in these tools that is implied by their high dependency on these tools. These traditional

[1] Usage of other tools is not only a factor in individual level, as usage is also influenced by the behaviors of peers.

tools provide direct access to trustworthy information with minimal manipulations (qualitative 2 and quantitative 3).

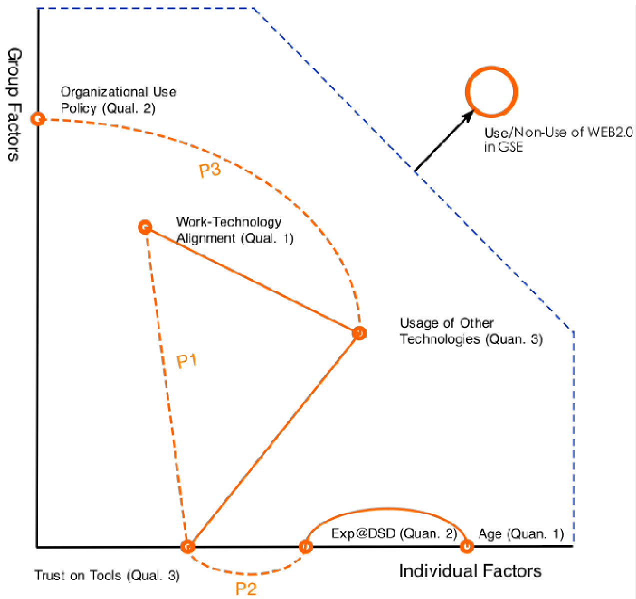

Figure 2. A proclivity model of use/non-use of Web 2.0 Technologies.

We then considered our findings within the larger context of previous work conducted by others and determined three conclusions. We represent the inter-relationships that we concluded from our review by a dash line, also in Figure 2. The first dashed line (P1) is between qualitative finding 1 and qualitative finding 3 and is derived from our review of D'Ambra and Wilson [25] and Dishaw and Strong [26] work. D'Ambra and Wilson [25] found that high task-technology fit reduces the users' uncertainty about information provided by the travel website. Dishaw and Strong [26] state that task-technology fit enhances the programmers' confidence of maintenance tools, hence promoting the utilization. Members of global distributed development teams may trust the information provided by the collaboration tools more when these tools fit their daily work well. Hence, we reach our first conclusion:

CONCLUSION 1. *The work-technology alignment is positively associated with distributed developer's trust towards collaboration tools.*

Tool adoption and trust has also been studied within the marketing and consumer research domain. These studies concluded that the positive experiences with web-technologies can engender greater user trust in e-commerce websites. Elliot and Fowell [27] state that prior experiences significantly influence the sense of trust towards a website. Our findings suggest that the underlying cognitive process is similar for Web 2.0 technology adoption, users of both technologies are making judgmental decisions to information provide by automated tools. Furthermore, experience working within distributed development teams also implies more exposure to different tools. This can mean that developers could better evaluate the trustworthiness of collaboration tools. Therefore, it is reasonable to assume team members' experience in distributed development teams will have significant influence to trust perception towards these tools. These deliberations led us to our second conclusion:

CONCLUSION 2. *The experience of being exposed to distributed development is positively associated with distributed developer's trust towards collaboration tools.*

Finally, the organization's policies regarding technology adoption (qualitative finding 2) also influences the usage of traditional collaboration tools. We found several instances in which participants reported that the organization is unwilling to invest in improving the IT infrastructure, which makes technology adoption challenging. The support of technologies from senior management is often considered one of the most important success factors of IT usage in organizations [28]. IM applications, for example, are still prohibited in many business organizations or allowed with only limited functionality [29][30]. Other organizations actively encourage the adoption of communication tools, e.g. IBM encourages their employees to use Lotus® Sametime to collaborate with remote colleagues and invested significant resources to support its adoption. These findings suggest the third and final conclusion:

CONCLUSION 3. *The encouraging organization policies on collaboration tools are positively associated with distributed developers' usage of traditional collaboration tools.*

VI. Study Limitations and Future Work

We recognize that our recruitment process (self-selection and snowball sampling) may lead to a biased sample. We feel that the sample size, diversity of sites, and diversity of roles within our participant pool can off-set this bias to some degree. Also, the study was conducted across five multi-national organizations, which further increases our confidence regarding our insights into why such technologies may not be used in distributed teams. Future work includes investigating the use and non-use of collaboration tools further. We plan to replicate this study in more agile software development organizations where Web 2.0 technologies may receive more acceptances in general.

In this paper, we chose to emphasize the results of a quantitative analysis of our field data. Yet our choice of research method and the richness of our resulting data provide an excellent opportunity to further *qualitatively* analyze the aspects of adoption of Web 2.0 technologies. Though we have provided some preliminary results in this paper, we plan to emphasize results from this analysis in future publications.

VII. Design Implications

In this research, we employed both qualitative and quantitative methods to analyze the data we collected *in-situ*. Together with our careful review of literature our data and subsequent analysis suggest some design implications for collaboration tools. We discuss these in the following sections. In general, we find that a more holistic collaboration environment is required, such that the tool can support the collaborations of all team members within their diverse roles. Our research also reinforces the idea of extending existing widespread tools typically utilized during collaboration e.g. e-mail application, rather than the creation of new environments.

A. Horizontal Integration of Collaboration Tools

Our qualitative findings imply that a balanced ecology of technologies is needed to support the inclusion of Web 2.0 technologies. According to Grudin [31], tools need to be natural metaphors of collaborations to succeed. The prevalent use and high acceptance of e-mail and video conferencing implies that one approach to greater acceptance is to integrate Web 2.0 technologies mechanisms within these applications. For example, tools may have functions such as sharing information via e-mail or instant messenger. In this way, even individuals who do not use Web 2.0 technologies could benefit. Video conferencing records may also be published and archived on Web 2.0 collaboration technologies as in archived conference notes. Our quantitative findings show that the increased use of traditional tools positively associate to higher possibility of Web 2.0 technologies utilization during collaboration. The *horizontal integration of collaboration tools*, integrating Web 2.0 mechanisms across tools, can influence team members' attitudes towards these tools implicitly, and potentially increase their usage.

B. Vertical Integration of Collaboration Tools

Groupware typically needs to spread vertically within organizations to succeed [28]. In organizations that develop computer-based products, developers need collaboration tools to support their development activities in addition to other team members (lawyers, managers, etc. and other stakeholders in the development process). This implies vertical integration is needed to support the various members' activities within the team. While current Web 2.0 style tools, have achieved some success in supporting programmers' collaborations [6], these technologies have failed to gain similar success in supporting the needs of other project staff. This failure can be due to the lack of task-technology fitness for team members who are not programmers [32]. This suggests that future designs of collaboration tools also need to consider non-developers' needs while maintaining the desirable features to meet developers' needs. This need for *vertical integration of collaboration tools* corresponds to the *horizontal integration* discussed in the previous section.

The vertical integration of collaboration tools, however, can lead to information overload and privacy concerns. Information overload is likely to occur when team members use a single application without information filtering. Information overload can lead to reluctance in seeking relevant information that is provided through the collaboration tools. Team members may also have concerns regarding privacy because they may want to share information with specific team developers but not necessarily all members in their team [33].

In designing Web 2.0 collaboration tools, we can leverage some ready-to-use solutions provided by existing social media websites such as Facebook and Google Plus. Facebook provides Publisher-Subscriber mechanisms to control the quantity of information that will be displayed and let its users define and personalize their privacy strategies. In Google Plus, implement personalized privacy policy in an efficient way while allowing users to include their contact information into different circles. Recent research on "collaborative traces" can also help development team members decide on different filtering mechanisms through mining the prior collaborations that provide heuristics to infer who needs what information [34]. These tools and research insights can help designers increase tool-work alignment as well as the users' trust of the information provided through collaborative tool.

VIII. Concluding Remarks

Web 2.0 technologies are perceived by some researchers as an extension of traditional collaborative software tools [35]. Interestingly while previous research has discussed how such technologies can positively support collaborations and the trust in the individuals (e.g. bloggers), and fulfill the needs of knowledge and information sharing; few have investigated the non-use of such technologies and possible negative attributions associated with them.

In this paper, we make several contributions to the domain of distributed development. First, we propose a proclivity model to illustrate the factors which influence the use and non-use of Web 2.0 technologies in addition to the interrelationship between these factors. The proclivity model can also be used to visualize existing theories of the use and non-use. Furthermore, our model can provide support for future systematic deliberations on research in this area as well as identifying future research opportunities.

Second, our results demonstrate high consistency with established theories such as UTUAT [15], Task-technology Fit [32][36], Success of Groupware [37], and others discussed in previous sections. Our work demonstrates the validity of these theories in a new context, which can help increase researchers' confidence in applying these theories to the context of distributed development. Third, our results, which focus on the Web 2.0 technologies, enhance existing theories that focus on the use of collaborative tools in general. Web 2.0 technologies are different from other collaboration tools. Our results shed light on understanding the use/non-use of these technologies for complex collaboration tasks. Finally, unlike other studies, our research took a much broader perspective as we consider non-programming team members within development teams as well as developers, which is more reflective of collaborations within distributed development teams.

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APPENDIX

TABLE II. BASIC STATISTICS.

Variable	Variables' Meaning	Type	Mean (Frequency)	STD.
Usage	The usage of Web 2.0 technologies. 0: non-use, 1: use.	Categorical	46:15	N. A
Language	Whether an interviewee can speak more than 1 language. 0: Mother tongue only, 1: Multi-language.	Categorical	23:38	N. A
Edu.	Whether an interviewee holds a post-graduate degree. 0: College level or lower, 1: Postgraduate.	Categorical	21:40	N. A
Gender	Female: 0 or Male: 1	Categorical	18:43	N. A
AGE	The age of interviewee, computed based on their year of born.	Continuous	42.328	10.545
EXP@DSD	The experience with distributed systems development, measured by year.	Continuous	11.148	6.563
Job_M	Whether an interviewee is a manager. 0: Not a manager, 1: A manager.	Categorical	31:30	N. A
Job_T	Whether an interviewee's work is technology or business oriented. 0: Technology oriented, 1: Business oriented.	Categorical	45:16	N. A
Communication Tech. Adopted	The number of communication technologies an interviewee has been used in their work except Web 2.0 technologies.	Continuous	2.525	0.808

TABLE III. PAIRWISE PEARSON CORRELATIONS

	Usage	*Lang.*	*Edu.*	*Gen.*	*Age*	*Exp@ DSD*	*Job_M*	*Job_T*	*Comm. Tech.*
Usage	1								
Lang.	-.027	1							
Edu.	-.067	.148	1						
Gender	.036	-.207	-.091	1					
AGE	-.073	-.538**	-.066	.010	1				
EXP@DSD	-.101	-.398**	-.111	.136	.578**	1			
Job_M	.047	-.250	.023	.061	.229	.116	1		
Job_T	-.167	.310*	.275*	-.104	-.065	-.128	-.065	1	
Comm. Tech.	.386**	-.335**	.044	-.070	.017	-.043	.052	-.204	1

Note: ** Significant at .01 level, * Significant at .05 level.

TABLE IV. NESTED MODELS WHEN (β_0 !=0)

	Model 1-1	Model 1-2	Model 1-3	Model 1-4	Model 1-5	Model 1-6	Model 1-7	Model 1-8	Model 1-9
(Constant)	-1.121 (.000)**	-1.041 (.028)*	-0.873 (.131)	-0.997 (.227)	0.352 (.854)	0.721 (.721)	0.647 (.751)	0.499 (.814)	-5.250 (.081)^
Language		-0.129 (.833)	-0.083 (.893)	-0.058 (.926)	-0.379 (.616)	-0.277 (.724)	-0.237 (.764)	-0.014 (.987)	1.184 (.224)
EDU			-0.308 (.620)	-0.300 (.630)	-0.298 (.633)	-0.261 (.681)	-0.264 (.679)	-0.094 (.886)	-0.518 (.485)
Gender				0.144 (.833)	0.079 (.909)	-0.065 (.927)	-0.079 (.912)	-0.121 (.868)	0.285 (.734)
AGE					-0.026 (.438)	-0.056 (.199)	-0.059 (.187)	-0.055 (.230)	-0.053 (.307)
Exp@DSD						0.078 (.201)	0.079 (.195)	0.078 (.204)	0.128 (.088)^
Job_M							0.309 (.622)	0.293 (.642)	0.435 (.542)
Job_T								-0.976 (.269)	-0.572 (.548)
Comm. Technologies									1.544 (.003)**
Model Summary	N. A.								
-2 Log Likelihood		68.006	67.762	67.717	67.112	65.400	65.156	63.795	52.696
R-Square (Cox & Snell)		0.001	0.005	0.005	0.015	0.043	0.046	0.067	0.223
R-Square (Nagelkerke)		0.001	0.007	0.008	0.023	0.063	0.069	0.100	0.331
Chi Square (Hosmer and Lemeshow test)		0.000 (df=0) N. A.	0.005 (df=2) .998	1.456 (df=5) .918	6.735 (df=8) .565	4.288 (df=8) .830	7.471 (df=8) .487	10.165 (df=8) .254	11.052 (df=8) .199

Note: ** Significant at .01 level, * Significant at .05 level, ^ Significant at .1 level.

TABLE V. NESTED MODELS WHEN (β_0 =0)

	Model 2-1	Model 2-2	Model 2-3	Model 2-4	Model 2-5	Model 2-6	Model 2-7	Model 2-8	Model O
Language	-1.170 (.002)**	-0.603 (.219)	-0.462 (.375)	-0.285 (.607)	-0.094 (.875)	-0.073 (.903)	0.116 (.850)	-0.021 (.976)	
EDU		-0.852 (.078)^	-0.643 (.231)	-0.227 (.652)	-0.224 (.721)	-0.235 (.710)	-0.071 (.912)	-0.495 (.483)	
Gender			-0.445 (.330)	0.133 (.833)	0.048 (.941)	0.021 (.974)	-0.044 (.946)	-0.394 (.577)	
AGE				-0.021 (.161)	-0.043 (.075)	-0.047 (.063)^	-0.046 (.070)^	-0.115 (.007)**	-0.123 (.002)**
Exp@DSD					0.074 (.211)	0.075 (.203)	0.075 (.208)	0.137 (.070)^	0.141 (.038)*
Job_M						0.324 (.604)	0.305 (.627)	0.257 (.705)	
Job_T							-0.988 (.262)	-0.808 (.386)	
Comm. Technologies								1.107 (.011)*	0.900 (.013)*
Model Summary									
-2 Log Likelihood	73.488	70.219	69.264	67.146	65.527	65.256	63.850	56.005	58.489
R-Square (Cox & Snell)	0.168	0.210	0.222	0.248	0.268	0.271	0.288	0.374	0.348
R-Square (Nagelkerke)	0.221	0.279	0.296	0.331	0.357	0.362	0.384	0.498	0.464
Chi Square (Hosmer and Lemeshow test)	0.000 (df=0) N. A.	2.395 (df=2) .302	1.271 (df=4) .866	10.962 (df=8) .204	9.339 (df=8) .315	5.837 (df=8) .666	5.451 (df=8) .709	3.148 (df=8) .925	5.944 (df=8) .653

Note: ** Significant at .01 level, * Significant at .05 level, ^ Significant at .1 level.