11

Team-Based Software Development Using an Electronic Meeting System: The Quality Pay-Off

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Abstract

To determine the effects of a home grown Electronic Meeting System (EMS) on product quality. We surveyed 40 software development teams and their project sponsors. Teams were part of a single software development laboratory which itself is part of a large international organization. A model of intra-group conflict management which incorporates using an EMS to reduce work uncertainty is a significant predictor of product quality. Further, teams with higher levels of experience relied less on the EMS. This leads us to believe that using the EMS acts as a conflict management surrogate for less experienced teams.

Keyword codes: D.2.2, H.5.3, K.6.3
Keywords: tools and techniques, group and organization interfaces, software management.

1. INTRODUCTION

This paper reports on product quality improvements realized by software development teams at a large software development laboratory. The changes in quality are one by-product of team-based software development using an electronic meeting support (EMS) system. This EMS was developed in-house, specifically to support software development. These EMS are suites of software tools available in specially designed meeting rooms, often with facilitation [1,2,3]. Research reported on here focuses on two questions:

(1) What characteristics of software development teams affect product quality?
(2) How does using an electronic meeting system affect product quality?

The EMS represents one intersection of two major developments in the organization of technologically sophisticated work [4]. First, organizations increasingly rely on groups, or teams, as the locus of work [5,6]. Second, organizations increasingly rely on technology to support work [7,8,9].

The research site is a software development laboratory: one site of a large international company. This site develops complex sub-system software. Both the scale and complexity of the development effort required to produce this type of software dictate using software development teams. Software developers at the site are accustomed to working in teams; and, they expect that appropriate software will be available to support their efforts.

In recent years developing software at this site has been rapidly growing more difficult. The size and complexity of the software products are expanding. Products are being ported to multiple platforms and core modules of the older products are being refined and re-written to improve system performance. These challenges are magnified by the organization's turbulence. The lab has had three site managers and two division managers in three years, and experienced difficulty in competing for new product areas.

2. THE ELECTRONIC MEETING SYSTEM

The EMS used at this site grew from the work experiences of the teams themselves. It began with a laptop computer, LCD projector, and a projector screen in a conference room. The concept has matured to where

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more than 20 meeting rooms at the site, representing 60% of available meeting space, have been configured as EMS. These EMS have a dedicated work station projecting onto a large screen. The screen is normally located at one end of the room and is the dominant feature. Rooms also have electronic whiteboards, facsimile machines, telephone lines, video equipment, and ergonomic layouts.

The EMS's computer is tied into the organization's local and wide area networks. These networks provide access to all software and work products accessible at any developers individual station. The workstation is identical to developer's systems. The facsimile, telephone, and whiteboards allow for additional communication and idea capture -- both in the room and to other sites and other EMS. Video allows for meetings to be taped and reviewed. This preserves the history behind decisions, provides training tapes, and helps to document projects.

3. THEORETICAL BASIS

The research stems from two existing lines of research. Research on group process suggests a causal relationship where group and individual characteristics affect the processes of working together, which in turn affects team performance [10,11]. The EMS-use research focuses on how EMS use affects both the process and the outcomes of team-based work [12,13,3]. Major components of the model are:

Team-Member Experience: From the observations and exploratory interview it was clear the developers and managers felt team member experience was a critical input. Previous group process research also posits the importance of team-member experience as a determinant of performance [14,15,16,10].

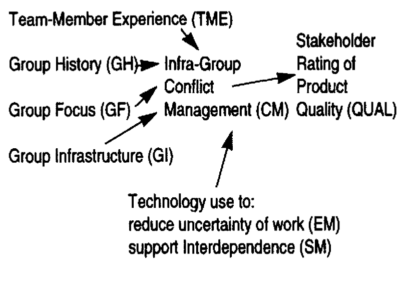
Group History: Exploratory interviews also indicated that teams had extensive group history. In addition, literature on ISD discusses group history as an importance predictor of performance [17,18,19].

Group Focus and Infrastructure: Hackman [14,15,16] defined a set of elements to characterize group processes. These can be described as elements of group focus or group infrastructure. Group focus encompasses team member's commitment to working together, the degree to which the work is an exciting challenge, the clarity of the group's goals, and the strength of the group's norms. Group infrastructure includes the material and technical resources available to the group and the team leaders managerial style.

Group Process: Process-oriented studies of software development have focused on relating the process of reducing intra-group conflict to improving performance [20,21,22,19]. Since groups of people bring differing levels of experience to a problem, as well as a broad range of views, conflicts between team members is endemic to tasks such as design [23,24,25,26]. In addition, EMS-use research often employs intra-group conflict management as the theoretical basis for their work [27,28].

Technology: Our view of technology builds on previous work by Fry and Slocum [29,30,31]. Technology is seen as a way to either reduce the uncertainty of the worki facing the group or to support the interdependence between team members.

Figure 1: Research Model



Product Quality: The performance variable is an aggregate measure of the quality of the final product [33]. We used stakeholder assessments of performance. Stakeholders are individuals who are not on the team but are directly affected by the product. Thus, their view of quality may be the most crucial evaluation of performance [33] when product quality is a critical performance measure [34].

Figure 1 presents the research model. The model posits that the group's conflict management process is affected by the experience of the individual team member, the length of time the group has been together, the degree to which the group is focused on their work, and the amount of project infrastructure provided to the team. The process is also affected by the use of the EMS as functionally characterized by its' ability to reduce work uncertainly (making tasks easier to perform) and its' ability to support team interdependence.

These are seen as a set of moderators and mediators to the software product's quality as measured by stakeholders.

Two hypotheses are developed from the model presented in Figure 2. The first hypothesis posits that the intra-group conflict management process of team-based software development is a moderation model, accounting for differences in software product quality [35]. Moderation means that the relationship between two variables is dependent on the level of a third variable. In this model, the group input elements' effect on product quality, are moderated by the conflict management process.

H1: The intra-group conflict management moderates the group and team-member inputs. This accounts for differences in software product quality.

The second hypothesis posits that using the EMS mediates the process of developing software. The interaction of intra-group conflict management and EMS using is a more powerful predictor of the process effects on software product quality. This is a mediation model [35] as the interaction between process and technology use becomes a significant predictor of product quality.

H2: EMS use mediates the intra-group conflict management. This accounts for additional differences in software product quality.

4. RESEARCH METHOD

This is a field-based study employing, cross-sectional surveys of development teams coupled with longitudinal data collection involving interviews with team members and observation of team meetings [36,37,38]. Over 16 months, 60 interviews and surveys of 40 teams were collected. During this time, more than 30 work days have been spent al the site observing meetings and collecting the data. A key-informants method was used to gather survey data [39,40,33]. Key informants are members of the team who provide a broad sample of the entire team. Researchers contacted each team directly about participating, describing the feedback they would receive if they participated.

4.1 Sample

Forty teams participated. The sample represents approximately 50% of the project teams at this site, and includes teams from all departments. At the individual level, 128 respondents from the 40 teams represent about 20% of all developers. For each team surveyed, key stakeholders were contacted to provide an external evaluation of software product quality. All respondents were assured of their anonymity: results are aggregated to team levels. Teams average 2 years as a unit. Team members average 9.8 years of professional experience and 7.9 years with this company.

Stakeholders were identified by the teams and these stakeholders were approached independent of the teams. Stakeholders were drawn from both customer and managerial positions to reduce organizational bias. For each team, from one to three stakeholders completed a survey. These stakeholders had an average of 13.7 years of professional software development, had managed software development for 8.3 years, and had been with this company an average of 10.2 years.

4.2 Instrumentation

To conduct the research two survey instruments ware employed: one for team members and one for stakeholders. This reduces method bias by separating independent and dependent variables [36,41]. Indicators for group history and team-member experience were developed from the exploratory interviews and observation. All other variables were measured using previously developed scales [16,6,26,27,42]. The dependent measure is a scale of quality in terms of the product's flexibility and maintainability [33].

5. ANALYSIS

This research focuses on two questions. First which characteristics of team-based software development best predict software product quality? Second, how does using an EMS affect software product quality? Since a mediation model is posited, path-analytic methods of analysis are used [35,43,44,46]. Further, EMS use is seen as an interaction effect [47,35].

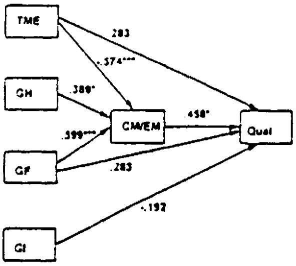
Path models decompose the total effect of one variable on another into direct, indirect, and spurious elements. They imply a causal ordering, and all paths must be calculated. Total effects are the zero-order correlations. Direct and indirect effects are calculated using the standardized coefficients of multiple regression and the linear path relationships between the model variables [44,45].

To test H1, a path model of the team-member and group inputs, group process, and outcome variables was estimated. The model is not significant ($F=2.05$, $p=.097$, adjusted $R^2=.121$). Thus, Hl is rejected. The moderated conflict management model of software development team process provides no significant predictors of software product quality.

To test H2, a path model of the team-member and group inputs, the interaction of the group process and EMS, and outcome variable was estimated. Testing for the interaction effects of the conflict management process and both technology variables indicated that only one interaction team was significant. Further, since the significance of the coefficient of the interaction team cannot be evaluated when first-order teams are included, the path model for H2 differs from H1's path model in that the process team reflects the interaction of EMS use to reduce work uncertainty and intra-group conflict management [47,35].

Table 1: Path Calculations of Interaction Model

Path Effects:	Total	Direct	Indirect	Spurious
TME-CM/EM	-.1794	-.5735	-.0235	-.4176
GH-CM/EM	.2516	.3889	-.1373	.0000
GF-CM/EM	.5068	.5985	.3212	-.4129
GI-CM/EM	.4793	.0692	.4087	-.0014
TME-QUAL	.1899	.2832	.1638	-.2571
GH-QUAL	.0989	-.1125	.0334	.1780
GF-QUAL	.4493	.2830	-.1061	.2724
GI-QUAL	.2910	-.1915	.4549	.0276
CM/EM-QUAL	.4194	.4579	.0000	-.0083



*p : .05 = *.p : .01 = **.p : .001 = ***. paths less than .011 not shown*

Figure 2: Final Path Model

Table 1 presents the path calculations and Figure 2 summarizes the most important paths. The model is significant ($F=2.98$, $p=.025$, adjusted $R^2=.207$). H2 is accepted: using an EMS moderates software development team intra-group conflict management and affects stakeholder views of software product quality. That is, there is a synergy between using the EMS to reduce work uncertainty and the management of intra-group conflict. The interaction team is a significant predictor of the variance in software product quality. Further, team-member experience, group history, and group focus are significant contributors to both software product quality and the interaction of EMS use to reduce work uncertainty and manage intra-group conflict.

6. DISCUSSION

This research has been motivated by two issues. First, the need to better understand the effects of intra-group conflict management has on software product quality. Second, to better understand the effect using an EMS has on software product quality. The data show that as team-member experience increases, the synergistic effect of EMS use to assist in intra-group conflict management decreases. This may mean that more experienced teams have developed successful conflict management processes. Thus, for these teams, using the EMS may not be as valuable for assisting in managing conflict or reducing work uncertainty. Interviews with developers and managers indicate that the way the EMS is used varies by the team's aggregate experience. Less experienced teams used the EMS to help them explore and define issues and to establish work processes. More highly experienced teams used the EMS to report on project status and deliverables.

The data further show that group history and focus are significant predictors of the EMS/conflict interaction. The model in Figure 2 also indicates there is a significant affect to produce quality through managing intra-group conflict and using an EMS to assist in this process. This supports the contention that process-focused models of software development provide both insight into how teams go about software development and what affect these processes have on outcomes.

This result is particularly interesting in that the EMS providesa vehicle for team members to more easily manage conflict. The large screen and ergonomic design make it easy to work in the room so that everyone can focus on the same work product [48]. More importantly, by facing the work product, and not each other, the product becomes less attached to any one person: it is shared by the team. Thus, it may be easier to criticize a dis-embodied product on the common screen than to face a colleague and disagree. It is also easier to accept criticisms since it is directed toward the work and not toward the developer. While managing conflict often means confronting criticism and trying to synthesize disparate views, using this EMS eases the difficulties in face-to-face confrontations by focusing attention on the common work-product, and not on the individual team members.

7. IMPLICATIONS

The opportunity to study actual software development teams, using EMS to perform their work, in their natural setting, makes this work valuable for both researchers and practitioners. For both parties, the EMS studied is interesting in that it grew from the experiences and needs of the teams. Its' simplicity is a key issue for continued study.

The site's software developers believe that quality has improved. While a causal relationship can not be made, data provided by the site indicates that, since teams began using the EMS, there has been a 50% reduction in defect rates of shipped products. Furthermore, these EMS are in high demand, with the 21 rooms booked 89% of the year, and often booked to 120% of capacity during peak periods. The EMS are part of these ISD team's normal work.

The results should be interpreted with the following limitations in mind. This is a single site, these developers are very experienced, well educated (89% have a college degree and 33% have an advanced degree), and familiar with team-based work (on average team members have worked on 10 ISD projects). Further, the EMS is atypical to what is reported in the literature (See McLeod, 1992) in terms of structure and functions. This site's use of their EMS reflect both the experience of the teams and the unique development of this system to meet their needs.

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