High Versus Low Performing Virtual Design Teams: A Preliminary Analysis of Communication

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Abstract

One way that firms have adapted to competitive pressures in today’s global marketplace is to use asynchronous communication technologies to support virtual project teams. To better understand the effectiveness of these dispersed teams, we compare the asynchronous communication transcripts of high and low performing virtual teams working on the early stages of software design. We also compare these results with data gathered from actual design teams working in a traditional face-to-face environment [11].

Preliminary findings show that the high performing virtual teams significantly out-communicated the low performing virtual teams in terms of the number of lines communicated between team members. High performing teams sent more communications regarding design alternatives and also spent considerably more effort summarizing their work and discussing the write-up of the design deliverable. Additionally, high performing teams mirrored the face-to-face teams from the field study in terms of the distribution of communication covering various design activities.

1. Introduction

Organizations in today’s global economy face continual pressures to remain responsive to changes in the competitive marketplace. One way that firms have adapted to these pressures is to emphasize project teams that link people and activities across organizational boundaries. Organizational project teams tend to be ad hoc, where members are assigned to the team for the duration of a project. Project teams bring together divergent perspectives, skills and talents of people to accomplish organizational objectives such as complex problem solving.

A critical component impacting team processes and collaborative work is the prevalence of computer-based communications technologies. Of special significance in the organizational arena is asynchronous electronic communication [5], which is used to support virtual project teams [17]. These virtual teams are composed of geographically dispersed knowledge workers who communicate and collaborate asynchronously, via electronic means such as email or computer conferencing, to complete projects. Thus, virtual teams are a special form of a team as the ability to communicate electronically increases the number of relationships that the team can foster due to its ability to work in a global context.

One area in which virtual teams are increasingly being used is that of software development, and particularly, software design. For example, Cutosky et al. [1] describe how a virtual, global, engineering team was able to design and prototype a complex device (i.e., an optical seeker used in missiles) in an unprecedented six months. The team accomplished the majority of work using asynchronous communication technologies.

What is the effectiveness of virtual design teams compared with their traditional face-to-face (FtF) counterparts? We have carried out a series of three experiments comparing teams of MIS graduate students working on the early stages of software design. We have found that virtual design teams outperform FtF teams in terms of both the quality of the resulting design and creativity of the design [8, 9, 10]. To date, we have analyzed only outcome measures; we have not analyzed aspects of the actual design discussions that have produced these results.

The research presented in this paper is a first step toward shedding light on some of the differences in the performance of the virtual design teams from our most recent experiment [10]. Specifically, the intent of this paper is to begin to answer two questions. First, how do high performing virtual design teams differ from low performing virtual design teams in
terms of amount and type of communication? Second, how do these high and low performing virtual teams compare to their face-to-face counterparts? In order to address these questions, we analyzed the computer conferencing transcripts of the highest and lowest performing virtual design teams by means of a content coding classification scheme developed by Olson et al. [11]. We compared our teams with traditional face-to-face teams from the Olson et al. study [11].

2. Olson et al. Study of Design Teams

Olson et al. [11] carried out a field study that analyzed ten face-to-face design meetings from four projects in two organizations. Like our teams, their design teams were working on the early stage of software design where small teams of software engineers discussed how to design systems which would be built later, usually by others. The sample design meetings occurred midstream in the early design process, such that the meetings were neither the first nor the last. The teams had been given general descriptions of the types of systems to be designed and the discussions contained a mixture of both requirements specifications and high-level design.

No technological support was provided to the software designers during these meetings. The meetings were content coded using a coding scheme that looked at the designers’ problem solving activities as well as their efforts to coordinate and manage themselves. It was found that 40 percent of the meeting time was spent discussing design, while 30 percent was spent assessing the teams’ progress through walkthroughs and summaries. Coordination activities accounted for 20 percent of the work effort.

2.1 Coding Scheme and Reliability

Olson et al. [11] developed a coding scheme to analyze the transcripts of their design teams, basing the coding categories on design rationale concepts [e.g., 6] and on group management processes [14, 13].

Their primary focus was on the problem solving aspects of design, which they viewed as a form of argumentation. Various design issues are raised; for each issue, alternatives are presented and discussed. Criteria are then used to decide upon an alternative. Coordination activities related to organizing the work of team members fall into goal, project and meeting management categories. Other recurring categories include summaries, walkthroughs and digressions. Olson et al. also used a category called clarification to code the explanation of ideas. Finally, they used a category called other to capture those comments that did not fit into any other category.

Due to the similarity between the group work between our study and the work of Olson et al., we based our coding scheme on the aforementioned eleven primary categories. However, since all of our groups were all working on the same design problem, we were able to modify the Olson et al. coding scheme to be a bit more specific, especially in terms of design categories. Rather than having the general category called issues, we subdivided this category into five categories based on the CPO task description. These categories are: functionality, interface, advantages, disadvantages, and implementation. Also, since we were coding the transcripts resulting from asynchronous discussions, we did not use the meeting management category, but rather, coded all statements having to do with team management into one general management category. Our teams did not participate in walkthroughs per se, but in a similar fashion to the Olson et al. design teams, generated segments of their team report for other team members to review. Therefore, we replaced the Olson et al. walkthrough category with the write-up category. Table 1 provides a comparison of the Olson et al. coding scheme and our adaptation of that scheme.

The first author modified and refined the Olson et al. coding scheme as described above by coding the transcripts of two teams. Two research assistants were trained to use the coding scheme. They also coded the same two teams as the first author. Together, the two research assistants met with the first author to compare their individual coding sheets for each team. Differences in coding were discussed until consensus was reached. The two research assistants then coded the remaining groups, meeting weekly to discuss the coding results of each group and to resolve differences. (The coding scheme proved precise and relatively easy to use. The research assistants reported only minor discrepancies when comparing their individual coding sheets for each group.)

3. Sample

Original Study: As shown in Figure 1, the data reported on in this paper come from the virtual teams from our third experiment [10]. All teams were composed of graduate students in the field of computer science, who worked for a two-week period to produce a written report describing the requirements and high-level design for a computerized post office (CPO). One set of virtual
Table 1. Comparison of Coding Schemes

<table>
<thead>
<tr>
<th>Olson et al. (1992)</th>
<th>Ocker &amp; Fjermestad</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Issues</strong> - major aspects of the designed object</td>
<td><strong>Functionality</strong> - services which may be offered</td>
</tr>
<tr>
<td></td>
<td><strong>Interface</strong> - description or actual presentation of the</td>
</tr>
<tr>
<td></td>
<td>user interface</td>
</tr>
<tr>
<td></td>
<td><strong>Advantages</strong> - advantages of the CPO</td>
</tr>
<tr>
<td></td>
<td><strong>Disadvantages</strong> - disadvantages of the CPO</td>
</tr>
<tr>
<td></td>
<td><strong>Implementation</strong> - considerations or concerns that feed into the next phase of developing an</td>
</tr>
<tr>
<td></td>
<td>implementation plan</td>
</tr>
<tr>
<td><strong>Alternatives</strong> - solutions or proposals about aspects of the designed object</td>
<td>Same</td>
</tr>
<tr>
<td><strong>Criterion</strong> - reasons, arguments or opinions which evaluate an alternative</td>
<td>Same</td>
</tr>
<tr>
<td><strong>Clarification</strong> - questions and answers where someone either asked or seemed to misunderstand</td>
<td>Same</td>
</tr>
<tr>
<td><strong>Project Management</strong> - statements referring to the assignment of people, when to meet again, etc.</td>
<td><strong>Management</strong> - statements not directly related to topic categories, in which work assignments are made or discussed, or the group process is discussed (e.g. first we will brainstorm, then we will evaluate), etc.</td>
</tr>
<tr>
<td><strong>Meeting Management</strong> - statements referring to orchestrating the meeting time's activities</td>
<td>combined into Management category</td>
</tr>
<tr>
<td><strong>Goal</strong> - statement of the purpose of the group's meeting and some of the constraints they are to work under, such as time to finish.</td>
<td>Same</td>
</tr>
<tr>
<td><strong>Summary</strong> - reviews of the state of the design or implementation</td>
<td>Same</td>
</tr>
<tr>
<td><strong>Walkthrough</strong> - a gathering of the design so far or the sequence of steps the user will engage in</td>
<td><strong>Write-up</strong> - associated with the report (draft or final report), used when the report is contained in the comment</td>
</tr>
<tr>
<td><strong>Digression</strong> - members joking, discussing side topics, or interruptions pertaining to things outside the meeting content</td>
<td>Same</td>
</tr>
<tr>
<td><strong>Other</strong> - statements not categorizable into the above categories</td>
<td>Same</td>
</tr>
</tbody>
</table>

teams, which we refer to as the asynchronous teams, were instructed to work entirely asynchronously while a second set of teams, which we call combined, had a face-to-face meeting at the beginning and end of the experiment, and were instructed to communicate between these two meetings solely through asynchronous means.1

The original study also included teams working strictly face-to-face with no technology support.

All teams were instructed to communicate electronically using a computer conferencing system called WEB-EIES developed at the New Jersey Institute of Technology. WEB-EIES is designed to support asynchronous communication via the World Wide Web; there are no “chat”

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1 The original study also included teams working strictly face-to-face with no technology support.
facilities. Due to the extended nature of the study, it is impossible to be completely certain that all groups adhered to the aforementioned asynchronous communication rules. However, team computer conference activity and message content were monitored by the researchers. Additionally, at the completion of the experiment, all students were questioned regarding their compliance with the experimental rules. As a result of these efforts, we are relatively confident that the vast majority of students complied with the experimental communication rules.

In order to evaluate the effectiveness of the teams, a panel of expert judges rated each team’s design report, using a seven point scale, in terms of both its overall quality of design solution as well as the level of creativity displayed in the solution. A total of 8 asynchronous teams and 11 combined teams were included in the original study. Overall, in terms of creativity, asynchronous teams were rated significantly higher than combined teams (5.88 vs.
Table 2. Judges Ratings of High and Low Performing Teams

<table>
<thead>
<tr>
<th>Communication Mode</th>
<th>Team</th>
<th>Number of Subjects</th>
<th>Quality Rating (1-7)</th>
<th>Creativity Rating (1-7)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Teams</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asynchronous</td>
<td>10</td>
<td>6</td>
<td>5.5</td>
<td>7</td>
</tr>
<tr>
<td>Asynchronous</td>
<td>36</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Combined</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>Combined</td>
<td>20</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>Low Teams</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asynchronous</td>
<td>12</td>
<td>6</td>
<td>2.5</td>
<td>5</td>
</tr>
<tr>
<td>Asynchronous</td>
<td>33</td>
<td>6</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Combined</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Combined</td>
<td>26</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

5.18, p=.02). However, concerning quality, no significant differences were found between the asynchronous and combined teams (4.43 vs. 4.82, p=.269).

Current Study: The research reported on in this paper focuses on comparing high and low performing virtual teams. To accomplish this, we selected the two highest and two lowest rated teams in terms of quality and creativity from the original study, in each of the asynchronous and combined conditions. When tied scores existed between teams, we broke the tie by choosing the teams that were high or low across both the creativity and quality categories. In this way, we were able to reduce the number of different teams that needed to be content coded.

As a result of this process, teams 9, 10, 20 and 36 were selected as the high performing teams, while teams 8, 12, 26, and 33 were chosen as the low performing teams. Thus, there are a total of eight teams that comprise the data sample for the current study. A t-test analysis showed no significant differences in the judges’ ratings of quality and creativity across the high performing (9,10,20,36) and low performing teams (8,12,26,33). However, there were significant differences between the high and low performing teams in terms of both quality and creativity. These results support our decision to merge teams from the two virtual conditions for purposes of analyzing high and low performing virtual teams. Table 2 shows the results of the judges’ evaluations for creativity and quality, respectively, for the high and low performing teams, as well as the number of subjects per team.

4. Data Analysis

As team size varied between five and six members per team, the number of comment lines per team was normalized by dividing the total number of comment lines by the number of members in the team. The number of comments per team was normalized in the same fashion. Therefore, all references to these numbers are made using these normalized figures.

4.1 Number of comments and number of comment lines

Table 3 shows the normalized total number of comment lines along with the normalized total number of comments generated by each team in the sample. We performed t-tests to test for significant differences between the number of lines generated and the number of comments sent by high performing versus low performing teams. There were no significant differences with respect to the total number of comments sent between the high and low performing teams (t=0.973, df=6, p=0.3671). However, the high performing teams generated significantly more comment lines compared to the low performing teams (t=3.092, df=6, p=0.0214).

4.2 Distributions of Comment Lines

How do high performing virtual design teams differ from low performing virtual design teams?
In order to analyze differences between high and low performing teams, we created two groupings, referred
Table 3. Normalized Comments and Comment Lines

<table>
<thead>
<tr>
<th>Performance Level</th>
<th>Group</th>
<th>Normalized Comments</th>
<th>Normalized Comment Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>10</td>
<td>8.3</td>
<td>73.6</td>
</tr>
<tr>
<td>High</td>
<td>36</td>
<td>16.7</td>
<td>140.3</td>
</tr>
<tr>
<td>High</td>
<td>9</td>
<td>7.3</td>
<td>114.8</td>
</tr>
<tr>
<td>High</td>
<td>20</td>
<td>9.5</td>
<td>102.3</td>
</tr>
<tr>
<td>Low</td>
<td>12</td>
<td>5.6</td>
<td>47.8</td>
</tr>
<tr>
<td>Low</td>
<td>33</td>
<td>5.8</td>
<td>46.7</td>
</tr>
<tr>
<td>Low</td>
<td>8</td>
<td>8</td>
<td>38.5</td>
</tr>
<tr>
<td>Low</td>
<td>26</td>
<td>12.4</td>
<td>84</td>
</tr>
</tbody>
</table>

to as high and low on the supporting charts and tables.

For ease of comparison and to help clarify relationships among the coded data, we created four composite categories from the eleven previously described coding categories: design, summary, coordination, and other. (These are comparable to composite categories used in the Olson et al. coding scheme.) The design composite category consists of the summation of the coding categories of functionality, interface, advantages, disadvantages and implementation. The summary composite category consists of the summation of the summary and write-up coding categories. The coordination composite category consists of the goal and management coding categories, while the other composite category is the summation of the digression and other coding categories. Figure 2 visually depicts the composite categories, while Figure 3 visually depicts the eleven primary coding categories.

Design Activity

As was anticipated, teams in general communicated the most regarding aspects of the CPO design (Figure 2). Within the category of design, teams communicated more about the functionality, interface design, and implementation of the CPO, as compared to aspects related to advantages and disadvantages (Figure 3). Teams also spent most of their time discussing design alternatives and relatively little time clarifying alternatives or evaluating alternatives (Figure 4).

In terms of actual number of lines communicated (Figure 3), the high performing teams communicated more about functionality aspects of the CPO than the low performing teams (32 lines per person vs. 14.7 lines per person). Similarly, high performing teams communicated more regarding interface design, (18.6 lines per person vs. 9.6 lines per person). This was also the case for comments regarding implementation (15.1 lines per person vs. 4.4 lines per person). There were no differences relating to the advantages and disadvantages design categories. Interestingly, in terms of percentage of comments (rather than number of lines), the low performing teams spent a higher portion of their comments discussing design aspects compared to the high performing teams (73% vs. 47%) (Figure 2).

Summary Activity

Overall, the summary composite category has the second highest amount of comments. Within this composite category, in terms of number of lines, the high performing teams spent more time summarizing their work for team members compared to the low performing teams (30.4 lines per person vs. 0 lines per person) (Figure 3). Also, these teams communicated more regarding the write-up of the report describing the design (9.9 lines per person vs. 0 lines per person) (Figure 3). When comparing the percentage of comments for the composite summary category, the high teams communicated much more than the low teams (36% vs. 2%) (Figure 2).

Coordination Activity

The coordination composite category was tied for third (i.e., last) place in terms of the proportion of comments coded into this category. On the whole, teams spent more time discussing management issues as compared to goal issues (Figure 3). In terms of both actual number of lines and the percentage of communication, there were no differences between high performing and low performing teams (Figure 2).

Other Activity

This composite category was tied for last place in terms of the percentage of comments coded into this category. Overall, there were no differences between high and low performing teams in terms of actual number of comment lines (Figure 3). In terms of the percentage of total communication, the low performing groups spent a larger percentage of time on this activity compared to high performing teams (12% vs. 8%) (Figure 2).
Figure 2. Communication- High & Low Performance Teams versus Olson's Data

Figure 3. Normalized Lines for High and Low Performance Teams by Detailed Coding Category
How do high and low performing virtual design teams compare to traditional face-to-face design teams?

In order to perform this comparison, we incorporated the results of the field teams studied by Olson et al. [11], described earlier in this paper. Figure 2 visually depicts these relationships. Overall, the high performing teams spent their time very similarly to the field teams. The field teams spent 41% of their efforts communicating on design aspects, while the high performing teams spent 47%. The field teams spent 30% of their efforts summarizing their work, while the high teams spent 36% of their efforts. Concerning the catch-all category of other, the field and high teams were tied at about 6%. The only notable difference was in the coordination category, where the field teams communicated at the 20% level, while the high teams were at approximately the 10% level.

However, concerning the low performing teams, we see that these teams spent a much higher percentage of communication on aspects of the design (over 70% compared to 41% for the field teams) (Figure 2). The low teams spent a much lesser amount of communication summarizing work and writing the report (0% compared to 30% for field teams) (Figure 2). There were no differences across teams concerning coordination activities. However, low performing teams spent a bit more time communicating in the other category compared with the field and high performing teams (12% vs. 8%) (Figure 2).

5. Summary and Discussion

Overall, the high performing teams significantly out-communicated the low performing teams in terms of the number of lines communicated between team members. High performing teams sent more communications regarding design (especially functionality, interface design and implementation considerations). They spent considerably more time summarizing their work and discussing the write-up of the report covering the CPO design. There were no differences between the high and low teams in regard to the amount of communication concerning coordination of the team effort. Likewise, there were no differences regarding the amount of extraneous (i.e., other) communication between the teams.

We find it very encouraging that the percentage of communication across coding categories for high-performing teams was so similar to face-to-face design teams examined by Olson et al. (1992) in their field study. Although Olson et al. did not attempt to measure team effectiveness in their study, they used teams from Andersen Consulting and MCC, two organizations which are well-respected in terms of the quality of their software development projects. What is most remarkable is that this similarity exists, not because our teams consisted of graduate students and the Olson et al. teams were professionals, but that our teams were working virtually via an asynchronous computer conferencing system while the field teams were working face-to-face.
From our analysis, there are two plausible reasons for the poor performance of the low performing teams. First, they just did not communicate as much as the higher rated teams. Second, they did not communicate as much regarding the design deliverable. Proportionately, it is the summary and write-up categories (i.e., summary composite category) in which the lower teams fell substantially short. It appears that poor time management and the inability to meet a firm deadline are culprits leading to the less-than-desirable results. Although we have not analyzed the data according to the distribution of comments over time (we intend to do so in the very near future), we expect that the low performing teams were slow starters and perhaps were just getting warmed up by the time the two-week experimental deadline was upon them. It is a well-known fact that asynchronous communication is much slower compared to synchronous media. The turn-around time required to get feedback on contributions from teammates can be an exasperating experience, as evidenced by some of the comments expressed by students.

6. Conclusion

While some teams perform quite well in virtual situations where no group interaction structure is given, other than providing the work assignment and a deadline, other teams seem to flounder under these circumstances. One of the major benefits of synchronous group support systems has been their ability to provide structure to synchronous meetings [7]. It seems that in the virtual world, time management skills and structure may be even more important, as it is much easier to ignore team members and your responsibilities when you are working virtually.

Our preliminary analysis has shown that there are indeed measurable differences between high and low performing virtual teams. The fact that, overall, virtual design teams in our series of experiments [8,9,10] have out-performed FtF teams in terms of the quality and creativity of the design deliverable, without any structure to the team interaction process, is encouraging. However, the results were not achieved without a cost. In terms of satisfaction with the communication mode, asynchronous teams (especially those with no initial FtF interaction) were dissatisfied, compared to traditional FtF teams. Our results reinforce the overall findings in other technology-mediated research that technology mediation improves performance while reducing satisfaction [3]. Contrary to previously held beliefs, researchers are finding that, given enough time, relational and social cues are conveyed in a manner comparable to that when communicating FtF [e.g., 15,16]. This, then, is most likely not the reason that virtual teams are less satisfied.

We think the lower levels of satisfaction are directly related to the difficulty some teams have in conducting the complex collaborative work of design via asynchronous means. Media richness theory [2] describes communication media as falling along a continuum of “information richness” where FtF is considered the richest communication medium and virtual communication is a much leaner, less rich medium. According to the theory, effective communication occurs when the richness of the medium matches the demands of the message. Daft’s assignment of richness to specific media took no account of the processes of appropriation and structuration [12] through which people can change the way in which a technology is used to serve their purposes.

Structuration theory proposes that the “richness” of a medium is not static, but changes through the appropriation process. This is particularly evident in the results of this study where high-performing teams used the technology to their advantage, while the low performing teams floundered. It appears that high performing teams may have better appropriation strategies than low performing teams. High performance, then, relates not only to content-specific knowledge that helps in design, but also to process knowledge that includes media-appropriation strategies. This finding has implications for teaching virtual systems design in an educational institution as well as in corporations.

Given the inherent difficulty of design work, the fact that some virtual teams failed miserably should not be surprising. Asking people to accomplish complex collaborative work without the freedom to regularly meet face-to-face could be considered by some to be setting them up for failure. We choose, instead, to view our experiment as another learning opportunity for students, as well as ourselves. Beyond our research, our intent is to provide students with experience in virtual collaborative design, in the hopes that when they encounter this situation on-the-job, they can bring some practical academic experience “to the table.” Hopefully, we can also shed some light on ways to support virtual design activities.

The conclusions we draw must be considered is light of the small number of teams analyzed. With such a small sample, it is easy for results to be swayed by a single anomalous group. Presently, we are conducting a fourth experiment designed to provide us with a more comprehensive database of group interaction processes of virtual
teams. It is our intent to create a picture of what effective versus ineffective virtual teams look like, and to delve into the media-appropriation processes used by these teams. This, then, will guide us in the development of tools and structures to support virtual teams.

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