

# The Relationship between Interaction, Group Development, and Outcome: A Study of Virtual Communication

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## Abstract

Twenty groups totaling eighty-three graduate students participated in a 17-day experiment to determine the requirements and high-level design for a computerized post office. The third in a series of experiments comparing virtual interaction to interaction combining both face-to-face and virtual communication, this study focuses on the relationship between group interaction, group development, and group effectiveness.

Data were collected on four dependent variables: quality, creativity, satisfaction, and group development. Findings reinforce results from previous experiments: virtual and combined groups generated work products of equivalent quality; virtual groups generated more creative solutions; combined groups were more satisfied with their interaction process and solution quality.

Findings indicate that combined groups reached a higher level of development than virtual groups. There was a positive relationship between the level of group development, the quality of the work product, and the degree of satisfaction. A negative relationship was found between group development level and creativity.

## 1. Introduction

Increased competition from overseas and differences in labor costs are driving Lucent, Sun Microsystems and others toward geographically distributed software development (2). However, distributed development can result in significant delays compared to traditional, co-located development. It isn't necessarily that more problems occur in virtual software development, but that the resolution of problems is more difficult and takes much longer.

To diminish the "virtualness," some companies are interspersing face-to-face (FtF) meetings in an otherwise virtual environment. For example, virtual teams at Sun Microsystems are advised to meet FtF at the beginning to "jump-start" a project, at the mid-point to assess and review the team's work prior to completion, and at the end so members can bring closure to the project and celebrate their accomplishments (27).

The large body of literature on group support systems (GSS) has primarily investigated teams interacting

synchronously while that of computer-mediated communication (CMC) has explored asynchronous interaction. However, there is a paucity of research exploring the relatively recent development of interspersing face-to-face (FtF) meetings in an otherwise virtual team environment – that is, to combine asynchronous CMC and FtF communication. The research described in this paper is the third in a series of studies that compare purely virtual groups with groups interacting via a combination of virtual and FtF communication, in order to determine the requirements and high level design of a computerized post office. (see 35, 36, 37 for previous studies).

## 2. Background

### Temporal Milestones in Group Development

Although there are many different and contradictory models (e.g., 4; 11; 18; 32) available to explain how groups develop, a synthesis of these models by Mennecke et al. (1992) and Chidambaram and Bostrom (6) point out various consistencies between models. For example, fundamental to sequential development models is the belief that groups go through a linear series of stages as they mature (e.g., 4), while cyclical models (e.g., 11) propose a nonlinear path to maturity. Many models highlight the importance of critical periods in a group's life. These temporal milestones pertain to the group's beginning, midpoint, and ending.

Concerning a group's beginning, the initial meeting(s) is different from other group meetings as members work to get acquainted with one another, develop project plans, and reach initial agreement on how to proceed (6, 25, 16). This phase is characterized by the lowest level of mutually-shared understanding, as members struggle with the newness of the group and project. During this period, groups should benefit from a highly interactive form of communication as they work to resolve ambiguity and build mutual understanding (16, 43). Studies show that where participants were given a choice, FtF interaction was preferred over virtual in the early stages of collaborative projects (12, 14).

Gersick (18, 19) found that groups working on a specific task with a preset time constraint made significant transitions (i.e., shifts) in approaches to their work, at or nearly at, the midpoint of the group's

existence. She found this to be true for naturally occurring groups and laboratory groups, and for groups with vastly different life spans. She explained this midpoint transition as occurring due to the perception of group members that time is becoming short. Her punctuated equilibrium model describes group development as consisting of two phases punctuated by a midpoint transition. During phase one, which lasts for the first half of the group's calendar time, the group follows the course set in the first meeting. Upon reaching the calendar midpoint, the group experiences a transition, which sets a revised direction for the second (and last) phase.

Gersick points out that, in addition to the initial and midpoint meetings, a group's final meeting is also important as groups endeavor to complete the their work. Although a group is at its most mature state in terms of group development and should be operating within a shared context built over the life of the project, the group may once again find higher levels of ambiguity as it strives to reach a consensus decision (25, 16). Additionally, groups must plan the format of any written documents and agree on their contents (17). These activities, while perhaps not as daunting as initial activities, should require a high interaction level between group members. In a study of teams working on software development, although participants were experienced with and positive towards CMC, as the project neared completion, the virtual teams experienced difficulties in integrating their individual task results into a single document (14). FtF communication was preferred for accomplishing this task. As Galegher (16) states, "These results appear to mean that participants felt meetings of this type were necessary, or at least desirable, to converge on a common perspective ..." (p. 205).

Between FtF meetings, group members work individually or in small groups to accomplish their assigned tasks. The primary need of the group between FtF meetings is to coordinate and communicate with all members, sharing work and information as tasks are completed. Kiesler and Sproull (25) speculate that groups can benefit from mechanisms that allow for the quick and frequent transmission of information in a form that will permit other members to interpret and use it.

### **Group Development**

In their review of the group development literature, Chidambaram and Bostrom (6) found agreement across models concerning characteristic behaviors that distinguish between well and not-so-well developed groups: (1) cohesiveness, (2) conflict, (3) task and socio-emotional needs (4) communication and (5) involvement in group activities.

**Cohesiveness:** This behavior characterizes how close members are to one another and their level of attraction to the group. A well-developed group exhibits cohesiveness such that group members are tightly coupled to one another and to the group as a whole (32). A cohesive group works together toward the same goal.

**Conflict:** Conflict can be characterized as positive or negative. Productive differences of opinion and constructive debates are examples of positive conflict. The absence or suppression of such conflict can result in groupthink with disastrous consequences (24). On the other hand, negative conflict is exhibited in personality conflicts between group members, refusal to cooperate, and belligerence on the part of one or more members. A well-developed group is adept at managing conflict – the group is open to positive conflict and works to minimize negative conflict.

**Task and socio-emotional needs:** Groups that devote too much of their effort to accomplishing work do so at the expense of members' needs for social and emotional well-being. This is also true in the reverse – too much time spent socializing does not get the tasks accomplished. Groups that achieve an equilibrium between tasks and socio-emotional needs are more likely to develop and become productive.

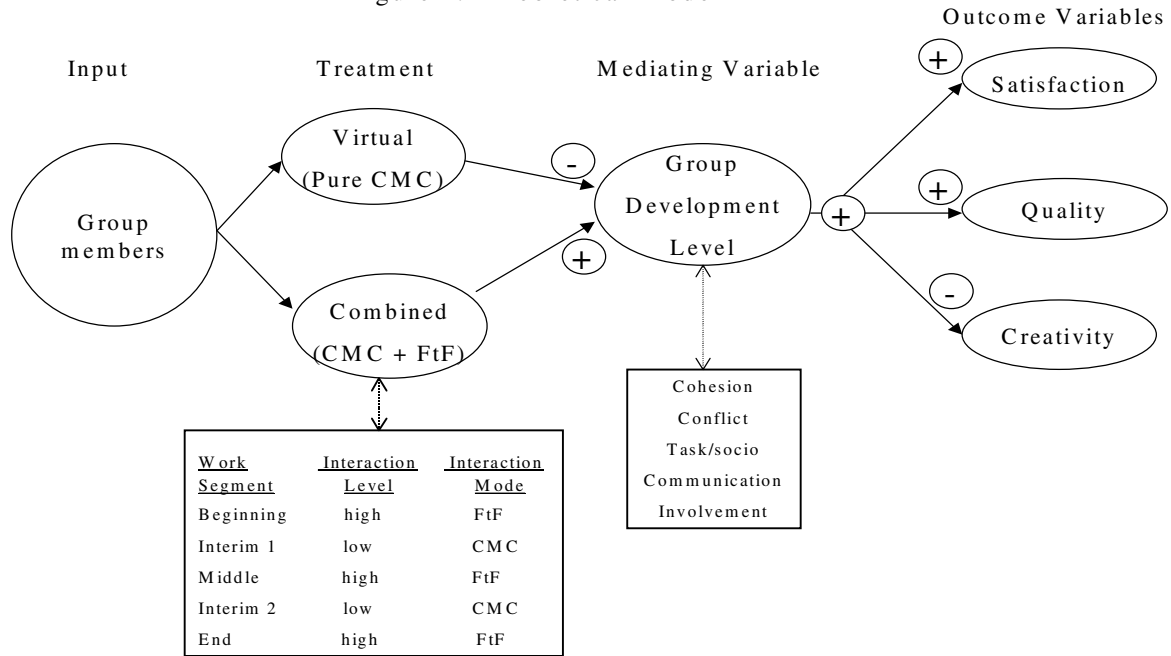
**Communication:** In a well-developed group, members work in an environment that fosters open communication, where constructive differences of opinion are encouraged. Mature groups develop a mutual understanding of their group work and are adept at sharing information. Misunderstandings and miscommunications are infrequent and verbal and nonverbal cues are accurately interpreted.

**Involvement:** Member commitment to group goals, cooperation, and participation are qualities of well-developed groups. Continued involvement and cooperation in the presence of conflict is essential to group development (5). Lack of interest in group outcomes, often a result of a lack of commitment to group goals, can limit group member involvement and hinder group development.

## **3. Theoretical model and hypotheses**

The previous discussion on group development raises some questions of the impact of computer-mediated communication on group development. Chidambaram and Bostrom (7) state that various contextual variables, including electronic support of groups, can alter group development. Although their focus is on synchronous group support systems (including features such as anonymity, agenda development and process structuring), their statement can also be applied to computer-mediated communication.

Figure 1. Theoretical Model



The theoretical model for this study is depicted in Figure 1. The model shows two relationships: (1) the impact of interaction mode on group development and (2) the impact of group development on satisfaction, quality, and creativity.

The model indicates that interacting virtually via pure CMC will result in less developed groups, whereas interacting using the “appropriate” combination of CMC and FtF interaction will result in more highly developed groups. In turn, a high level of group development will lead to high levels of member satisfaction with the solution (e.g., work product) as well as increased levels of solution quality. However, high group development will result in lower levels of solution creativity. Thus, group development is viewed as an intervening variable as it transmits the effects of interaction mode onto the outcome variables. The reasoning behind these relationships follows.

**Interaction and group development**

FtF interaction should increase the level of cohesion within a group as members have an opportunity to meet each other, share information about themselves and interact in an environment rich in social cues. Combining FtF and CMC should result in a balance between task focus and socio-emotional behavior -- FtF interaction fosters social interaction as well as task-oriented interaction, while CMC encourages task focus at the expense of social interaction (42). The combined

interaction modes should allow conflict to be managed better -- misunderstandings that can arise under conditions of reduced social context (41) should be diminished due to regular interaction in the richer FtF environment. This intertwining of interaction modes should result in more effective communication as the different needs for interaction are fulfilled within each period of group work. Finally, it has been argued that FtF communication speeds up group development (6). Therefore it is hypothesized that:

- H1. Combined groups will be more highly developed compared to virtual groups. More specifically, it is hypothesized that:
  - H1a. Combined groups will be more cohesive than virtual groups.
  - H1b. Combined groups will manage conflict more effectively than virtual groups.
  - H1c. Combined groups will meet the task and socio-emotional needs of group members better than virtual groups.
  - H1d. Combined groups will communicate more effectively than virtual groups.

Contrary to the other behaviors where combined groups are expected to outperform virtual groups, participation among members of virtual groups has been found to be more equal than in FtF groups (e.g., 25). Since the combined condition incorporates three FtF meetings, it is hypothesized that:

*H1e Virtual groups will have more equal participation than combined groups.*

### **Group development and outcome**

There is general agreement in the literature that a highly developed group is desirable and leads to high performance (6 for a review). That is to say, a frequently interacting, cohesive group where there is commitment to group goals and involvement in group tasks, where there is attention not only to the task at hand, but to the social aspects of group membership, where little miscommunication occurs, and where positive conflict prevails over negative conflict, is more likely to produce a higher quality work product than when these conditions do not exist. It is hypothesized that:

*H2. More developed groups will produce higher quality solutions than less developed groups.*

Various behavioral theories focus on the needs of an individual, explaining that as certain needs are met, an individual's satisfaction level increases (e.g., 1, 28, 29). These theories discuss an individual's need to interact with others. In his Needs Hierarchy Theory, Maslow (28) describes this need as *belongingness* while Alderfer's ERG Theory (1) refers to it as *relatedness*. Similarly, in the Learned Needs Theory, McClelland (29) discusses an individual's need for *affiliation*.

These theories also delineate an individual's need for *achievement*. Maslow explains that an individual's need for self-esteem is enhanced through achievement while Alderfer talks of how a person's need for growth is met through achievement. McClelland discusses the implications of a person's need for achievement, relating it to an increase in accomplishments.

The theoretical model shows members of highly developed groups as being more satisfied. It is expected that more mature groups will be cohesive, interact frequently, and exhibit more off-task, interpersonal behavior. It is expected that these groups will better satisfy a group member's need to interact, compared to underdeveloped groups. Similarly, high performing groups are expected to produce high quality work products and thus, to satisfy a member's need for achievement. In terms of McGrath's TIP theory (32), mature groups attend to both their production function (i.e., produce high quality work) and to their member well-being function (i.e., satisfied with their group experience) better than less developed groups. Therefore, it is predicted that:

*H3a. More developed groups will be more satisfied with the interaction process than less developed groups.*

*H3b. More developed groups will be more satisfied with their groups' solution than less developed groups.*

Highly developed groups are cohesive. Festinger (13) asserts that the level of group cohesiveness has a

proportional impact on pressures to conform. A cohesive group is a group in agreement. Should it experience disagreement, it quickly acts to restore its previous state of compliance (34a). Thus, members in these groups experience pressure for uniformity of opinion (13). Social influence is the key to maintaining this uniformity. Conformance to the group opinion is essential (13). In contrast, social influence is diminished in less developed groups, so that the pressure to conform is greatly reduced. As social standards are reduced in importance, communication becomes more impersonal and uninhibited (25). These circumstances increase the exchange of diverse opinions, and thus, increase the chance for a creative solution. The sharing of diverse opinions expands the number of solution alternatives and fosters a more creative outcome (e.g., 26). Therefore, it is hypothesized that:

*H4. Less developed groups will be more creative than more developed groups.*

The model shows a transitive relationship between treatment, group development level, and outcome. Thus, if combined groups are more highly developed, it follows that they should be more satisfied and produce higher quality solutions compared to virtual groups. However, there is a negative relationship between group development level and creativity. Thus, the more highly developed combined groups should generate a less creative work product compared to virtual groups. Therefore it is hypothesized that:

*H5. Combined groups will generate higher quality solutions compared to virtual groups.*

*H6a. Combined groups will be more satisfied with the interaction process than virtual teams.*

*H6b. Combined groups will be more satisfied with their solution than virtual teams.*

*H7. Virtual groups will generate more creative solutions compared to combined groups.*

## **4. Research Design and Method**

**Design:** A 1 X 2 factorial design was employed. The single factor, mode of interaction, had two treatments: combined and virtual. The combined treatment had a sequence of three FtF meetings which were spaced exactly one week apart, beginning on the first day of the experiment (FtF meetings days 1, 8, and 15; virtual interaction days 1-17). Group members communicated asynchronously via a computer conferencing system between FtF meetings. Groups in the virtual treatment communicated *only* asynchronously using the computer conferencing system for the entire experimental period. These teams had no FtF contact. The experiment ran for 17 days.

**Task:** The Computerized Post Office (CPO) was the task used in this experiment. This task was adapted

from Goel and Piroli (20) and Olson et al. (38). Olson et al. characterize this task as incorporating planning, creativity, decision-making, and cognitive conflict (30). Groups were required to reach consensus on the requirements and high-level design for the CPO and to submit these requirements in a written report at the end of the experiment. Each group produced a single report.

**Subjects & group composition:** Subjects consisted of graduate students in the MBA and MSIS program at a branch campus of a large university. For their participation, all subjects received course credit.

Subjects were assigned to groups randomly. Due to the study of group development, all groups had a zero history of working together.

There were a total of 83 subjects participating in the experiment: 47 in the virtual treatment and 36 in the combined treatment. Females accounted for 37% of the membership in the virtual treatment and 30% in the combined treatment. The average amount of work experience for subjects across treatments was almost identical at approximately 8 years. Similarly, the distribution across age categories was very similar. The two most populated age categories were the 23-30 year range, accounting for about 55% of the subjects in both treatments, and the 31-35 year range, with 28% of the subjects. All but six subjects were Caucasian. Overall, the background characteristics of subjects across both treatments were practically identical.

Although every attempt was made to assign groups to conditions so that each condition was balanced according to number of groups, group size and academic major, this goal was not entirely achieved. There were a total of 20 groups participating in the experiment, ranging in size from four to five members. The virtual treatment had 11 groups, each with a group size of four, while the combined treatment had nine groups, three with five members and the remaining six with four members. Concerning academic major, in the combined treatment, 22% of the subjects were enrolled in the MSIS program, while MSIS students accounted for 31% in the virtual treatment.

**Technology and Facilitation:** Both the combined and virtual groups communicated electronically using the FirstClass computer conferencing system (see [www.softarc.com](http://www.softarc.com) for a demo system). Each group communicated in its own conference set up on FirstClass. The conferences were minimally facilitated. The conference facilitator's role was that of a technical assistant, helping groups with equipment problems and answering questions of a technical nature.

FirstClass is a commercially available conferencing system with a GUI interface. In addition to sending and receiving messages within conferences, the conferencing software supports the sorting of messages by subject and date, in addition to message threading.

There is also a history file associated with each message, showing which group members have read conference messages.

**Training:** Subjects met within their respective classes for training on the essential aspects of FirstClass. Within classes, subjects were randomly assigned to training conferences. Training was completed within one hour. All subjects were trained using the same practice problem, a modified version of "Entertainment for Dutch Visitors" (38).

**Pilot Study:** A pilot study was run with five groups per treatment. Training and experimental procedures were tested. Originally, the experimental time frame was 14 days. However, the combined groups reported that their last (3<sup>rd</sup>) FtF meeting would be more beneficial if there were several days after the meeting to incorporate modifications to their report. Thus, the length of the experiment was extended to 17 days. Also, the sound on some of the video-tapes was difficult to hear. Therefore, equipment use and setup was also modified.

**Procedure:** All subjects completed a consent form and a background survey prior to the start of the experiment. Each group in the combined condition met in a separate classroom for each FtF meeting and used the same classroom for all three meetings. Each meeting was video-taped. All groups had access to the FirstClass computer conferencing system throughout the entire experimental period. FirstClass was available both inside and outside of the university via the Internet.

Combined groups began the experiment with their first one-hour FtF meeting. After the meeting, these subjects completed a meeting survey. (The same survey was administered after each FtF meeting.)

At the beginning of the second week (day 8), combined groups met for their second one-hour meeting. Subjects in both the combined and virtual treatments completed a midpoint survey. This survey was completed by the combined groups at the end of their 2<sup>nd</sup> FtF meeting, when they completed a second meeting survey. Subjects in the virtual treatment completed only the midpoint survey at the end of their scheduled class (day 8).

At the end of the 2<sup>nd</sup> week (day 15), subjects in the combined treatment met for their 3<sup>rd</sup> one-hour FtF meeting. These subjects completed a third meeting survey and also completed a post-experiment survey. Subjects in the virtual treatment completed only the post-experiment survey.

All groups had a leader who volunteered for the role at the beginning of the experiment. The leader was instructed that his/her job was to ensure that the written report was submitted in the group's conference on FirstClass by midnight of the last (17<sup>th</sup>) day of the experiment. Any other leadership responsibilities were left to the discretion of the groups. The content and

layout of the written report were determined by each group, although the CPO task called for analysis of several different aspects.

Each combined group had a secretary who volunteered for the role. The secretary was required to take minutes of each FtF meeting and post them to the conferencing system.

**Debriefing:** All groups were debriefed in a FtF session where the experimental design and research questions were explained. All participants were questioned regarding their adherence to the rules for communication. No one indicated failure to comply with the experimental rules.

**Surveys:** All participants completed several surveys. The background survey was used to collect demographic and other background data on subjects and was administered prior to the start of the experiment. The midpoint survey was designed to measure perceptions regarding a transition in group strategy or activity. The post-experiment survey was used to collect data on the five group development behaviors. Additionally, subjects in the combined treatment completed a meeting survey after each FtF meeting.

### Measures of the Dependent Variables

**Expert Judges:** Two expert judges with academic and/or work experience rated each group's solution, as presented in the written report, in terms of quality and creativity. All reports were printed using the same word processing package and aspects of each group's mode of communication were masked. Thus, judges were blind to experimental treatments.

**Quality:** The quality of each group's solution can be considered from several aspects (38): functional requirements analysis and design (system functionality, system interface, and coherence of these ideas), nonfunctional requirements analysis (maintenance of the system, and costs and benefits), the quality of the written report (organization and clarity), and finally, the general, overall quality of the report. The judges rated each of these aspects of solution quality.

**Creativity:** According to Amabile, a "product or response is creative to the extent that appropriate observers independently agree it is creative" (2). There is little agreement otherwise as to the appropriate subcategories used to rate creativity. Therefore, the expert judges were not provided with explicit details on rating creativity. Rather, they were instructed to rate the creativity of each group's solution using the general category of "Creativity of Solution."

**Satisfaction with the interaction process:** Interaction process refers to the method used by a group in order to reach the group solution. The five-item scale used to measure process satisfaction was developed and validated by Green and Taber (22).

**Satisfaction with the solution:** Solution refers to the outcome that a group developed. The five-item scale used to measure solution satisfaction was also developed and validated by Green and Taber (22).

**Group Development:** Each of the five behaviors associated with group development (cohesiveness, conflict management, task and social-emotional needs, communication and involvement in group activities) was measured using separate scales. All scales were culled from the literature and had been previously validated and reliable, except where noted.

**Cohesiveness:** Seashore's Index of Group Cohesiveness (40) is a widely used scale that measures how connected group members feel toward one another and their attraction to the group. Although the original instrument was designed for workgroups in organizations, Chidambaram et al. (5) modified it for use with student groups. This modified version was used in this study. The measure contains five items, each with a five-interval response scale.

**Conflict Management:** The ability to manage conflict was measured using a two-item scale developed and validated by Chidambaram et al. (5).

**Task and socio-emotional needs:** Gouran et al. (21) developed a scale measuring group member behavior. The scale was originally designed to ascertain which aspects of a group's behavior led to judgments of quality regarding decision-making activities. The original scale consists of nine items designed to capture three types of behaviors: task-oriented, socio-emotional, and procedural. The six items measuring task and socio-emotional behavior were used in this study. The measure uses an anchored five-interval response scale.

**Effective Communication:** Davidson (10) developed a scale to measure aspects of a group's communication. The scale contains four items that are measured using an anchored five-interval response scale. Slight modifications in wording were required to apply the scale to this experiment.

**Participation:** Hemphill (23) developed a ten-item participation scale. However, not all items applied to the current experimental situation. For example, some items relate to a group's reputation or whether nonproductive members are ejected from the group (not a possibility in this experiment). Five of the scale items applied directly to this experiment and were measured using an anchored five-interval response scale.

## 5. Results

There was an unbalanced distribution of MSIS students between the two experimental treatments. Additionally, group size varied between four and five members; five-member groups were unevenly

distributed between treatments. Therefore, two separate analyses of covariance (ANCOVA) were run on all dependent variables. The ANCOVA results with MSIS as the covariate did not produce any significant results. However, the ANCOVA using group size as the covariate produced significant results for the dependent variable "participation." Therefore, all results are presented using group size as the covariate.

**Interaction & group development:** Combined groups outscored virtual groups on 4 out of 5 measures (cohesiveness, conflict, task/socio, and communication, but not participation). A composite score for overall group development was calculated as the average of the 5 measures. Combined groups outscored virtual groups, supporting hypothesis H1 (3.95 vs. 3.59 out of 5,  $p = .009$ ).

Results for each measure are provided below.

**Cohesiveness:** This scale had an acceptable inter-item reliability of .72. Members of combined groups rated their groups as more cohesive than members of virtual groups (4.00 vs. 3.62 out of 5,  $p = .001$ ), providing support for hypothesis H1a.

**Conflict:** This scale had a reliability of .90. Members of combined groups rated their group's ability to manage conflict higher than members of virtual groups (4.13 vs. 3.43, out of 7,  $p = .002$ ). Hypothesis H1b was supported.

**Task/Socio-Emotional:** The original task scale had a low reliability. One item was dropped from the scale, improving the reliability to .78. The socio-emotional scale had a rather low reliability of .51.

The combined groups rated their task discussions as more effective than virtual groups (4.15 vs. 3.69, out of 5,  $p = .005$ ). Similarly, the combined groups rated the social aspects of discussions higher compared to virtual groups (4.28 vs. 3.57 out of 5,  $p = .000$ ). Hypothesis H1c was supported.

**Communication:** This scale had an acceptable inter-item reliability of .77. Members of combined groups rated their groups higher in terms of effective communication than virtual groups (4.53 vs. 3.95 out of 5,  $p = .01$ ). Therefore, hypothesis H1d was supported.

**Participation:** The original scale had a very low inter-item reliability. Two items were dropped, resulting in a reliability of .95. There was no significant difference between combined and virtual group members' scores (3.29 vs. 3.32 out of 5,  $p = .86$ ). Hypothesis H1e was not supported.

**Group development & outcome:** In order to perform the analyses for hypotheses H2 through H4, the 20 groups were ranked according to group development scores and then divided into two categories of 10 each to form the high and low groups. The high category consisted of seven combined groups and three virtual groups while the low category included two combined

groups and eight virtual groups. In terms of group development level, the mature groups significantly outscored the less mature groups (4.01 vs. 3.49 out of 5,  $p = .000$ ).

The quality of the written report was judged using a seven-point response scale. The judges had an acceptable inter-rater reliability of .78. The mature groups did not generate a higher quality solution compared to the less mature groups. Therefore, hypothesis H2 was not supported (4.80 vs. 5.55 out of 7,  $p = .09$ ).

Two types of satisfaction were measured: interaction process and solution. Both the interaction process satisfaction scale and the solution satisfaction scale had high inter-item reliabilities of .91 and .82 respectively. As predicted, on a scale from one to five, the higher developed groups were more satisfied with both the interaction process and the solution (4.28 vs. 3.56 out of 5,  $p = .000$  and 4.25 vs. 3.80 out of 5,  $p = .000$ ). Thus, hypotheses H3a and H3b were supported.

Creativity of the written report was measured using a seven-point response scale. The expert judges had a lower, but acceptable inter-rater reliability of .68. The less developed groups were judged as generating more creative solutions than the mature groups, providing support for hypothesis H4 (6.03 vs. 5.30 out of 7,  $p = .02$ ).

**Interaction & outcome:** There were no significant differences in the quality of the group solution between the combined and virtual modes (4.95 vs. 5.36 out of 7,  $p = .47$ ). Therefore, hypothesis H5 was not supported.

Members of the combined groups were more satisfied with both their interaction process and group solution than were members of virtual groups (4.28 vs. 3.65 out of 5,  $p = .001$ ; 4.22 vs. 3.88 out of 5,  $p = .01$ ). Thus, hypotheses H6a and H6b were supported.

The solutions of the virtual groups were judged to be more creative than those of the combined groups (6.05 vs. 5.19 out of 7,  $p = .02$ ), providing support for hypothesis H7.

## 6. Discussion and Conclusion

The theoretical model in Figure 1 depicts two relationships: (1) interaction mode (combined; virtual) and group development and (2) group development and the outcome variables of quality, satisfaction and creativity. The model shows the level of group development as a mediating variable between interaction mode and the outcome variables.

It was predicted that virtual teams interacting using the leaner, purely asynchronous interaction mode would be less developed compared to groups interacting via a series of three FtF meetings combined with virtual

communication between meetings. Experimental results support this relationship – combined teams rated themselves higher than virtual teams on four out of five group development measures. The combined groups viewed themselves as more cohesive and better able to manage conflict. They perceived themselves as communicating more effectively and achieving a better balance between task-related and socio-emotional communication. However, they did not perceive themselves as having more equal participation among team members.

The model indicates a positive relationship between the level of group development, quality and satisfaction. As expected, mature groups were more satisfied with both their interaction process as well as the quality of their solutions. It was predicted that more mature groups would produce higher quality reports compared to less mature groups. However, this prediction was not supported. The model shows an inverse relationship between creativity and group development. The results support this finding – less mature groups generated more creative reports.

Finally, it was predicted that groups interacting via the combined mode would be more satisfied with the group experience and produce higher quality reports. The results support the satisfaction hypotheses, but not the quality hypothesis. It was also predicted that virtual teams would be more creative than combined teams. This was supported. A summary of experimental findings is presented in Table 1.

can see why both “a” and “b” occurred. An extensive review of GSS experiments (which includes CMC experiments) shows that “no significant difference” is the most common result (15), however this does not constitute an explanation.

Group members had no prior experience working together, and yet they completed a complex assignment and met a strict deadline. This indicates a high level of motivation among participants. However, virtual group members most likely exerted more effort to achieve the same quality results compared to combined groups, as keyboarding takes longer and requires more effort than speaking (42). Thus, virtual groups, in all probability, worked harder to accomplish the same tasks as their counterparts (33). Thus, one argument is that virtual groups exerted more effort in order to produce reports of comparable quality compared to combined groups. These groups adapted their behavior in response to the leaner, less interactive communication modality as explained by adaptive structuration theory (39). The level of participant effort as well as motivation should be included in the model and measured in future experiments.

However, another explanation is simply that the strategically placed FtF meetings did not add any value to the quality of the group product. Although high interactivity appears to increase levels of group development, the more mature groups’ reports were actually judged to be of lower quality than those of the less developed groups. Although this result was not significant, at the  $p=.09$  level, it warrants attention and further study.

In summary, the level of group development was studied as a possible means for explaining differences in outcome between combined and virtual groups. It was found that combined groups perceived themselves as more developed than virtual groups and that more developed groups achieved high levels of satisfaction. Virtual groups, on the other hand, perceived themselves as less developed than their counterparts. Less developed groups scored higher on creativity but perceived themselves as less satisfied. No differences were found in terms of quality between more and less developed groups or between combined and virtual groups.

*What implications do these results have for organizations using virtual teams?*

There are several consistent results originating from the three studies (36, 37 and the current study) comparing virtual and combined interaction. If the singular objective is to generate a high quality product, organizations can save the time and money associated with bringing distant team members together, as it appears that FtF interaction in an otherwise virtual environment does not enhance quality. Furthermore, if

**Table 1. Summary of Findings**

Hypoth.	Variable	Prediction	Result
H1	group development	$C > V$	supported
H1a	Cohesion	$C > V$	supported
H1b	manage conflict	$C > V$	supported
H1c	task/socio balance	$C > V$	supported
H1d	effective communication	$C > V$	supported
H1e	equal participation	$C < V$	unsupported
H2	Quality	$GD_h > GD_l$	unsupported
H3a	process satis.	$GD_h > GD_l$	supported
H3b	solution satis.	$GD_h > GD_l$	supported
H4	Creativity	$GD_h < GD_l$	supported
H5	Quality	$C > V$	unsupported
H6a	process satis.	$C > V$	supported
H6b	solution satis.	$C > V$	supported
H7	Creativity	$C < V$	supported

Why weren’t higher quality results generated by (a) more developed or (b) combined groups? As combined groups, overall, were more highly developed, then we



a high value is placed on the creativity of the work product, then organizations are ill-advised to incorporate FtF interaction as it appears to enhance group development and thus, lessen group creativity. However, when member satisfaction is the most important goal, bringing team members together for some FtF meetings is apparently beneficial as it increases both the maturity of the group and member satisfaction levels.

The experimental results indicate that achieving both high creativity and high satisfaction may be incompatible goals. One appears to be maximized at the expense of the other. Thus, a group may very well exhibit high quality and creativity with low satisfaction through purely virtual interaction. Groups using a combined mode of interaction, on the other hand, can be expected to exhibit high quality and satisfaction at the expense of creativity.

#### Limitations

There were a relatively small number of experimental groups (i.e., 20). Although this can be a limiting factor when generalizing results, the fact of consistent results across three experiments greatly reduces this limitation. However, students groups were used rather than naturally occurring groups, so caution must be used in generalizing these results to organizational groups.

More group development measures covering the same behaviors would increase the validity of the experimental results on this construct. Also, some behaviors, such as involvement, are complex and different aspects could be measured by separate scales.

#### Future Research

More experimental conditions varying the number and placement of FtF meetings should be conducted to ascertain the effectiveness of these meetings. Perhaps only one FtF meeting is necessary to increase levels of satisfaction. Longer experiments covering several weeks or months are necessary to see if length of time impacts the dependent variables in this study. A factor analysis including items from many scales should be run in order to create a more robust group development survey.

Acknowledgements: This research was partially supported by a grant from the National Science Foundation (CISE ITO 9732354) and by the New Jersey Center for Multimedia Research.

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