Improving the Effectiveness of Virtual Teams: A Comparison of Video-Conferencing and Face-to-Face Communication in China

—ZIXIU GUO, JOHN D'AMBRA, TIM TURNER, AND HUIYING ZHANG

***Abstract*—*As virtual teams become more and more important in organizations, understanding how to improve virtual team relational development and meeting outcomes is vital to project success. The objective of this study was to investigate how the dialogue technique that facilitated building of shared understanding in virtual teams can be used to enhance virtual team relational development and decision outcomes in a Chinese cultural context. The results from an experiment demonstrate that the adopted dialogue technique can indeed help team members develop their team relations and enhance their perceived team meeting outcomes. Video-conferencing virtual teams with shared mental models may be engaged as effectively as traditional face-to-face teams. Moreover, this study reveals that the dialogue technique can enhance face-to-face team outcomes. Therefore, the findings of this study have both theoretical and practical implications for helping teams develop shared understanding of effective communication and enhance decision-making outcomes in the Chinese cultural context.*

***Index Terms*—*Face-to-face interaction, meeting outcomes, shared mental models, video-conferencing system, virtual teams.*

The increased globalization of organizations and recent advances in internet and telecommunications have spawned a new type of team structure—the virtual team. Virtual teams are groups of people engaged in a common organizational task through electronic information and communication technologies (email, video-conferencing, etc.) [1]. Given their ability to transcend the traditional constraints of time, location, social networks, and organizational boundaries, virtual teams can enhance the competitive flexibility of organizations [2]. However, for virtual teams to be successful, effective communication and knowledge sharing among members are necessary [1]. The importance of these increase because the exchange of knowledge and information relies purely on computer-mediated communication (CMC) systems. Compared to traditional face-to-face interaction, effective communication under a CMC environment may become more difficult due to reduced social context [3] and the use of "leaner" communication media [4]. In the virtual work environment, traditional social mechanisms that facilitate communication and decision making are effectively lost and participants must find new ways to communicate and interact effectively within the new technical context [1].

Huang et al. proposed a dialogue-based framework aimed at supporting a virtual team in building clear goals of effective communication [5]. Later work suggests that this framework is useful in helping virtual teams develop a shared understanding about effective communication that enhances team relational development and outcomes [6], [7]. However, these studies are limited to examining the framework using only one asynchronous computer-mediated technology; there was no visual contact or audio communication between team members. Computer-mediated technologies differ quite considerably in the degree to which they transmit social context cues [8]. Social context cues play a vital role in the reduction of ambiguity, which in turn has important social consequences for guiding the degree of intimacy and the quality of team meetings [9]. Thus, when we discuss virtual teams, we must be aware that virtual teams may operate in the context of different types of communication technologies and that the type of communication technologies implemented may have a significant impact on team interaction [10]. Future research would benefit by employing different types of technologies, such as synchronous video-conferencing systems. Also, examining the framework with only one medium fails to justify whether the framework can help virtual teams to outperform face-to-face teams [7]. Without a comparison between computer-mediated

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and face-to-face team interaction, the question of whether computer-mediated technologies enable virtual teams to function as effectively as face-to-face teams remains unanswered.

This paper describes a laboratory experiment that examined the impact of the dialogue technique on virtual team relational development and meeting outcomes by comparing team interactions in traditional face-to-face teams and teams interacting via video-conferencing systems in China. The remainder of this paper is organized as follows. First, virtual team meeting outcomes in CMC environments are discussed. The dialogue technique is introduced next based on the review of shared mental models. The research hypotheses are developed and presented next. This is followed by a description of the research methods and the experimental procedures. Next, the data analysis results are reported. Finally, the paper concludes with a discussion that focuses on interpreting the results and on examining the theoretical and practical implications of the study.

Virtual Team Meeting Outcomes in CMC Environments

As CMC technologies have the ability to overcome constraints of time and place, to retrieve and search for associated materials, to reprocess and merge different contents, and to support many-to-many communication flows, they have been fully utilized to support and enhance virtual team interaction effectiveness [11]. Among various CMC technologies used to facilitate virtual teams' interactions, video-conferencing systems are the core system around which the rest of virtual team technologies are built [1]. Synchronous video-conferencing systems allow team members separated by geographical distances to interact in an approximation of face-to-face interaction through audio and video communication capabilities. Video-conferencing systems allow virtual teams to "meet" without the time, effort, and financial costs of traveling to a face-to-face meeting. Video-conferencing systems have changed the way people keep in touch and the way business is done. They provide an infrastructure across which the virtual team will interact and provide technological empowerment to the virtual team's operation [12].

However, the mediation of a team's interaction by CMC technologies creates both opportunities and challenges. According to two related theories, media richness theory [13], [14] and social presence theory [15], media differ in the extent to which they (a) can overcome various communication constraints of time, location, permanence, distribution, and distance; (b) transmit the social, symbolic, and nonverbal cues of human communication; and (c) convey equivocal information [16]. Rich media or media with a higher degree of social presence, such as face-to-face, are better suited to complex social interaction and interpersonal communication that requires rich information to facilitate shared meaning and consensual understanding. In contrast, lean media or media with low social presence, such as CMC technologies, may not be suitable for intersubjective interpretation when interactivity and reciprocity are needed in communication [17]. This is because CMC technologies restrict the transmission of nonverbal cues and paraverbal cues, the ability to perceive many individual differences, and the physical presence of others [8]. Those social context cues are important for team members to regulate interaction, express information, monitor feedback from others, and create a sense of common ground and shared understanding [8], [18], [19]. Consequently, communication efficiency and team outcomes will be decreased if CMC technologies are used to facilitate virtual teams' performance of team functions that require collaborative problem-solving and decision-making [14], [15].

In face-to-face interaction, team members have full access to all the nonverbal cues: They share the same physical location, can see and hear one another (tones, gestures, feelings, etc.), can experience the immediacy of interacting and being involved with physically present team members, receive messages in "real time" as they are produced, and send and receive information simultaneously and in sequence [10]. CMC technologies attenuate to at least some degree the social context cues available in face-to-face interaction [3]. Such reduced capacity of CMC to convey social information about communication partners was thought to eliminate social presence, degrade the quality of communication, impair working relationships, and undermine task performance [19].

Video-conferencing systems are designed with the possibility of being able to simulate for remote participants some of what people share when they meet in the same physical space by preserving visual, audio, and verbal information [20]. However, visual access to the head and shoulders of the person with whom one is conversing (typical of video-conferencing systems) might be fundamentally different from sharing the same

TABLE I
SUMMARY OF KEY DIFFERENT FEATURES BETWEEN FACE-TO-FACE AND VIDEO-CONFERENCING MEETINGS

Feature	Face-to-Face Meeting	Video-Conferencing Meeting
Co-presence	Yes	No
Visual quality	Unmediated visual access	Good quality, color image
Number of images per monitor screen	N/A	3 continuously available*
Camera angle	N/A	Head and shoulders only
See own image	No	Yes
Selective gaze supported	Yes	No
Audio quality	Unmediated audio access	Full duplex, no lag

*There were three members in each video-conferencing team in this study.

physical space (typical of face-to-face interactions). Communicating with remote participants means that team members may lose proxemic, haptic, and environmental cues [19]. Video-conferencing interaction differs from face-to-face interaction because team members who work on a common task do not share the same spatial location. Remote participants may find it more difficult to mutually determine the physical distance between themselves than if they shared the same place. Physical proximity promotes higher degrees of involvement and fosters psychological closeness and mutuality—a sense of connection, similarity, solidarity, openness, and understanding [18]. Sellen found that compared to face-to-face interaction, technology-mediated teams (with and without video) exhibited clear symptoms of depersonalization and psychological distance [20]. She concluded that some forms of interaction might be fundamentally altered when team members do not share the same space. Table I summarizes the key differences between face-to-face and video-conferencing meetings.

Straus and McGrath found that the overall effectiveness of CMC groups was lower than that of face-to-face teams, especially for tasks that required higher levels of coordination [8]. Yet research has found that time may mitigate the effects of communication modality. That is, if given enough time, virtual teams might be able to gain enough knowledge with the media, the task, the context, and each other. Then the differences between face-to-face and CMC may be diminished by enriching the "lean" electronic media [21]. It has been argued, however, that virtual teams need to be effective quickly as teams may only interact for a short period of time or may be working on a task that is of great importance and urgency [7], [22]. To compensate for the losses resulting from reduced social context cues, virtual teams have to invest extra energy and time for positive team-building [9], [19]. Recent research has suggested that the effectiveness of computer-mediated virtual teams can be enhanced upon formation where the team members had a shared history [22]; training in developing media use and communication-related issues took place [23]; teams had the ability to build personal relationships in the mediated environment [24]; the media allowed the team to adapt its behavior to match the nature of the task and other constraints; and the team had shared understanding of effective communication [7]. This study focuses on enhancing team satisfaction with communication and outcomes by building an adequate level of shared common understanding, a critical attribute of successful virtual teams [1].

DIALOGUE TECHNIQUE: BUILDING SHARED MENTAL MODELS OF EFFECTIVE COMMUNICATION

The notion of shared mental models or common ground in teams has been used to help explain team functioning for several years [22], [25]–[29]. Team mental models are the content and organization of team-interaction knowledge held by team members within a performance setting [27]. Accordingly, a lack of shared mental models in a team would be represented by team members who hold different knowledge structures and are unable to predict what their team members are going to do and what they are going to need in order to do it.

Effective communication between people requires that the communicative exchange takes place with some level of common ground [30]. Common ground refers to knowledge that the participants have in common and that they are aware that they have in common [29]. Building common ground is a collaborative process in which the participants mutually establish what they know so conversation can proceed [29]. Olson and Olson further suggested that the more common ground

people can establish, the easier the communication and the greater the productivity [29].

The lack of shared mental models or common ground can lead to conflict and disruption. To cope with difficult and changing task conditions, team members have to be able to adjust their strategy quickly and adapt effectively. The function of shared mental models is to allow team members to draw on their own well-structured knowledge as a basis for selecting actions that are consistent and coordinated with those of their team members [28]. Cannon-Bowers and Salas suggested that under conditions in which communication is difficult, shared mental models become more crucial to team functioning because they allow team members to predict the information and resource requirements of their team members [26]. In fact, researchers suggested that these "team mental models" lead to higher quality communication, particularly in situations where teams must come together to make sense of complex or equivocal tasks [27].

As we discussed earlier, the reduced capacity of CMC to convey social context cues about communication partners is likely to generate less interaction and reciprocity than is required for building shared understanding [31]. By allowing limited social cues, CMC technologies may also decrease redundant and complementary information that contributes to team mutual understanding [19]. Building a shared team mental model of effective communication would help virtual teams compensate for structural shortfalls [19]. Shared mental models will enable virtual team members to overcome limitations inherent in the CMC technologies, leading teams communicating through computer-mediated media to approach the levels of effectiveness found in face-to-face teams [22].

Building a shared team mental model of effective communication is important since it allows team members to engage in a team-building activity to engender mutual understanding. Ignoring this step might speed up the team process, but at the cost of poorer team outcomes. Researchers have suggested that shared team knowledge is more important than media differences in explaining communication processes [22]. Indeed, as Zack's study of editorial teams highlights, face-to-face interaction may be more facilitative of building shared knowledge, but once a shared interpretive context has been built, objectively leaner media, such as email, can be used to communicate effectively [32]. If a team mental model can be established, shared understanding of team members is possible. The more a team achieves this, the easier it is for the team to reach a collective decision, and the more likely the decision will be implemented in the way the team wants [33].

Dialogue theory offers suggestions on how team mental models can be developed. Dialogue is a basic process for building common understanding, and it is at the root of all effective team actions [34]. Through dialogue, team members will be able to determine whether or not the communication is valid and will be able to build sufficient common ground and mutual trust for future effective interaction. The key function of the dialogue is to build a common mental model that facilitates shared understanding among team members.

Based on preceding and other related literature on team building, Huang et al. proposed a dialogue technique to facilitate shared understanding in virtual teams [5]. The main premise of this framework is that through dialogue, team members can build common mental models of effective communication [5]. These models serve as team norms to guide future interaction and activities of the team. The dialogue framework is illustrated in Fig. 1, aiming to support a team building a shared mental model of effective communication (for detailed discussion of the framework, see Huang et al. [5]).

(1) Small Talk: Communicators take part in a small-talk session to introduce themselves and get to know the other communication partners (see [5]).
(2) Corner Stone: Communicators engage in a dialogue defining and generating shared goals for effective communication.
(3) Infinite Container: The core of the framework is a dialogue session adopted from MIT's dialogue procedure [35]. First, communicators reflect on their past experience of cooperation in terms of good communications. Second, communicators, in concert, disclose and share their past cooperative working experiences, identifying characteristics of their past experience related to experiences of good communication protocols. Third, given the shared goals, communicators exchange feedback on the derived characteristics of good communication. Fourth, communicators are not allowed to criticize others' input. A dialogue facilitator would intervene, when necessary, to clarify or elucidate any issue. Fifth, the dialogue will be closed when no further exchange and clarification from communicators are possible.

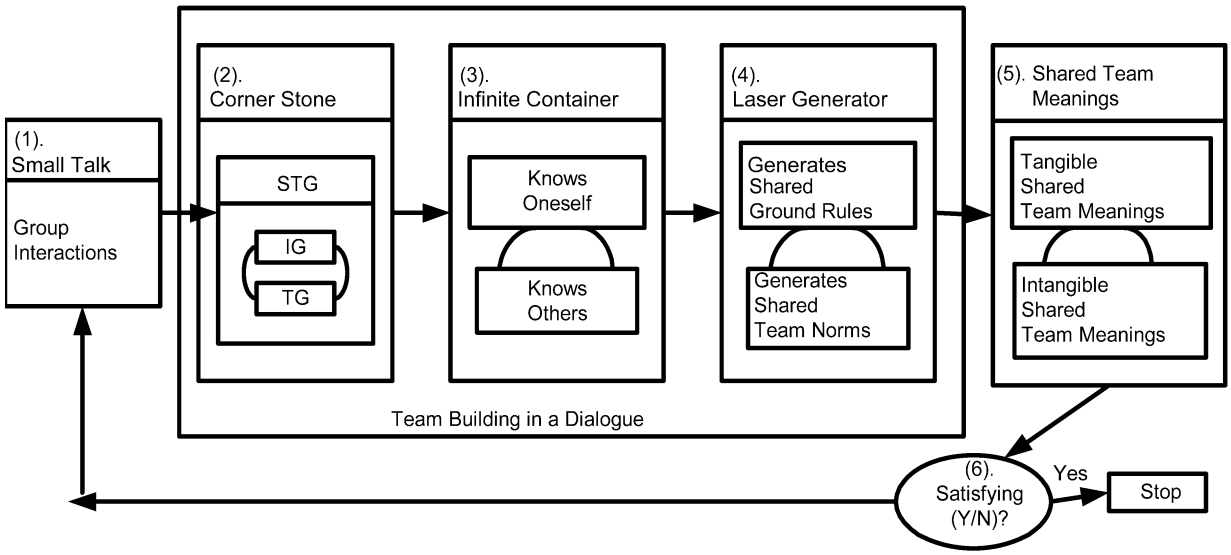

Fig. 1. Dialogue-theory-based, team-building framework (adapted from Huang et al. [5]).

(4) Laser Generator: Outcomes of the dialogue that are described as "laser" can be produced [36]. Communicators rank the characteristics discussed at step (3). This can result in a specific team mental model of effective communication shared by all members.
(5) Verification of an outcome that will support effective communication in a mediated environment. If a team does not achieve a satisfactory level of team building, the dialogue can be repeated until a satisfactory level is achieved. Team members are reminded that in the course of their teamwork, these agreed mental models of effective communication should be used to guide team member interactions.

The central research issue here is that if virtual teams can develop a shared mental model of effective communication through the dialogue technique, social context cues reduced in the CMC technologies will become less important [9]. Virtual teams that use the dialogue technique can enhance their team communication quality and decision-making outcomes.

Research Hypotheses

The dialogue technique discussed above can potentially facilitate the building of sufficient common ground and mutual trust for all problem-solving teams. This technique is particularly important for virtual teams' mental model development since most virtual teams, facilitated through electronic communication technology with restricted social cues, may not have met each other in person and are typified by a lack of shared understanding [7]. Thus, this study examines the impact of the dialogue technique on enhancing virtual team relational development and team decision outcomes. In addition, to answer the question of whether virtual teams can perform as effectively as face-to-face teams, we formulate our hypotheses to compare virtual and face-to-face teams. Dependent variables include team cohesion, communication satisfaction, team decision-process satisfaction, decision satisfaction, and decision quality. The first dependent variable reflects the process of virtual team development. The last four dependent variables reflect the outcomes of virtual team development.

Team cohesion is the degree to which an individual feels attracted toward his or her team [37]. Dialogue is at the root of all effective group actions since only dialogue can make it possible for the teams to determine whether the communication is valid [34]. The dialogue technique discussed in this study allows team members to discuss specific issues influencing team communication effectiveness. This leads to the generation of shared team communication norms and ground rules, which establish guidelines for future team interaction [5]. Such a shared team understanding is important for teams to be effective. Further, such a shared understanding can enhance the sense of "we-ness" among team members [5]. As a result, team members should also be more willing to communicate freely with each other and feel

closer to each other as well as to the team [7]. Thus, virtual teams that use the dialogue technique will have higher team cohesion than virtual teams that do not use the dialogue technique.

H1. Virtual teams that use the dialogue technique will have higher team cohesion than virtual teams that do not use the dialogue technique.

COMMUNICATION SATISFACTION refers to the extent to which members feel part of team discussion and can actively get involved in team interaction [38]. Communication satisfaction has gained considerable attention in the research literature, and a high correlation between communication satisfaction and overall job satisfaction and job performance was found [39]. Hecht described communication satisfaction as one important criterion for assessing outcomes of the input attributes and process variables of actual communication behavior [38]. Employees' communication satisfaction has been considered as an important component in organizational communication audits to assess communication effectiveness [40]. The dialogue technique employed in this study intends to enhance communication effectiveness by building shared common understanding among team members. Such a shared mental model of effective communication can create common frames of reference, common language, and ultimately a common experience base that allows team members to learn collectively [34]. The more the teams achieve such collective understanding, the easier the team members communicate with each other, and the more satisfied the team members will be. Thus, virtual teams that use the dialogue technique will have higher team communication satisfaction than virtual teams that do not use the dialogue technique.

H2. Virtual teams that use the dialogue technique will have higher team communication satisfaction than virtual teams that do not use the dialogue technique.

DECISION-PROCESS SATISFACTION refers to the extent to which team members are happy with their decision-making process [41]. The dialogue technique can be employed to enhance team cohesion and team communication satisfaction (as formulated in H1 and H2). Team members are likely to be more comfortable working in such a cohesive team environment. Guided by shared understanding, cohesive teams are more likely to participate actively so that their views are incorporated in team decisions [7]. Consequently, team members may be more satisfied with such a cohesive decision-making process [5]. Previous research has shown that when team cohesion is high, members exchange information more freely and are more satisfied with the team experience [42]. Thus:

H3. Virtual teams that use the dialogue technique will have higher team decision-process satisfaction than virtual teams that do not use the dialogue technique.

DECISION SATISFACTION is the extent that members are happy with their team decision [41]. The satisfaction users have with the decision-making process and outcomes of the teamwork itself often determines the ultimate adoption and sustained use of the technologies [43]. Thus, team decision satisfaction is the critical measure of teamwork success [44]. Fjermestad and Hiltz found that over 25% of group support systems (GSS) research hypotheses addressed team meeting satisfaction [45]. Accordingly:

H4. Virtual teams that use the dialogue technique will have higher team decision satisfaction than virtual teams that do not use the dialogue technique.

DECISION QUALITY refers to the degree to which team members think that their team's decision is good [46]. Numerous studies in various disciplines have demonstrated the direct relationship between group cohesion and group decision-making quality [47] with substantial evidence in CMC group research (e.g., [48]–[51]). The dialogue technique can enhance virtual team cohesion by building a shared common understanding. Such a common understanding will guide team members to commit to team goals, be involved actively in team tasks, and have little miscommunication occurring [52]. Under such conditions, teams are more likely to produce high-quality products, ultimately leading to better decisions. Thus:

H5. Virtual teams that use the dialogue technique will have higher team decision quality than virtual teams that do not use the dialogue technique.

The research hypotheses are formulated only for the virtual communication setting, rather than face-to-face, as the objective of the research is to consider how the dialogue technique may be used to enhance outcomes of virtual meetings. However, as discussed earlier, in order to demonstrate

that the dialogue technique can be an effective mechanism to improve virtual team performance to the same levels as face-to-face meetings, the following hypotheses will be formulated to compare team meeting outcomes between face-to-face and virtual teams, in which face-to-face teams are treated as controlling groups.

Prior research has demonstrated that when communicators possess shared experience or social constructions, a lean medium such as CMC can be used as effectively as face-to-face meetings for rich information, enhancing virtual team work performance for solving a complicated equivocal problem (e.g., [21], [27], [53], [54]). Therefore, the following hypotheses are developed to test the ability of this adopted technique in enhancing video-conferencing team meeting process and outcomes. Accordingly:

H6. Perceptions of team cohesion will not differ between video-conferencing teams that use the dialogue technique and face-to-face teams that do not use the dialogue technique.

H7. Perceptions of team communication satisfaction will not differ between video-conferencing teams that use the dialogue technique and face-to-face teams that do not use the dialogue technique.

H8. Perceptions of team decision-process satisfaction will not differ between video-conferencing teams that use the dialogue technique and face-to-face teams that do not use the dialogue technique.

H9. Perceptions of team decision satisfaction will not differ between video-conferencing teams that use the dialogue technique and face-to-face teams that do not use the dialogue technique.

H10. Perceptions of team decision quality will not differ between video-conferencing teams that use the dialogue technique and face-to-face teams that do not use the dialogue technique.

METHOD

This research adopts a 2×2 factorial design. (See Table II.) Communication settings (face-to-face and video-conferencing) and dialogue technique framework (presence versus absence) are the two independent variables. Because all dependent variable measures and the dialogue technique procedure were originally developed in English,

TABLE II
FORMAL EXPERIMENTAL RESEARCH DESIGN

Communication Medium	Framework: Dialogue Technique	Framework: Without Dialogue Technique
Face-to-face (FTF)	C (10 teams)	D (10 teams)
Video-conferencing (VC)	A (10 teams)	B (10 teams)

we translated them into Chinese and then translated back to ensure that the Chinese versions of the questionnaire and dialogue instructions represented the intent and spirit of original documents and were not merely a literal translation. We also conducted a pilot study with 24 Chinese university students before the formal experiments. The main purpose of this pilot study was to modify and fine-tune experimental tasks, settings, procedures, and instruments. Students had been invited to identify any issues they might have with the questionnaire. A few minor changes were made. The pilot study was also helpful in determining the amount of time required for the dialogue technique and task completion.

Teams A total of 120 undergraduate students from a large university in China voluntarily participated in this study. Interest in understanding how communication practices enhance virtual team meeting outcomes in the context of China is motivated by the development in the relations between China and Western countries in recent years. Given the increased international business opportunities in China, it is vital for multinationals to understand the challenges of different national cultures. Examining the impact of the dialogue technique on enhancing the Chinese virtual team meeting outcomes may assist managers and organizations in finding ways of enhancing effective collaboration in the Chinese business environment.

Subjects were administratively and randomly assigned into 40 three-person groups in such a way that none of them was known to each other. The random assignment of subjects to teams controlled for differences due to subject characteristics. The average age of participants was 22, and 56% of the participants were male. T-tests showed that subjects under each treatment did not differ significantly in terms of age, experience with using media, and experience working in project teams.

A Mann-Whitney test revealed that there was no significant gender difference across treatments. Twenty teams (A and C in Table II) were assigned the dialogue technique framework. Twenty teams (A and B in Table II) were using the video-conferencing medium for interaction. This left one group of teams (D in Table II) that represented the control groups without technology and framework.

Communication Medium The two communication conditions were traditional face-to-face and video-conferencing systems. The physical environments for both the face-to-face and video-conferencing teams were the same. There were tutorial rooms and computer laboratories, respectively, for all the teams. Participants in a video-conferencing team were located in three physically separated rooms. The equipment for the video-conferencing experiment consisted of a PC, video camera, and microphone/headset. The software used in the experiment was an installation of EPH, a free Chinese video-conferencing system. Each participant had visual access to the head and shoulders of the people with whom they were conversing. Only audio and video features of EPH were available throughout the meeting. The major advantage of this software, compared with others such as Lotus Notes SameTime, is that all participants are visible to each other throughout the meeting. All participants in the video-conferencing teams were trained in how to use the software. The duration of the demonstration was about five minutes.

Dialogue Technique Treatment For teams that were assigned to the dialogue technique framework, detailed instructions were given to each team member. (See Fig. 1 for the procedure.) As specified in the instruction, team members were asked to list all characteristics of effective communication from their past experience. At the end of the meeting, team members were asked to determine (by ranking) what characteristics of team communication are most important to the attainment of effective communication. All team members agreed to accept the team norms of effective communication and use them as the guidelines for further interaction.

Task The task chosen for this study was the "van management" task [55]. The subjects assume the role of a group of executives making a decision about how to best manage vehicles for their sales staff in their region. Each subject was provided the same information and each team had to reach an agreement at the end of the team meeting. This task has been adopted in a number of CMC studies (e.g., [51]). Prior studies have found that task type moderates the effects of technology on team outcomes [56]. In tasks that are more complex and/or require more interdependent activities, computer-mediated teams are less effective, and the greater the importance of understanding how computer-mediated technologies can be facilitated during team interactions to resolve those complex tasks [57]. According to McGrath, the task chosen in this study was classified as a preference task because the task has no demonstrably correct answer and team members are required to negotiate and resolve conflicts [58].

Measurement A questionnaire was designed to capture participants' personal information and their perceptions about team relational development and meeting outcomes. Team cohesion, gauging an individual's attraction to and feelings toward his/her team, was measured using Evans and Jarvis's Group Attitude Scale (GAS) [37]. GAS has been used in previous CMC research that has examined the impact of group cohesion on group consensus [51] and the influence of technology on group cohesion [59]. Communication satisfaction was measured using the Communication Satisfaction Inventory [38]. After a principal component factor analysis followed by varimax rotation, seven items were loaded at one factor with a satisfactory reliability of 0.80 for team cohesion, and ten items were loaded at one factor with a satisfactory reliability of 0.86 for team communication satisfaction. Decision-process satisfaction and decision satisfaction were measured using Green and Taber's questions [41]. Team decision quality was measured using Gouran, Brown, and Henry's scale [46]. Green and Taber's instruments and Gouran et al.'s instrument have frequently been used by researchers to measure group meeting process satisfaction, outcome satisfaction, and outcome quality (e.g., [43], [51], [60], [61]). After a principal component factor analysis followed by varimax rotation, single factors were generated for decision-process satisfaction, decision satisfaction, and decision quality; satisfactory reliabilities of 0.88, 0.73, and 0.80 were obtained, respectively. The questions used to measure each dependent variable, as well as reliability and validity analyses results, are provided in Table III.

Procedure When participants arrived at the experimental site, they were randomly chosen to participate in one of the four different treatment

TABLE III
QUESTIONS AND RESULTS OF RELIABILITY AND VALIDITY ANALYSIS MEASURING DEPENDENT VARIABLES

Constructs	Questions	Loadings
Team Cohesion		
TC1	I want to remain a member of this group.	(0.78)
TC2	I like my group.	(0.80)
TC3	I look forward to coming to the group.	(0.73)
TC4	I feel involved in what is happening in my group.	(0.61)
TC5	I feel included in the group.	(0.63)
TC6	In spite of individual differences, a feeling of unity exists in my group.	(0.64)
TC7	Compared to other groups I know of, I feel my group is better than most.	(0.61)
		Cronbach's alpha: 0.80
Communication Satisfaction		
CS1	The interaction went smoothly.	(0.78)
CS2	We each got to say what we wanted.	(0.85)
CS3	I was very satisfied with the interaction.	(0.85)
CS4	I would like to have another interaction like this one.	(0.53)
CS5	The other person genuinely wanted to get to know me.	(0.73)
CS6	I felt I could talk about anything with the other person.	(0.82)
CS7	The other person showed me that he/she understood what I said.	(0.51)
CS8	The other person expressed a lot of interest in what I had to say.	(0.73)
CS9	The other person let me know that I was communicating effectively.	(0.65)
CS10	During the interaction I was able to present myself as I wanted the other person to view me.	(0.77)
		Cronbach's alpha: 0.86
Decision Process Satisfaction		
DPS1	Our group decision-making process was efficient.	(0.88)
DPS2	Our group decision-making process was satisfying.	(0.91)
DPS3	Our group decision-making process was coordinated.	(0.81)
DPS4	Our group decision-making process was fair.	(0.83)
DPS5	Our group decision-making process was confusing.	(0.69)
		Cronbach's alpha: 0.88
Decision Satisfaction		
DS1	How satisfied are you with the quality of your group's solution?	(0.90)
DS2	To what extent does the final solution reflect your inputs?	(0.87)
DS3	To what extent do you feel committed to the group solution?	(0.82)
DS4	To what extent are you confident that the group solution is correct?	(0.86)
DS5	To what extent do you feel personally responsible for the correctness of the group solution?	(0.57)
		Cronbach's alpha: 0.73
Decision Quality		
DQ1	The overall quality of the discussion was good.	(0.84)
DQ2	The outcome of the discussion was satisfactory.	(0.76)
DQ3	The issues explored in the discussion were substantial.	(0.71)
DQ4	The manner in which team members examine the issues was constructive.	(0.66)
DQ5	The movement of team members toward the conclusion was significant.	(0.79)
		Cronbach's alpha: 0.80

conditions. (See Table II.) The experimenter described the nature and scope of the experiment. Participants then signed consent forms. Based on Chidambaram and our own pilot study, the

maximum time allowed for each meeting was 100 minutes [62]. All teams in the four treatments went through the following steps, adapted from Chidambaram [62].

(a) The first step took up to 60 minutes. Teams assigned to treatments with the dialogue technique were asked to have their dialogue session to develop their own team's effective communication ground rules. Teams assigned to a treatment without the dialogue technique were asked to have a warm-up exercise with team members discussing their experience with the most popular Chinese online-chatting software, QQ, and any other non-task-related discussion to match the time spent for each type of team [63].
(b) The second step took up to 40 minutes. All teams, both face-to-face and video-conferencing, were asked to work on the van management task. They generated decision alternatives, discussed their decision alternatives, and chose their preferred alternative through a ranking process.
(c) Team members individually completed a post-meeting questionnaire to capture their personal information: their media use experience, their perceptions of the media richness, and their perceptions of the team relational development and meeting outcomes. They then attended a short post-meeting debriefing.

If the teams had not completed the session after 50 minutes for step (a) or 30 minutes for step (b), they were given a warning to indicate that they should complete their session within the next 10 minutes.

RESULTS

Manipulation Check of Communication Media Richness Two communication media are used in this study to manipulate media richness in terms of social context cues. We used the perceived media richness scale developed by D'Ambra and Rice for a pre-experiment manipulation check on media richness. (See Table IV for instrument items [64].) We found significant differences in terms of media richness. Face-to-face interaction (mean $= 6.25, SD = 0.72$) was perceived to be significantly richer than the video-conferencing system (mean $= 5.32, SD = 1.10$). A t-test confirmed the significance of this difference ($t_{118} = 5.45, p < 0.001$) and provided the evidence of successful manipulation of media in terms of richness. So, the planned comparison could be made.

TABLE IV
QUESTIONS MEASURING MEDIA RICHNESS

1a	If communicators are unclear about something or do not understand it, **FTF** allows them to ask questions and obtain answers as they arise.
1b	**FTF** allows communicators to add meaning to what they want to say by using as many cues (body language, voice, tone, etc.) as possible.
1c	**FTF** allows communicators to be flexible with the way words are used in order to increase understanding.
1d	If communicators feel very strongly about something (positively or negatively), **FTF** allows them to show their feelings.
2a	If communicators are unclear about something or do not understand it, **VC** allows them to ask questions and obtain answers as they arise.
2b	**VC** allows communicators to add meaning to what they want to say by using as many cues (body language, voice, tone, etc.) as possible.
2c	**VC** allows communicators to be flexible with the way words are used in order to increase understanding.
2d	If communicators feel very strongly about something (positively or negatively), **VC** allows them to show their feelings.

Note: All items were on a scale of 1 (strongly disagree) to 7 (strongly agree).

Hypotheses Testing Table V summarizes the descriptive statistics for all dependent variables. To test the hypotheses, a MANOVA test was conducted to determine whether there were significant differences between team means for all dependent variables across the different techniques and media. The results of the MANOVA demonstrate significant main effects due to the dialogue technique (Wilks's Lambda $F = 11.66, p < 0.001$) and medium (Wilks's Lambda $F = 14.67, p < 0.001$), while no significant effects were revealed when considering medium by dialogue technique interaction. The results are shown in Table VI. With these significant results, we performed separate t-tests for all dependent variables to test our hypotheses.

H1, H2, H3, H4, and H5 predicted the effect of the dialogue technique framework on virtual team relational development and meeting outcomes. Virtual teams that used the dialogue technique were expected to have higher perceptions of team cohesion and meeting outcomes than virtual teams that did not use the dialogue technique.

TABLE V
DESCRIPTIVE STATISTICS FOR THE DEPENDENT VARIABLES

Communication Medium	Framework	Team Cohesion (TC)		Communication Satisfaction (CS)		Decision Process Satisfaction (DPS)		Decision Satisfaction (DS)		Decision Quality (DQ)	
		Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
FTF	With DT	6.29	0.18	6.21	0.21	6.40	0.13	6.13	0.13	6.25	0.12
	Without DT	6.01	0.22	5.98	0.19	6.12	0.40	5.90	0.30	5.95	0.24
VC	With DT	5.99	0.22	5.95	0.23	6.16	0.33	5.95	0.23	5.89	0.37
	Without DT	5.46	0.20	5.59	0.19	5.63	0.40	5.73	0.42	5.62	0.28

TABLE VI
RESULTS OF MANOVA TESTS FOR DEPENDENT VARIABLES

	TC *F*-value	CS *F*-value	DPS *F*-value	DS *F*-value	DQ *F*-value
Framework (with/ without DT)	36.91***	20.18***	14.77***	6.20*	10.93**
Communication Medium	41.91***	25.60***	11.63***	3.74	16.01***
Framework x CM	3.81	1.04	1.48	0.01	0.02

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

TABLE VII
T-TEST RESULTS FOR HYPOTHESES 1 TO 5

Hypotheses (VC with DT better than VC without DT)	H1: TC	H2: CS	H3: DPS	H4: DS	H5: DQ
t-value	5.57***	3.78***	3.27**	1.45	1.83
Supported	Yes	Yes	Yes	No	No

***$p < 0.001$

TABLE VIII
T-TEST RESULTS FOR HYPOTHESES 6 TO 10

Hypotheses (VC with DT equal to FTF without DT)	H6: TC	H7: CS	H8: DPS	H9: DS	H10: DQ
t-value	-0.26	-0.40	0.28	0.43	-0.42
Supported	Yes	Yes	Yes	Yes	Yes

Table VII provides t-test results. This prediction was supported for team cohesion ($t = 5.57, p < 0.001$), communication satisfaction ($t = 3.78, p < 0.001$), and decision-process satisfaction ($t = 3.27, p < 0.01$). Thus, H1, H2, and H3 were supported, while H4 and H5 were rejected.

H6, H7, H8, H9, and H10 predicted that after virtual team members built up a common understanding for effective media use, video-conferencing could be used as effectively as traditional face-to-face interaction. This interaction effect was examined by comparing video-conferencing teams that employed the dialogue technique framework and face-to-face teams that did not employ the dialogue technique framework (A and D in Table II). Table VIII shows the t-test analysis results. No significant differences were found between these two types of teams across all dependent variables, leading to the support of H6 to H10.

This study also revealed some significant effects that were not hypothesized. First, the adopted dialogue technique was found to be useful for face-to-face teams as well. The significant framework effect was found for face-to-face team cohesion ($t = 2.98, p < 0.01$), communication satisfaction ($t = 2.54, p < 0.05$), decision-process satisfaction ($t = 2.07, p < 0.05$), decision satisfaction ($t = 2.27, p < 0.05$), and decision quality ($t = 3.46, p < 0.01$). Second, after building a shared common understanding of effective communication, both face-to-face and video-conferencing teams improved their perceptions of team relational

development and meeting outcomes, resulting in better perceptions of face-to-face teams than video-conferencing teams in terms of team cohesion ($t = 3.24, p < 0.01$), team communication satisfaction ($t = 2.68, p < 0.05$), team decision-process satisfaction ($t = 2.11, p < 0.05$), team decision satisfaction ($t = 2.25, p < 0.05$), and team decision quality ($t = 2.86, p < 0.01$).

Discussion and Implications

This research yields three useful findings. First, this study confirmed the effect of the adopted dialogue technique to improve virtual team cohesion, team communication satisfaction, and team decision-process satisfaction. Second, video-conferencing virtual teams with the dialogue technique framework embedded could be engaged as well as traditional face-to-face teams (teams without the framework embedded). Third, the dialogue technique was found to be useful for face-to-face teams for building shared understanding. This better support for face-to-face teams has improved team relational development and meeting outcomes, outperforming video-conferencing teams that also used the dialogue technique.

Face-to-face interaction has always been considered the most effective medium for teams to resolve equivocal problems. Compared to CMC media, face-to-face is able to support the highest level of interactive activities by providing continuous feedback during the interaction, using various social cues and body language, and enabling unpredictable and spontaneous remarks. This study has demonstrated that this impact continued to exist even though teams built up a common understanding before they worked on their tasks. So, if both face-to-face and video-conferencing teams all have a chance to build shared common understanding before they work together as a team, face-to-face interaction may still outperform video-conferencing teams.

However, if it is not feasible for teams to meet face-to-face to conduct projects, they can still be as effective as face-to-face teams as long as they can share their values of effective communication and their frame of reference, and reach a consensus of team interaction ground rules. Just like the brainstorming tool that has been considered an inherent part of a computer-mediated technology, the adopted framework in this study can be considered as an integral part of a virtual team. There has been some argument about whether video-conferencing offers an effective alternative or supplement for face-to-face communication [65]–[67]. In this respect, this study has demonstrated that after employing the dialogue technique to a virtual team, the team members may be able to improve their team meeting outcomes using video-conferencing to a level approaching face-to-face interaction.

This study found that the adopted dialogue technique had a better impact on face-to-face teams than video-conferencing teams in terms of team meeting outcomes. In other words, face-to-face interaction teams found it easier to build team mental models for further interactions. This finding confirmed the speculation that it is easier for co-located teams to build mental models than distributed teams since the social contextual cues required for team mental model development can be more easily achieved when they are psychologically closer [29]. Without that contextual input, team members might have problems evaluating each other's level of attention and concentration, determining how positive or negative others were feeling, determining whether others needed help, and knowing when to interrupt [10]. Due to the physical separation of team members, the social presence of virtual teams has been lessened, compared with face-to-face interaction. One important feature of co-location that is missing in virtual teamwork is awareness of the state of one's coworkers, both their presence–absence and their mental state. Both awareness and more general familiarity make communication easier [29].

Several limitations and opportunities for future research are noteworthy. First, the data for this research are cross-sectional rather than longitudinal. McGrath has noted, "[g]roups develop and exist in a temporal context" [68, p. 23]. Chidambaram found that virtual teams mediated through computer technologies can improve their relational development and meeting outcomes over time [42]. Previous studies examining the impact of the dialogue technique on virtual teams in an asynchronous environment have found that the impact due to time and the impact due to the dialogue technique are additive [6], [7]. Even though the results of this study have indicated that the dialogue technique appears to give teams a head start, a longitudinal research design examining the impact of the dialogue technique and time on team relational development and meeting outcomes when teams interact through different technologies would further our knowledge. We could better understand how the amount of time that teams

have spent working together moderates the role of the dialogue technique in team development process and meeting outcomes in face-to-face and video-conferencing communication environments.

Second, data were collected in a Chinese cultural context. In other words, the teams we used were Chinese-only teams. Empirical studies have demonstrated the moderating role of culture on the technology used in virtual teams [56], [69]. Further, in their cross-cultural study, Zhang et al. found that the majority influence, which may result in poor group decisions and unfavorable outcomes, was manifested more strongly on Chinese minorities in heterogeneous teams than in homogeneous Chinese teams in a distributed CMC setting [70]. In this study, we only examined the impact of the dialogue technique with Chinese virtual team members who are characterized with collectivistic values. It is unknown how virtual teams may employ the technology (i.e., video-conferencing systems) and the technique (i.e., the dialogue technique) when these communication technologies and the technique go against the grain of the culture of team members [7]. Caution should be taken when generalizing the conclusion about this study's findings to other cultural settings, such as homogeneous virtual teams from an individualistic culture, or culturally heterogeneous virtual teams from both individualistic and collectivistic cultures.

The third limitation is the use of students as subjects. Students have less experience in working with teams and solving complex organizational problems than virtual teams in real organizations. Nevertheless, this study does demonstrate that the dialogue technique may be a useful tool for virtual teams to become effective quickly upon the formation of the team.

Limitations discussed above notwithstanding, the findings from the present study firmly establish the need to incorporate the shared mental models into theories of virtual teams. Computer-mediated virtual teams can improve their team relational process and meeting outcomes if they can build team mental models of effective communication. In particular, this study found that the shared mental models might bring virtual teams interacting via synchronous technology closer to the traditional face-to-face teams. Travel is costly. The adopted dialogue technique in this study may help virtual teams communicating via video-conferencing function as effectively as traditional face-to-face teams, leading to both reduction in transportation costs and a commensurate improvement in the time taken for team deliberations.

This study was conducted in the Chinese cultural context, a collectivistic culture that values consensus. However, as distances are spanned, cultural differences emerge. Many organizational virtual teams probably consist of members from different countries, forming a global virtual team. Since mental models are shaped by cultural background to a great extent [7], [71], global virtual teams with different cultural values make mental model development difficult [72]. How the adopted dialogue technique can assist global virtual teams to establish shared understanding among team members remains unknown. Thus, further research is needed to test how the adopted dialogue technique might help teams working in the virtual environment best manage these cultural differences as they develop and reinforce their team mental models [7], [72].

With the rapid uptake of video-conferencing usage within organizations, a better understanding of how to use video-conferencing for virtual teams' effective communication is crucial. The dialogue technique adopted in this study may be a useful framework for helping virtual teams achieve improved team meeting outcomes. Furthermore, due to the better meeting outcomes of face-to-face over video-conferencing, as found in this study, a mixed mode of interaction that temporally sequences face-to-face and computer-mediated communication may be a better solution for virtual teams' communication since team relational development is an important factor for a team's success, and face-to-face communication appears to facilitate relational development [73].

CONCLUSION

This study examined the impact of the dialogue technique on computer-mediated communication by comparing teams working face-to-face and teams interacting via a video-conferencing system. Results from the study show that the adopted dialogue technique can help teams develop their relationship and achieve improved team meeting outcomes. Furthermore, this technique can be useful for both traditional face-to-face teams and virtual teams that communicate via video-conferencing systems. Results also show that virtual teams with a shared understanding can obtain improved team meeting outcomes, approaching the level of traditional face-to-face teams.

With the rapid development of communication technologies, combined with flatter organizational structures and geographically dispersed organizational sites, virtual teams are increasingly used to accomplish complex organizational work. Organizational managers must not only be cognizant of the inherent difficulties associated with geographically distributed teams, but must be informed about how to reduce these drawbacks. Computer-mediated video-conferencing systems can be a supplement for face-to-face interaction by providing shared knowledge among team members. The dialogue technique adopted in this study may be used to increase productivity of virtual teams who need to work together but may be separated geographically.

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