Journal of Management Information Systems

ISSN: 0742-1222 (Print) 1557-928X (Online) Journal homepage: http://www.tandfonline.com/loi/mmis20

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**To cite this article:** Paul Benjamin Lowry , Nicholas C. Romano , Jeffrey L. Jenkins & Randy W. Guthrie (2009) The CMC Interactivity Model: How Interactivity Enhances Communication Quality and Process Satisfaction in Lean-Media Groups, Journal of Management Information Systems, 26:1, 155-196

**To link to this article:** http://dx.doi.org/10.2753/MIS0742-1222260107

Published online: 08 Dec 2014.

# The CMC Interactivity Model: How Interactivity Enhances Communication Quality and Process Satisfaction in Lean-Media Groups

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*Journal of Management Information Systems* / Summer 2009, Vol. 26, No. 1, pp. 155–195.

0742–1222 / 2009 $9.50 + 0.00.
DOI 10.2753/MIS0742-1222260107

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Abstract: Process satisfaction is one important determinant of work group collaborative system adoption, continuance, and performance. We explicate the computer-mediated communication (CMC) interactivity model (CMCIM) to explain and predict how interactivity enhances communication quality that results in increased process satisfaction in CMC-supported work groups. We operationalize this model in the challenging context of very large groups using extremely lean CMC. We tested it with a rigorous field experiment and analyzed the results with the latest structural equation modeling techniques. Interactivity and communication quality dramatically improved for very large groups using highly lean CMC (audience response systems) over face-to-face groups. Moreover, CMC groups had fewer negative status effects and higher process satisfaction than face-to-face groups. The practical applications of lean CMC rival theoretical applications in importance because lean CMC is relatively inexpensive and requires minimal training and support compared to other media. The results may aid large global work group continuance, satisfaction, and performance in systems, product and strategy development, and other processes in which status effects and communication issues regularly have negative influences on outcomes.

Key words and phrases: audience response systems, CMC interactivity model (CMCIM), collaboration, human–computer interaction (HCI), interactivity, large groups, ultra-lean interactive media, ultra-lean interactivity.

The phenomenon of interest in this study is process satisfaction (PS) as a subset of general satisfaction. Marketing research has long noted the importance satisfaction plays in customer adoption and repurchase (e.g., [95, 96]). Research in e-commerce has shown that satisfaction is just as—if not more—critical for long-term growth and profitability in electronic markets [9, 69]. In information systems (IS) research, satisfaction and related affect have been shown to play a strong role in system adoption and, more importantly, in system continuance [9, 12, 58, 84, 85]. Wixom and Todd [115] integrated satisfaction and the technology acceptance model (TAM) theory to show that information satisfaction—driven by information quality—can positively affect perceived usefulness and that system satisfaction—driven by system quality—can positively affect perceived ease of use. Liao et al. [57] extended the theory of planned behavior (TPB) and found that satisfaction was the primary determinant of one's intention to continue using an e-service. This brief review of IS, marketing, and e-commerce theory reveals the impact satisfaction has on both adoption and continuance.

In particular, PS is an important determinant of work group success. Group and PS largely determine team performance and are critical to establish commitment to, and confidence in, team decisions [72]. PS facilitates team acceptance of decisions and technologies that will benefit the group; conversely, dissatisfaction often inhibits team acceptance and results in team rejection of decisions and technologies, regardless of the potential benefits to the group [84]. Satisfaction is a significant determinant of meeting success [84] and group collaboration success [1]. In contrast, lack of satisfaction leads to dysfunctional teams, whether face-to-face or virtual, and to a lack of organizational commitment [41, 66].

Given the significance of PS in IS and work group success, we address the research question "How can IS promote PS in work groups?" Specifically, we study the theoretical foundations of PS in computer-mediated communication (CMC)–supported groups, which is a seldom-studied area, even though satisfaction has been studied in many CMC contexts [37]. Most research involving CMC PS has focused on a team's decision-making or meeting process with a tool (e.g., [84, 85]), the effects of work modality or work team proximity (e.g., [7, 47, 93]), or specific system features that affect satisfaction (e.g., [6, 46]). These important studies have helped improve our understanding of PS in CMC groups; however, they do not provide an overarching extant theory of how PS is derived independent of a particular tool.

Our objective is to theoretically explain how CMC technologies can improve perceived interactivity, communication quality (CQ), and PS in groups—operationalizing to the specific case of very large groups using highly lean CMC. We operationalize our model in the specific context of large CMC-supported groups because they are increasingly used in system development [2, 62]. Unfortunately, large groups are more prone to communication breakdowns and interaction process losses that undermine results and group "continuance" (the desire of group members to continue to work together) than small groups. Limitations in human attention, communication bandwidth, and cognition often negatively affect large-group stability, efficiency, and productivity [3, 97]. In addition, individual participation is frequently more limited in large groups than in small groups. Members of large groups are more likely to fall victim to evaluation apprehension, social loafing, and production blocking than members of small groups (e.g., [39, 97]). Our research investigates how PS can minimize these problems.

The benefits of highly lean CMC technologies in large groups have received little attention in the literature but show promise. For example, in proposing a theory on compensatory adaptation, Kock [53] found that "lean" electronic communication media, compared to face-to-face interaction, may have a positive effect on knowledge sharing, outcome quality, and group success. However, Kock's findings were limited to groups of 7 to 15 members and did not differentiate between lean and rich electronic media. His findings also do not suggest attributes of electronic media that create group success. Later, Kock [54] found that lean electronic communication media may cause communication fluency burdens when compared to face-to-face communication, although his study did not address how different levels of electronic communication interactivity influence communication fluency. The biggest limitation of Kock's compensatory adaptation theory [53, 54] is that it posits that lean media may result in *paradoxical* increases in team performance outcomes due to members compensating—often *involuntarily*—for obstacles posed by lean electronic media. While this is a useful start, such built-in limitations undermine the explanatory power of the theory.

Other studies have shown that CMC technologies influence team cognition, reduce social cues, generate more alternative solutions, and allow equal participation [24]. However, these studies tend to focus only on small groups. Finally, Nobel Prize laureate Carl Edwin Wieman is championing the use of "clickers," an ultra-lean CMC technology, in education because of their promise of transforming interaction and engagement in the classroom [22], as preliminarily suggested in a few studies [4, 22, 111]. The limitations of this research include a lack of theoretical grounding and a lack of applicability to business and organizational settings.

If it is true that lean CMC technologies can positively influence perceived interactivity and CQ in large groups, then CMC technologies are also likely to positively influence PS in large groups. Interactivity has been shown to build shared interpretive contexts among group members [118], improve CQ for business Web sites, improve customer satisfaction [19, 36], and improve communication processes and outcomes (e.g., credibility, attractiveness, influence, and decision quality) [15]. Interactivity is also a fundamental part of communication in successful teamwork, particularly in lean management models [36]. CQ leads to partnership success [74] and trust between communication partners [117]. The quality of communication during the design of an IS determines its success [26]. CQ also affects group acceptance of human resources and managerial innovation [89].

In this paper, we propose a theoretical model to explain how CMC technologies may benefit groups by increasing PS through perceived interactivity and CQ. We rigorously test this model in what we believe is the most challenging CMC environment: large groups using extremely lean CMC technologies. We chose this environment not simply because it is a promising area that is underresearched but also because we are working from the assumption that, if our theory holds under extreme conditions, it will hold in conditions of smaller groups and with richer CMC media.

## Proposing the CMC Interactivity Model (CMCIM)

The primary purpose of this paper is to propose a new theoretical model—the CMC interactivity model (CMCIM)—which can be used to explain and predict how the combination of interactivity and CQ increases PS in interacting CMC groups. A key contextual assumption of this model is that CMC technologies generally provide for more lean communication interactivity than face-to-face technologies. Here, we briefly summarize the theoretical grounding and propositions of CMCIM, and then we support our definitions and propositions in detail in the remainder of this section.

Our research is theoretically grounded in interpersonal interactivity theory and literature—particularly the theoretical basis for interactivity itself, the *direction of*

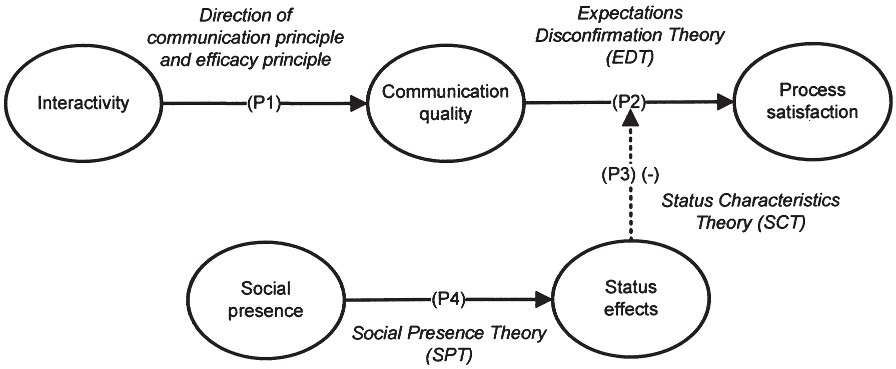


*Figure 1.* CMC Interactivity Model (CMCIM)

*communication* principle and the *efficacy* principle. These theoretical principles lead us to propose that interactivity increases CQ (P1). We then use the expectations disconfirmation theory (EDT) to explain how increased CQ increases PS in groups (P2). Our model further recognizes that group processes can suffer from negative status effects, which undermine the relationship between CQ and PS. Thus, we use social presence theory to propose that increased social presence in a group increases status effects (P4), and then we use status characteristics theory to explain how these negative status effects adversely moderate the relationship between CQ and PS. While there are many potential forms of process losses in groups, CMCIM focuses on status effects because CMC technologies typically employ lean communication richness that can diminish status effects, while still providing the necessary interactivity to induce sufficient CQ to provide PS. Figure 1 summarizes CMCIM.

## Basic Scope and Conceptualization of Interactivity

The driving independent construct of CMCIM is interactivity; thus, we start by providing a theory-based conceptualization of interactivity. Interactivity is a particularly difficult construct to define because it has different meanings in different contexts, and thus is generally poorly understood [15, 19, 49, 59]. Some of the areas in which interactivity has been addressed include mass media, communication and interpersonal communication, marketing, advertising, electronic marketplaces, mobile commerce, CMC, education, and Web sites and the Internet [15, 16, 19, 43, 49, 56, 59, 60, 92, 100, 101, 118]. Even though several typologies of interactivity have been created, little work has been done to theorize the causes and effects of interactivity. We believe this deficiency is due to the lack of a common definition of interactivity, which makes it difficult to build the cumulative tradition necessary for substantive theory building.

One reason for confusion and disparate interactivity research findings is that interactivity has been conceptualized on three different levels, and authors typically do not differentiate between these levels. The literature distinguishes the three levels of interactivity as a *feature* of technology, as a *process* of message exchange, or as something that a user *perceives* after using a technology or going through a process [71]. We have not reviewed any empirical studies that combine all three perspectives; however, several authors and articles have mixed all three or at least two of these perspectives (e.g., [15, 16, 71]). We assert that all three are valid perspectives, are not mutually exclusive, and simply represent lenses from which one can study interactivity. For example, a feature of a technology can lead someone to perceive that the technology is interactive. Conversely, interactive features of a technology may not always lead to perceived interactivity [94]: users may perceive a highly interactive feature as annoying rather than interactive, or they may not use the feature. We focus on features of a technology that can lead to *perceived interactivity.* Perceived interactivity is a meaningful construct because it accounts for only those features of a technology that actually lead to an increase in users' perceptions of interactivity.

In addition to the three levels of interactivity, three major contexts of interactivity are discussed in the literature: (1) *interpersonal,* which refers to two-way and reciprocal communication between humans [8, 82, 101, 114]; (2) *computer-mediated communication,* in which computers mediate interpersonal communication (e.g., [15, 16]); and (3) *mass media,* which comprises one-way broadcasting and media interactions between people and Web sites (e.g., [101]). We disregard noninterpersonal interactivity, such as interactions between two computers, because it is outside of our social communication scope. We also do not address the process of CMC interactivity but instead address technological features that should give rise to interactivity perceptions. Given this focus, we carefully examined perceived interactivity literature that involves CMC, which led us to define three key subconstructs of interactivity, as similarly conceptualized by Liu [59]—two-way communication, control, and synchronicity.

## Grounding Interactivity in Interpersonal Communication Theory

We theoretically ground perceived CMC interactivity subconstructs in interpersonal interactivity theory and literature, because CMC interactivity is a specialized form of interpersonal interactivity. Perceived interactivity was originally based on the concept of *communication efficacy,* or users' beliefs of control and the recipient's ability to process and act on a message [94]. In a CMC-supported work group context, the CMC technology will likely influence the user's perception of control and the recipient's ability to process and act on the message, as the CMC technology transmits and presents the message to the recipient. Therefore, we include *efficacy* as a theoretical basis to define CMC interactivity. Furthermore, building on the organizational communication model and the interpersonal communication model, past research has included *direction of communication* as an additional theoretical basis for interactivity [94]. This theory relates to the communication channel's ability to facilitate two-way communication [94]. Because CMC technologies facilitate two-way communication, we also include *direction of communication* as a theoretical basis to characterize CMC interactivity.

Both the direction of communication and efficacy principles are necessary theoretical components for CMC interactivity. The direction of communication implies that an essential component of human-to-human interpersonal interaction is the participation of two or more parties in a communication exchange as senders and receivers and vice versa [49, 52, 71]. Although necessary, the mere implementation of the direction of communication principle alone is not sufficient for effective communication to take place. Communication efficacy is also required, and without fulfillment of the direction of communication principle and communication efficacy, effective communication cannot occur [75, 94].

*Communication efficacy* is a second-order construct comprising externally based efficacy and internally based efficacy. *Externally based efficacy* refers to the receiver's ability to process the sender's message as useful input and then to act on or respond to it [94]. This message-response process is referred to as *reciprocity* in a great deal of literature [49]. Notably, a communication exchange may occur through verbal or written words, facial expressions, or kinesics [120]. Thus, the more a receiver is able to process various communication forms, the more externally based efficacy can be supported. *Internally based efficacy* is one's personal sense of communication efficacy, or one's perception of control over where one is and where one is are going in communication [75, 94].

Using the direction of communication and efficacy principles, we now explain why we include two-way communication, control, and synchronicity as theoretical subconstructs of perceived interactivity and how it then acts to facilitate effective communication.

*Two-way communication* allows one or more senders and one or more receivers to communicate with each other [15, 16, 59] and to engage in reciprocal communication that is responsive to the communicating parties' needs [43, 71, 81]. Two-way communication captures both the ideas of communication (direction of communication) and reciprocity (externally based efficacy) and thus is an important subconstruct of interactivity. Hence, two-way communication is necessary for effective communication.

*Control* is a subconstruct of interactivity that denotes influence over the communication experience, emphasizing individual choice and lack of obligation in the interaction [43], including the abilities to interrupt and to be spontaneous and unpredictable [118]. Perceived control thus directly relates to the internally based efficacy principle. Recall that internally based efficacy is the user's perception of control over where he or she is and where he or she is going [94]. Some researchers describe interactivity in a communication system as a function of control that users can exercise over the system environment [116]. In CMC contexts, one example of such control is that users can choose to submit text anonymously [19, 50]. Thus, control is necessary for effective communication.

*Synchronicity* is "the degree to which users' input into a communication and the response they receive from the communication are simultaneous" [60, p. 55]. High perceived interactivity is contingent upon the continuity of communication or synchronicity. If synchronicity is low (e.g., there are delays in communication), the communication flow will be hindered [116] and users will be more likely to devote their attention—which is critical to establishing high perceived interactivity—elsewhere. Synchronicity thus supports effective communication by acting as a support for two-way communication (supporting the direction of communication principle and externally based efficacy) and control (supporting the internally based efficacy principle).

Combining the three subconstructs of interactivity, we adopt the definition that *interpersonal interactivity* is two-way interpersonal "communication that offers individuals active control and allows them to communicate both reciprocally and synchronously" [59, p. 208]. Notably, effective establishment of interpersonal interactivity supports the implementation of the direction of communication principle and communication efficacy, both of which are requisite for effective communication. *CMC interactivity* is interpersonal interactivity in the context of CMC. In summary, Liu [59] leads us to infer three postulates upon which we will build propositions—two-way communication, control, and synchronicity all lead to increased CMC interactivity.

## Impact of CMC Interactivity on Communication Quality

In this section, we extend our model to assert that CMC interactivity will increase CQ. We further explain our prediction of the effects of CMC interactivity on CQ through the *interactional view* of communication (e.g., [110]). A key axiom we borrow from this theoretical perspective is that one alone *cannot* communicate. In other words, all communication symbols (e.g., spoken, written, silence, analogical codes, relationship and environmental factors, etc.) are interpreted by others with whom one interacts, whether the interaction is intentional or unintentional. Originally, this axiom was assumed to be valid only if communicating parties were in the physical presence of one another. However, we propose that CMC allows an extension of virtual presence. In our context, CMC interactivity is a communication symbol that is interpreted by both the sender and receiver during a CMC communication exchange. This is consistent with prior research that explains how the properties of the medium used to transfer a message are interpreted by communication partners [94].

A closer comparison of the efficacy and direction of communication principles with the subconstructs of CQ explains how CMC interactivity will act as a communication symbol during an interaction and enhance CQ. We define CQ in the terms of communication openness, discussion efficiency, and discussion effectiveness. CMC-supported interactions that exhibit high internal efficacy will likely increase communication openness between group members: members are more likely to be open in communication when they feel they have control in the communication. High external efficacy will improve the message sender's perception of the recipient's ability to process and act on the message, thereby creating more effective and efficient discussions. Likewise, direction of communication will likely enhance CQ in terms of communication openness, discussion efficiency, and discussion effectiveness as users are more likely to productively participate in discussions if they believe the CMC technology is capable of facilitating communication between the senders and receivers and vice versa.

Thus, CMC interactivity produces a form of interpersonal communication, and communication signals sent via CMC technologies will be interpreted by the parties involved. However, in a CMC context, interactivity acts as a communication symbol only if parties are in the virtual presence of each other (i.e., the CMC technology is running and participants are able to access it to communicate).

A wealth of literature supports the notion that CMC interactivity can enhance interpersonal communication. For example, CMC interactivity can send multiple verbal and nonverbal communication cues [15, 16, 118]. Multiple cues not only increase the quality of communication but also create a heightened sense of interpersonal connectedness [43, 81], which in turn improves interaction and openness within a group. A high-quality group discussion involves multiple perspectives that provide more openness [15, 16]. Hence, increased CMC interactivity should directly increase CQ (P1).

## Impact of Communication Quality on Process Satisfaction

In this section, we extend our model to propose that higher CQ increases PS using the foundation of expectations disconfirmation theory. Spreng et al. [96] define s*atisfaction* as an affective state resulting from an emotional reaction to a product or service. *PS* is a subset of overall satisfaction and can be defined as the degree to which group members are happy with the way (e.g., procedures, deliberations) they arrived at an outcome [84, 103]. Although PS can be conceptualized on many levels—such as on an information level or a system level [69]—here we focus solely on PS related to interaction and communication between group members.

Currently, the yield shift theory [12] provides the most comprehensive theoretical model to explain the major satisfaction effects, which were previously explainable only through a combination of several independent models. The theory explains that satisfaction is a result of a shift in the utility people ascribe to their goals (the goal produces higher utility than expected), a shift in the likelihood people ascribe to their goals (goal attainment was less than likely but the goal was attained), or a change in the goals that comprise the goal set [12]. In our study, we are specifically interested in how CQ affects PS through the disconfirmation effect.

The disconfirmation effect is similarly explained by EDT, a popular satisfaction theory from marketing. Although EDT is not as inclusive as the yield shift theory, it has been empirically tested and provides additional insights into the disconfirmation effect. Therefore, we build on EDT (e.g., [96]) as modified in an IS context by Bhattacherjee [9], Liao et al. [57], and McKinney et al. [69].[1] Traditional EDT distinguishes between disconfirmation caused by expectations and disconfirmation caused by desires. Both Liao et al. [57] and McKinney et al. [69] simplify traditional EDT by referring to *expectations* alone.[2] The basic idea of this model is that people have an expectation about an experience, engage in the experience, assess the experience based on their initial expectations, and feel satisfaction to the extent that their expectations are positively or negatively disconfirmed. This satisfaction then drives other behaviors, such as consumer repurchase, system adoption, and repeat Web site visits.

Since PS is a subset of satisfaction, EDT should also apply to the development of PS. In fact, EDT-based models relating to system adoption and continuance developed by Bhattacherjee [9], Liao et al. [57], and McKinney et al. [69] conceptualize satisfaction as process evaluation, not outcome evaluation, and thus predict PS, not outcome

Table 1. Potential Outcomes in Our Application of EDT

| | Expectations < perceived performance | Expectations = perceived performance | Expectations > perceived performance |
|---|---|---|---|
| Perceived performance was not desired | Negative disconfirmation (decreased PS) | Negative confirmation (decreased PS, but not as much as negative disconfirmation) | Positive disconfirmation (increased PS) |
| Perceived performance was desired | Positive disconfirmation (increased PS) | Positive confirmation (increased PS, but not as much as positive disconfirmation) | Negative disconfirmation (decreased PS) |

satisfaction. We do the same here. This is an important distinction because people can be satisfied with an outcome while being entirely dissatisfied with the process or the system that led to that outcome. Thus, PS more strongly determines process and system adoption [85].

*Perceived performance* is a person's perception of how an experience fulfilled his or her expectations [69]. A *confirmation* occurs when a person's evaluation of an experience is the same as his or her preexperience expectations. *Disconfirmation* results when the outcome of an experience differs from a person's preexperience evaluation, and it can be either positive or negative. *Positive disconfirmation* is overperformance, leading to increased PS, while *negative disconfirmation* is underperformance, leading to decreased PS. Table 1 summarizes the potential PS outcomes from EDT.

We now extend EDT to explain how expectations of CQ in CMC interactivity affect PS. Based on our literature review, we define *CQ* in terms of three dimensions—communication openness, discussion efficiency, and task-discussion effectiveness. *Communication openness* is the receptiveness of a group member to the communication of others [64, 77, 87]. One who is open to experience evaluates threats more accurately and tolerates change more maturely than someone who is more closed to experience. In an open environment, people are more able to explore their own ideas, the group's perceptions of their ideas, and the ideas of others in the group [64]. *Discussion efficiency* [25] reflects how results-oriented group members are, how effectively they spend time on interactions, how meaningful their interactions are, and how thoroughly they discuss issues. *Task discussion effectiveness* reflects the degree to which group members participate in the discussion, develop discussion content, exchange information, and examine issues and ideas effectively and critically [42, 63].

We rely on the assumption that group members expect CQ in terms of communication openness, discussion efficiency, and task-discussion effectiveness. Therefore, the level of PS will be a function of the degree to which users' expectations of CQ are positively disconfirmed in a CMC context. Interactivity is grounded in interpersonal communication [15, 49], so people will naturally judge CMC interactivity against interpersonal communication. This assumption also concurs with the notion that "human communication processes and outcomes vary systematically with the degree of interactivity that is afforded and/or experienced" [15, p. 34]. Furthermore, a host of CMC interactivity literature asserts the importance of CMC interactivity resembling interpersonal communication [16, 43, 81, 118].

However, the media used will temper expectations. For example, many people would have lower expectations for a CMC interaction that involves asynchronous e-mail because they know that this is a socially lean form of communication. Conversely, they would likely have higher expectations for a CMC interaction involving synchronous chat with a parallel video feed. Therefore, higher CQ (from more CMC interactivity) than expected will result in higher satisfaction, whereas lower CQ than expected will result in lower satisfaction. Hence, we propose that increased CQ will increase PS with the interaction process (P2).

## Impact of Status Effects on CMC Interactivity Satisfaction

### General Impact of Status Effects

Group effects due to differences in social status are called *status effects* [35]. S*tatus characteristics theory* posits that status differences are communicated through a variety of verbal and nonverbal cues that are not entirely voluntary [27]. Furthermore, it asserts that an individual's referents—people whose status is significantly different than the individual's—modify an individual's group interactions, and that status is transferred from one task to another. Considerable research on status effects attests to the power and subtlety of social cues in shaping the tone and content of a group's face-to-face communication patterns [35, 103, 104, 105, 113, 119]. Knotternus and Greenstein [51] extended the theory of expectation formation to status effects, finding that group members perceived the performance and interaction of others based on status stereotypes given from task information; this reinforcement exacerbated inequalities. Accordingly, status characteristics theory predicts that status effects negatively impact group interactions.

One common status effect is evaluation apprehension. *Evaluation apprehension* occurs when group members withhold ideas because they fear criticism from other group members (particularly their "referents") [30, 34]. Those who feel they cannot or do not want to communicate with group members do not feel the process is as open, fair, and satisfying as those who feel they can fully participate. Another common status effect is *conformance pressure,* which occurs when team members do not want to criticize or dissent from a group because of a desire to be polite or because of fear of retaliation or rejection [44]. Such pressure tends to increase in larger groups, especially when there are status differences [28]. In congruence with status characteristics theory, group members are most susceptible to conformance pressure with their "referents." A third common status effect is *first advocacy effect,* in which the group member with the highest status tends to speak first and has more influence than later advocates.

Status effects prevent members from fully contributing to a group, which negatively mediates the relationship between PS and CQ in terms of communication openness, discussion efficiency, and task-discussion effectiveness. For example, status effects promote less equal participation among group members, leading to lower generation of high-quality ideas and lower communication openness [106]. Status effects also lead to less objective and honest evaluation of ideas, which decreases decision quality and group performance [23], both of which relate to task-discussion effectiveness and discussion efficiency. Holingshead [48] found that groups experiencing status effects made poorer decisions and communicated less about critical information than groups with no status effects. Poor information exchange, interactions, and outcomes are likely to decrease PS to the degree to which a group member experiences negative status effects from a referent. Thus, we propose that status effects will be a negative moderator between CQ and PS (P3).



## General Impact of Socially Lean Media on Status Effects

Given P3, we now explain and predict how the degree of social presence affects status effects. *Social presence* is the degree to which a medium facilitates awareness of other people and interpersonal relationships [38]. Status characteristics theory explains that status differences are communicated through a variety of verbal and nonverbal cues. Thus, status differences are harder to communicate in media with fewer cues. Group members actively seek information that confirms status stereotypes [51]. If this information is removed through socially lean media, then it will be difficult to validate such stereotypes.

Our concept of socially lean media is a direct extension of social presence theory. Short et al. [90] first proposed the concept of *social presence* as the number and quality of communication channels available for transmitting verbal and nonverbal communication cues [64]. Biocca et al. later added that social presence provides a "sense of being with another" [10, p. 456]. In a CMC context, Lowry et al. provided a more precise definition that we adopt in our study:

> The degree to which a communication medium allows group members to perceive (sense) the actual presence of the communication participants and the consequent appreciation of an interpersonal relationship, despite the fact that they are located in different places, may operate at different times and that all communication is through digital channels. [64, p. 633]

Hence, the degree to which CMC is socially lean in providing verbal and nonverbal social cues should determine the degree to which status effects can be mitigated. Complete anonymity is the most extreme form of social leanness, and the majority of evidence suggests that anonymity can be highly beneficial to large groups. Anonymity can increase group members' motivation to participate [31] because it diminishes status effects [30]. For example, anonymity may alleviate conformance pressure by shielding a contributor from a group's reactions, thus providing lower status group members with more equality [28]. Dubrovsky et al.'s [35] work on CMC and status effects supports these claims. They found that CMC reduced social information, which reduced status effects. They also found that first advocacy effects were made more equal between high- and low-status participants. Tan et al.'s [104] studies in the United States and Singapore later showed that CMC's status-reduction effects apply to both individualistic and collectivistic cultures.

However, other research indicates that there are some exceptions. Weisband [112] found that anonymity social cues were increased (not reduced) if groups were aware of status differences going into an anonymous interaction. Likewise, Holingshead [48] found that mixed-status groups shared less information and made inferior decisions compared to non-mixed-status groups, regardless of whether they communicated face to face or through CMC. Hence, status effect reduction is likely effective with CMC only to the degree that group members are unaware of status differences prior to an interaction. Socially lean CMC media may reduce status effects, but it may negatively affect CQ. Given these caveats, we propose that the degree of social leanness in a communication media determines the degree to which status effects can be reduced; conversely, more social presence should cause more status effects (P4).



## Operationalizing CMCIM to Ultra-Lean Interactive Media

Again, to test CMCIM, we decided to use some of the most socially lean CMC media available, which we call ultra-lean interactive media (ULIM). Our basis for doing so is that if CMCIM holds for ultra-lean media, it is likely to hold for more interactive CMC as moderated by additional status effects.

ULIM is in the broad family of CMC technology that has a wide range of social presence. On the high end of social presence are group support systems (GSS) and groupware. *GSS* are interactive media with high social presence that support highly collaborative group processes, including decision making [76]. Similarly, *groupware* provides highly interactive media with high social presence; however, it does not provide advanced decision-making tools for the group. Although all of these technologies fit into the CMC family, traditional CMC involves media with less social presence, such as e-mail, instant messaging, hypertext/hypermedia, bulletin board systems, computerized conferencing, and chat.

We define ULIM as interactive group media that can facilitate group interactions but that have the lowest level of social presence—even lower than traditional CMC. Specifically, ULIM does not support full-text input, voice input, or distributed work. Table 2 summarizes social presence differences for these collaborative media. Several high-quality studies have focused on the richness and social presence of GSS, groupware, and CMC (e.g., [17, 29, 86, 91]). Despite the depth of this research, we are not aware of any theoretical applications to ULIM technologies. It is also important to note that as more handheld devices are created (e.g., iPod™, iPhone™, cell phones,

Table 2. Comparing Social Presence of Major CMC Technologies

| Comparison item | GSS | Groupware | Traditional CMC | ULIM |
|---|---|---|---|---|
| Example technologies | GroupSystems Think Tank, Central Desktop, Huddle | Lotus Notes, Groove, Collanos Workplace, Skype | e-mail, EIES, instant messaging, blogs, group wikis | CPS, e-instruction, iRespond, H-ITT |
| Social presence of media | Extremely high | Moderate to extremely high | Lean to moderately high | Ultra-lean social presence* |
| Quick feedback? | Yes | Yes | Possible (not typical) | Possible (not typical) |
| Multiple cues? | High | Moderate | Low | Very low (typically one) |
| Use of natural language? | Yes (voice and text) | Yes (voice and text) | Partial (typically just text) | No (no text, no voice) |
| Personal focus | Extremely high | Extremely high | Moderate | Low—group summary focus |
| Level of training needed | High | High | Low to moderate | Extremely low |
| Typical input devices | Keyboard, mouse, microphone, camera | Keyboard, mouse, microphone, camera | Keyboard, mouse, microphone, camera | Handheld wireless device only; proprietary* |
| Full text input capability? | Yes | Yes | Yes | No* |
| Audioconferencing? | Yes | Yes | No | No |
| Video conferencing? | Yes | Yes | No | No |
| Group awareness? | Yes; high | Yes; high | Yes; moderate | Partial* |
| Group memory; meeting notes? | Yes | Yes | Yes; not formalized | Partial* |

| | | | | |
|---|---|---|---|---|
| Parallelism? | Yes | Yes | Yes | Yes |
| Anonymity? | Yes; must choose | Yes; must choose | Yes; must choose | Yes; default* |
| Requires facilitated support? | Yes; unless using agents | No | No | Yes* |
| Face-to-face work support? | Yes (ideal condition) | Yes | No | Yes; only work mode* |
| Distributed work support? | Yes (not ideal) | Yes | Yes (ideal condition) | No (must be in same location)* |
| Supports communication to specific group members? | Yes | Yes | Yes | No* |
| Synchronous support? | Yes | Yes | Yes | Yes |
| Asynchronous support? | Yes | Yes | Yes | No* |
| Group outlining tools? | Yes | Partial | No | No |
| Brainstorming tools? | Yes | No | No | No |
| Voting tools? | Yes | No | No | Yes |
| Decision support tools? | Yes | Partial | No | Partial |
| Collaborative writing tools? | Yes | No | No | No |
| Collaborative modeling? | Yes | Partial | No | No |
| Customizable group processes? | Yes | Partial | No | No |
| Size of groups typically supported | 3 to 20 (more is possible but not ideal) | 3 to 20 (more is possible but not ideal) | 2 to several hundred | 7 to several hundred (small groups not ideal)* |

* Distinguishing feature of ULIM that is not found in GSS, groupware, or traditional CMC.

BlackBerry™, etc.), the likelihood increases that the same device can play the role of ULIM or of much more advanced social presence technologies.

For the ULIM in our context, we have chosen to use audience response system (ARS) technology, also known as personal response systems and group response systems. The system consists of small, handheld devices that allow simple, parallel text or numeric input from everyone involved in a meeting or group activity. ARS technologies are typically designed for large groups, which further creates socially lean conditions. Our operationalizations assume that the use of large ARS groups—which are susceptible to interaction challenges—should result in perceptions of more interactivity than would happen in large non-ARS groups.

Group process losses and status effects tend to increase with group size, especially in large face-to-face groups [39, 107]. For example, large groups inhibit individual participation and create more communication difficulties than smaller groups [97]. These problems may lead to other serious difficulties in that, relative to smaller groups, larger groups tend to be less stable, create more stress, and experience more evaluation apprehension, social loafing, and production blocking. As such, large groups are relatively inefficient and unproductive at many common tasks (e.g., [39, 97]). Human limitations in communication bandwidth and attention cause these problems because simultaneous cognitive activities can interfere with one another [3]. Although optimal group size is around five to six members for most interactions [45], we employ far larger groups for our operationalizations.

Although ARS provides low social presence, parallelism is a feature of ARS that should increase interactivity for large groups. *Parallelism* is the ability of group members to contribute information simultaneously [31]. Parallelism may cause information overload or reduced attention to important information [32]; however, it generally allows more opportunities for group members to participate at the same time [31]. Hence, parallelism in large ARS groups should provide more synchronicity than in face-to-face groups. Also, because parallelism allows more opportunities for contributions, group members tend to perceive more control in group interactions [31]. Supporting research shows that socially lean media decision groups using CMC perceive significantly more control than face-to-face decision groups [108]. For example, Walther [108, 109] proposed that lean media allow people to better control information and interaction with others, which is actually more engaging and satisfying than in face-to-face interactions. Walther notes that nonverbal signals can create less control, more complexity, and higher expectations in face-to-face interactions and that these are not present in lean media interactions. Research has found that socially lean media groups can process information [86] and support knowledge sharing [55] better than rich-media groups for similar reasons.

Parallelism should also result in reduced cognitive interference because participants do not have to wait to contribute their ideas. *Cognitive interference* occurs when the idea generation of a group interferes with the idea generation of individuals [30]. This occurs because people have limited ability to concentrate and cannot divide their attention among multiple conflicting concepts. It may also occur because of cognitive inertia. *Cognitive inertia* happens when groups focus on a limited aspect of an overall task, creating a group mental rut [30]. The reduction in production blocking, cognitive interference, and cognitive inertia should result in better two-way communication. Summarizing all the support in this section, we predict the following:

*Hypothesis 1: Large ARS groups will perceive greater interactivity than will large, verbally interacting groups.*

Given P1–P4 and the operationalizations of CQ, we predict the following:

*Hypothesis 2: Large ARS groups that perceive increased interactivity will perceive greater increased CQ than will large, verbally interacting groups.*

*Hypothesis 3: Large ARS groups that perceive increased CQ will perceive greater increased PS than will large, verbally interacting groups.*

*Hypothesis 4: Increased perceived status effects in large ARS groups will decrease the strength of the relationship between CQ and PS (acting as a negative moderator).*

Finally, to operationalize P4 in our context, we emphasize that interactions via ARS are naturally going to be more socially lean than verbal interactions. ARS do not support rich text input. Often they only support numeric input, and at most they support basic text input but no multimedia input (e.g., voice, sound, visual). All ARS support anonymity by allowing those who provide input not to be identified. Hence, we hypothesize the following:

*Hypothesis 5: Large ARS groups will perceive fewer status effects than will large, verbally interacting groups.*

# Method

## Design

THIS STUDY EMPLOYED A QUASI-EXPERIMENTAL nonequivalent groups design with multiple outcome measures, which is appropriate when random assignment is not possible. Two large sections met for two instructional quarters of the same course: large-group interaction without ARS (control group) and large-group interaction with ARS (treatment group).

## Participants

A total of 346 undergraduate business majors at a large public, southern California university participated, providing more than adequate a priori power.[3] All participants were enrolled in one of two sections of the same introductory-level IS course. Participants' gender was 60.7 percent male and 39.3 percent female. Average age was 22 (standard deviation [SD] = 2.8). Average grade point average (GPA) was 3.01 (SD = 0.44). Ethic distribution was Asian (49.7 percent), Caucasian (16.5 percent), Hispanic (15.0 percent), African (1.7 percent), and other/no response (17.1 percent).

## CMC ARS Tool

We used the CMC ARS tool Classroom Performance System (CPS) by eInstruction Inc. for this research. CPS provided all group members with a small, handheld, eight-button response pad that transmitted an infrared signal to a receiver connected to the facilitator's computer. The system's software recorded participant responses and graphically displayed results in real time.

The instructor used CPS to create text questions with answer choices that participants could select with their response pads. Question types included true/false, yes/no, and multiple choice ranging from two to five possible answer combinations. Text questions and answers could be augmented with graphics. The questions were displayed via computer projection. When used in conjunction with other software, such as Microsoft PowerPoint, a CPS toolbar allowed the facilitator to toggle between the presentation and CPS questions and answers. CPS provided an anonymous response mode.

As soon as the question is displayed, the system accepts responses. Responses transmitted prior to the start of the question were ignored. The facilitator sets the duration of questions, and participants can respond whenever the question timer is running or is paused. All responses were recorded well within the allotted 45 seconds, thereby providing a high degree of parallelism and synchronicity in the participants' responses.

## Treatment and Control Procedures

Treatment groups used our selected ARS (less social presence, more interaction opportunity) whereas control groups used verbal interaction (more social presence, less interaction opportunity). This study was designed to alleviate the differences in presentation style that could influence participants' perceptions of the ARS. Both the treatment and the control sessions were from the same course and had the same facilitator, discussions, assessments, and projects. Both treatments met at a similar time of day and week for a total of 30 sessions that lasted approximately one hour and five minutes for 10 weeks. Daily session attendance ranged from 125 to 155 participants.

The research was conducted in a 180-seat music recital hall with tiered, theater-type seating facing a 45-foot-wide stage with a large projection screen. The facilitator stood at ground level in front of the stage and presented written content and interactive questions via a laptop and LCD projector. The facilitator's laptop was located on the podium, and the LCD projector was on a movable cart.

### Treatment

Participants in the treatment group were required to purchase response pads and register them on the Internet for approximately $20. The response pads were used for recording attendance, taking nine five-point quizzes, and answering questions asked during lectures and discussions.

Participants were given 30 to 45 seconds to answer questions using their response pads. At the end of the response period, a histogram displayed the number of participants who had selected each answer choice.

The ARS software also facilitated discussions. During discussions, the facilitator would ask a question soliciting experience or opinions. To choose a participant to share his or her ideas, the software randomly selected a student from the class list and projected his or her name on the screen.

Technology failures typically consisted of participants forgetting to bring their response pads to sessions, batteries running low, and slow computer reception. The software froze twice during the 10-week course, causing a loss of information and the need to readminister a quiz.

### Control

The intention of the control group design and procedures was to make the non-ARS sessions in every way similar to the treatment group, with the important exception that the participants would not use ARS devices for interaction. This ensured that differences in outcomes could be best attributed to use or non-use of ARS.

Participants in the control group were asked the same questions at the same points in the lectures and discussions as those in the treatment group. The questions were projected using the same ARS software as the treatment group; however, instead of responding with handheld ARS devices, control group participants responded by raising their hands when the facilitator read the answer choice. Because responses were not transmitted to the laptop, there was no histogram of answers; however, participants could physically see how many of their peers were raising their hands for a particular answer, and the facilitator verbally explained correct answers. Thus, the participants and their responses were not fully anonymous and had more social presence.

To mimic the random selection of participants, the facilitator generated a random list of participants before each session, and then simply called on participants from the list. Attendance at the control sessions was virtually the same as at the treatment sessions.

## Measures

We measured the second-order construct of interactivity with a reliable, Web-based instrument, using Liu's measures of interactivity [59]. PS was measured using a validated scale derived from Tan et al. [102]. Status effects were measured using an instrument created and validated by Davison [25] that identified four components of status effects: (1) attempts to intimidate others; (2) using influence, status, or power to force issues on others; (3) inhibiting other group members from participation; and (4) pressuring others to conform to a particular view. These four components closely mirror the outcomes of several common status effects such as evaluation apprehension, conformance pressure, first advocacy effect, and so on. Finally, we operationalized CQ as a second-order construct with three reliable and validated subconstructs and related measures: communication openness, discussion efficiency, and task-discussion effectiveness. The Appendix provides details on the measurement scales.

## Analysis

### Testing Nonequivalent Groups

Quasi-experiments can approach the validity of controlled, randomized experiments as long as they have high participation rates and no major environmental differences exist that will likely skew the results. We analyzed and compared the demographic nature of the two condition groups to determine if there were significant differences in the nonequivalent groups that would bias outcome measure results. Our analysis found no statistical difference in any major demographic variables, including mean GPA, mean course grade, age, and ethnic distribution.

### Establishing Factorial Validity

A key step before assessing factorial validity, which has recently come to light in IS research, is to determine which constructs are formative and which are reflective [33, 65], as each type has to be analyzed differently.[4] We used Diamantopoulos and Winklhofer [33] as the basis to determine which constructs are formative and which are reflective. All of our constructs were reflective, with the exception of discussion efficiency and PS. Interactivity is a second-order construct made up of the first-order reflective constructs synchronicity, two-way communication, and control. CQ is a second-order construct made up of the first-order formative construct discussion efficiency and the first-order reflective constructs communication openness and task discussion effectiveness.

#### Factorial Validity of Reflective Constructs

We then performed confirmatory factor analysis (CFA) on the reflective constructs to establish factorial validity, following the procedures as outlined in Gefen and Straub [40] and Straub et al. [99]. We first established convergent validity. According to Gefen and Straub, "convergent validity is shown when each of the measurement items loads with a significant *t*-value on its latent construct" [40, p. 93]. To do so, we generated a bootstrap with 200 resamples. We then examined the *t*-values of the outer model loadings; all of the outer loadings were significant at the 0.05 $\alpha$ level. These results indicate strong convergent validity in our model for the constructs.

To establish discriminant validity of our indicators, we used two common techniques: (1) correlating the latent variable scores and (2) calculating the average variance extracted (AVE). The first approach requires one to generate correlations of the latent variable scores with all the measurement items. These correlations represent a CFA where the correlations are the actual loadings. Exact guidelines on this have not yet been established, but the fundamental idea is that "all the loadings of the measurement items on their assigned constructs should be an order of magnitude larger than any other loading" [40, p. 93]. Using latent variable scores, strong discriminant validity was established for all items except for the fifth item of synchronicity, which we therefore dropped.

The second approach that we used to establish discriminant validity was the AVE test. "Conceptually, the AVE test is equivalent to saying that the correlation of the construct with its measurement items should be larger than its correlation with the other constructs" [40, p. 94], which is similar to correlation tests with multitrait-multimethod (MTMM) matrices. The AVE is calculated through PLS-Graph by computing the variances shared by the items of a particular construct (see Table 3). To establish discriminant validity, the diagonal elements must be greater than the off-diagonal elements for the same row and column. The AVE analysis showed very strong discriminant validity for all subconstructs and thus further confirmed our choices of items to retain and drop.

Finally, we established the reliability of the measures. *Reliability* refers to the degree to which a scale yields consistent and stable measures over time [98]. Partial least squares (PLS) computes a composite reliability score (similar to Cronbach's $\alpha$ in that both are measures of internal consistency) as part of its integrated model analysis (see Table 4). Specifically, composite reliability is an index that reflects the impact of error on the measure [83]. Each construct in our research model demonstrated high levels of reliability that exceeded the standard thresholds.

## Factorial Validity of Formative Constructs

Validating formative indicators is more challenging than validating reflective indicators because the established procedures to determine the validity of reflective measures do not apply to formative measures [79, 99], and because the procedures validating formative measures are less known and established [33]. Formative measures are particularly challenging because they can move in different directions, and they can theoretically covary with other constructs; thus, construct validity and reliability do not apply as easily or as readily, and procedures other than the traditional procedures for convergent and discriminant validity must be used [67, 79].

Researchers have traditionally used theoretical reasoning to support the validity of formative constructs [33], although there are approaches beyond theoretical reasoning alone [67, 79]. Although no single technique is widely accepted for validating formative measures, the modified MTMM approach, as presented in Loch et al. [61] and Marakas et al. [67], is a promising solution that we followed.

For reflective measures, loadings are used because they "represent the influence of individual scale items on reflective constructs; PLS weights represent a comparable influence for formative constructs [11]" [61, p. 49]. For formative items, we created new values that were the product of the original item values by their respective PLS weights (representing each item's weighted score). We then created a composite score

Table 3. Discriminant Validity Through the Square Root of AVE

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Control | AVE = 0.507<br>(0.712) | | | | | |
| 2. Two-way communication | 0.547 | AVE = 0.528<br>(0.727) | | | | |
| 3. Synchronicity | 0.469 | 0.605 | AVE = 0.655<br>(0.809) | | | |
| 4. Communication openness | 0.271 | 0.324 | 0.337 | AVE = 0.769<br>(0.877) | | |
| 5. Discussion efficiency | 0.255 | 0.391 | 0.455 | 0.640 | AVE = 0.828<br>(0.910) | |
| 6. Status effects | –0.117 | –0.260 | –0.168 | 0.245 | 0.179 | AVE = 0.803<br>(0.896) |

*Notes:* The AVE square roots are shown in parentheses. Off-diagonal elements represent the correlations between the constructs.

Table 4. Composite Reliability

| Construct (latent variable) | Composite reliability |
|---|---|
| Control | 0.800 |
| Two-way communication | 0.870 |
| Synchronicity | 0.883 |
| Communication Openness | 0.943 |
| Discussion efficiency | 0.828 |
| Status effects | 0.942 |



for each construct by summing all the weighted scores for a construct. Finally, we produced correlations of these values, providing intermeasure and item-to-construct correlations.

To test convergent validity, we checked whether all the items within a construct highly correlate with each other, and whether the items within a construct correlate with their construct value.[5] This was true in all cases, inferring convergent validity. We would ideally want interitem correlations to be higher within a given construct, but this cannot be strictly enforced as there are exceptions depending on the theoretical nature of the formative measure [33, 61]. Also, large matrices will introduce exceptions that are not necessarily meaningful, and thus careful theoretical judgment needs to be used before removing any items [33, 61, 67, 79]. Thus, we believe the most meaningful discriminant validity check with formative measures is to look at the degree to which items within a construct correlate to a given construct.

Finally, we used another approach to assess formative validity as suggested by Petter et al. [79], which involves testing the multicollinearity among the indicators. This is particularly important with formative indicators because multicollinearity poses a much greater problem than it does with reflective indicators. Hence, low levels of multicollinearity are usually indicated with levels of the variance inflation factor (VIF) below 10, but in the case of formative indicators, the VIF levels need to be below 3.3 for a more stringent test [79]. In our case, the VIF between the two constructs was 1.0, which is far below 3.3.

In sum, using MTMM analysis and assessing VIF levels, we conclude that reasonable discriminant validity exists with our formative constructs. Finally, because of the nature of formative measures, reliability checks cannot be reasonably made [33].

## Testing for Common Method Bias

Because the self-reported data was collected using a paper-based survey with similar-in-appearance scales, we tested for common method bias to establish that it was not a likely factor in our data collection. To do so, we used two approaches. The first approach—which is increasingly in dispute—was to conduct Harman's single-factor test [80]. This test required that we run an exploratory, unrotated factor analysis on all of the first-order constructs. The aim of the test is to see if a single factor emerges that explains the majority of the variance in the model. If so, then common method bias likely exists on a significant level. The result of our factor analysis produced 27 distinct factors, the largest of which only accounted for 29.89 percent of the variance of the model.

The second approach, which is more accepted, was simply to examine a correlation matrix of the constructs (see measurement model statistics) and to determine if any of the correlations were above 0.90; if so, this qualifies as strong evidence that common method bias exists [78]. In no case did our correlations reach this threshold. Not surprisingly, the highest correlations were with related first-order constructs that belonged to the same second-order construct. A more advanced approach has been proposed in Podsakoff et al. [80], but unfortunately, it was designed for models with reflective indicators only, not for mixed models such as ours. Given that our data passed both tests of common method bias, we conclude that there is little reason to believe the data exhibit negative effects from common method bias.

## Manipulation Checks

Given the strong validation results, we next performed the manipulation check. We predicted that the control condition would have lower perceived interactivity than the treatment condition (H1); therefore, it was crucial to ensure a significant interactivity difference existed between these conditions. The average perceived interactivity for the control condition was 5.1 (SD = 0.95) and 5.31 (SD = 0.79) for the treatment condition. Analysis of variance (ANOVA) showed that this difference was statistically significant ($F_{(1, 344)} = 4.67$, $p = 0.03$). We thus conclude that the expected manipulation of interactivity differences was successful and that H1 is supported.

H5 also provides a useful manipulation check because it predicts that large groups using ARS will perceive fewer status effects than verbally interacting groups of the same size because ARS removes social cues and social presence. The difference between perceived status effects in the control condition ($\mu = 2.70$, SD = 1.46) and the treatment condition ($\mu = 2.12$, SD = 1.27) was in the predicted direction and statistically significant ($F_{(1,344)} = 13.41$, $p = 0.000$). Thus, H5 was supported.

## Testing the Baseline and Interaction Model

Given the manipulation checks, we then tested the path model. We performed our PLS analysis, using PLS-Graph version 3.0. PLS is especially suited for early theory development—such as the research gathered here—as opposed to situations in which theory is highly developed and further testing and extension is the objective. In such cases, maximum likelihood or generalized least squares are often preferred [20, 21, 40]. PLS is particularly helpful in cases that use interaction terms and a mix of formative and reflective indicators [21], as ours does.

Because we theorized a model that includes interaction terms (status effects), also known as moderators, we followed the latest techniques for testing these terms by creating both a baseline model and an interaction model, using the product-indicator approach detailed in Chin et al. [21]. A hierarchical process similar to that used in first-generation statistical techniques assesses whether or not moderators exist in a model. First, two models—one with the moderator relationship and one without [21]—are constructed and compared. In creating the baseline model, the main effects of the interaction term need to be included; thus, status effects are included. We also added age, years of education, years of work experience, and computer experience as potential covariates.

The interaction term approach that we used to test our model is the well-accepted product-indicator approach proposed by Chin et al. [21] because it is the most effective approach in identifying interaction terms in complex path models. This approach adds three critical improvements to measuring interaction effects. First, this approach models paths between each exogenous and endogenous construct—a critical step because "when the main effect variables are missing in the analysis, interaction path coefficients are not true interaction effects" [21, p. 196]. Second, it standardizes or centers the individual items for the moderation scores.[6] Third, no information is eliminated from the model. All of the interaction indicators stand alone without being summarized and are free to vary on their own to take advantage of PLS analysis.

Adding the product-indicator interaction terms dramatically increases the number of indicators in the overall model to 159 indicators. Notably, the interaction of status effects and CQ was significant at an $\alpha$ protection level of 0.05 ($t = 2.85$). As expected [21], adding in the interaction term decreased the strength of the path between CQ and PS from the baseline model (0.798 to 0.699); the $R^2$ for PS also increased from 0.651 to 0.668. Finally, in the interaction model, the negative path between status effect and PS is now significant ($t = 2.80$). Our significant interaction had an effect size of $f^2 = 0.05$ for a small interaction effect;[7] however, even small effects using the product-indicator approach indicate important model relationships [21].

Figure 2 summarizes the results of the interaction model. Variance explained is indicated for each construct as $R^2$. The path coefficients, or $\beta$s, are indicated on the paths between two constructs, along with their direction and significance. The significance of the path estimates was calculated using a bootstrap technique with 200 resamples.

## Mediation Check

As a final theoretical test, the nature of our model requires us to check our theorized mediating effects of CQ. We follow the simple test of mediation proposed by Baron and Kenny [5].[8] Full mediation occurs when the independent variable no longer has a significant effect when the mediator is included; partial mediation occurs when the independent variable still has a significant effect but its effect is diminished.

Based on these rules, we tested for mediation. First, the unmediated path between interactivity PS (still including covariates and the interaction terms) had a significant $\beta$ of 0.460 and produces an $R^2$ of 0.537 for PS. When the mediation relationship with

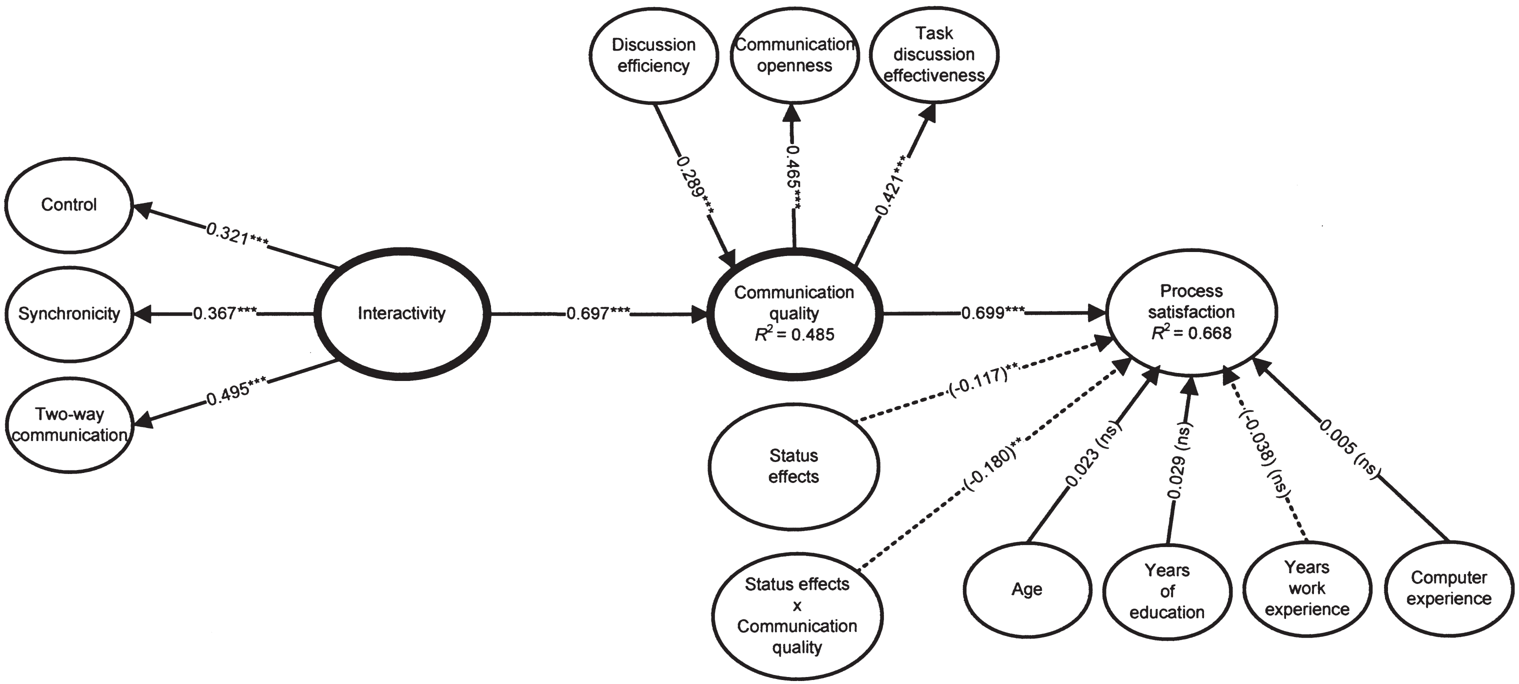


*Figure 2.* Model with Interactions of Status Effects Using Product-Indicator Approach

*Notes:* The second-order formative constructs of interactivity and communication quality are indicated in the model by dotted lines. Interactivity is composed of the reflective first-order constructs of control, synchronicity, and two-way communication. Communication quality is composed of the first-order formative construct of discussion efficiency and the reflective constructs of communication openness and task discussion effectiveness. ns = not significant; ** $p$ 0.01; *** $p < 0.001$.

CQ was added, the new paths were significant (interactivity to CQ has a β of 0.693 and CQ to PS has a β of 0.648). Moreover, the direct path between interactivity and PS became insignificant with a β of 0.068. Meanwhile, the new $R^2$ for PS increased to 0.672. These results validate our model by providing strong evidence that CQ acts as a full mediator and that predicting a direct relationship between interactivity and PS is suboptimal and theoretically unsupported.

Finally, Table 5 summarizes the measurement model statistics and Table 6 summarizes the propositions, the path coefficients, and the *t*-values for each path.

# Discussion

## Summary of Results

The purpose of our study was to propose and test CMCIM, which explains and predicts how interactivity increases CQ and subsequently leads to increased PS in CMC groups. CMC systems employ a wide range of communication technologies that are generally leaner than face-to-face communication. Furthermore, the challenges of communication increase with group size. Thus, we chose to test CMCIM under the extreme case of very large groups using ultra-lean CMC technologies (ULIM), on the basis that if our model holds under these conditions, it will likely hold under less adverse conditions.

The results of our study support our hypothesis that large ARS groups perceive more interactivity than large, verbally interacting groups (H1). We found that perceived interactivity leads to an increase in perceived CQ (H2). Likewise, perceived CQ was found to be a significant positive predictor of PS (H3). We also found that status effects negatively moderate the relationship between CQ and PS (H4). The full interaction model revealed that status effects directly decrease PS. Finally, large groups using ARS perceived fewer status effects than large, verbally interacting groups (H5). Figure 3 depicts the refined path model that summarizes the results of the tested hypotheses, and outlines our final proposed version of CMCIM.

## Contributions to Theory and Practice

PS is a particularly important phenomenon of interest because our literature review indicates that PS is a key determinant of system adoption and system continuance. Our quasi-experiment to test CMCIM intentionally centered on ultra-lean interactive media (ULIM). Our operationalization of ULIM involved an ARS that consisted of handheld devices with extremely limited media capabilities that were designed for large-group settings, which is also useful because little theoretical work has been conducted with large groups using ULIM. Every portion of CMCIM was empirically supported in our studied context. Our experimental controls increased the likelihood that parallelism accounted for the predicted interactivity differences. Since parallelism can be used in many different ways by different CMC tools (e.g., chat, brainstorming, instant messaging) and devices of various levels of social presence (e.g., cell phones,

Table 5. Measurement Model Statistics ($n$ = 346)

| Construct | μ | Standard deviation | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 1. Control | 4.97 | 1.14 | | | | | | | |
| 2. Two-way communication | 5.13 | 1.20 | 0.547 | | | | | | |
| 3. Synchronicity | 5.12 | 1.22 | 0.469 | 0.605 | | | | | |
| 4. Task discussion effectiveness | 4.97 | 1.18 | 0.338 | 0.508 | 0.402 | | | | |
| 5. Communication openness | 4.50 | 1.72 | 0.271 | 0.324 | 0.337 | 0.418 | | | |
| 6. Discussion efficiency | 4.78 | 1.74 | 0.255 | 0.391 | 0.455 | 0.486 | 0.640 | | |
| 7. Status effects (7) | 2.21 | 1.59 | –0.117 | –0.260 | –0.168 | –0.065 | 0.245 | 0.179 | |
| 8. PS | 5.18 | 1.34 | 0.364 | 0.490 | 0.429 | 0.733 | 0.519 | 0.582 | –0.062 |

Table 6. Summary of Path Coefficients and Significance Levels

| Hypotheses and corresponding paths | Expected sign | Path coefficient | *t*-value (df = 345) |
|---|---|---|---|
| H3: Interactivity → CQ | + | 0.697 | 13.63*** |
| H4: CQ → PS | + | 0.699 | 15.29*** |
| H5: Status effects negatively moderates the relationship between CQ and PS | – | (–0.180) | 2.85** |
| Two-way communication is a first-order factor of interactivity | + | 0.495 | 44.18*** |
| Synchronicity is a first-order factor of interactivity | + | 0.367 | 34.90*** |
| Control is a first-order factor of interactivity | + | 0.321 | 28.38*** |
| Discussion efficiency is a first-order factor of CQ | + | 0.289 | 26.50*** |
| Communication openness is a first-order factor of CQ | + | 0.465 | 29.65*** |
| Task discussion effectiveness is a first-order factor of CQ | + | 0.421 | 49.30*** |

** $p < 0.01$; *** $p < 0.001$.

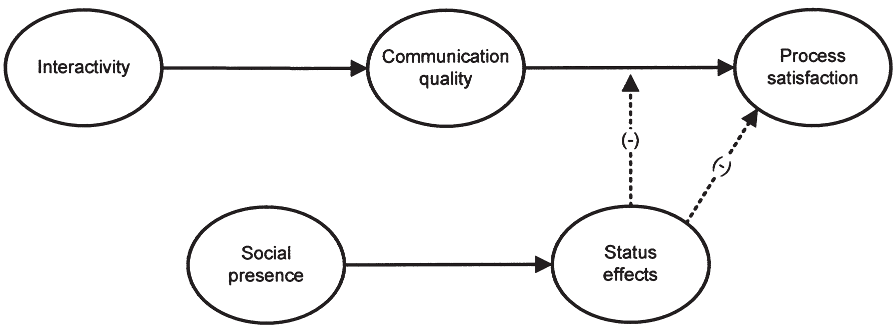


*Figure 3.* Refined Version of CMCIM



ARS, laptops), our findings will likely have a wide application in practice. We also provide several other contributions to theory and practice.

First, we further clarify and validate the nature of interactivity in a CMC context, which reduces the ambiguity in the extant literature. Because CMC interactivity is a specialized form of interpersonal interactivity, we theoretically base CMC interactivity on two principles borrowed from interpersonal interactivity theory—communication efficacy and direction of communication. In doing so, we validate perceived interactivity as a second-order construct made up of three reflective subcontracts—two-way communication, synchronicity, and control. We found that ARS did indeed create higher levels of perceived interactivity in large groups compared to large groups interacting verbally only (H1).

Next, we explained the connection between interactivity and CQ. The interactional view of communication suggests one cannot *not* communicate and all communication signals are interpreted by the parties involved in the communication exchange [110]. In accordance with this axiom, the defining principles of interactivity, efficacy, and direction of communication explain that interactivity subconstructs may act as communication signals that are interpreted by parties involved in CMC communication exchanges as predicted: increases in perceived interactivity led to increased perceived CQ (H2).

We then explained the connection between communication and PS based on an innovative extension of EDT (e.g., [69, 96]) and the assumption that people will judge CMC interactivity in terms of interpersonal communication and the kind of media used. In doing so, we illustrated that increased perceived CQ leads to increased PS (H3). Satisfaction has been shown to positively affect software adoption [84, 85], Web site adoption [57], perceived usefulness and perceived ease of use [115], system continuance after adoption [9], interpersonal trust [68], and trust related to systems [70]. Thus, increased satisfaction could also increase group cohesiveness, group members' desire to work together again, and the group's decision-implementation capabilities.

Moreover, we extended status characteristics theory [27] to explain and predict that status effects encountered during a group's communication process can diminish PS. We found that status effects not only negatively moderated the relationship between CQ and PS (H4) but also decreased PS directly. Finally, we combined status characteristics theory [27] and social presence theory [73] to explain and predict that the more socially lean an interaction, the fewer status effects participants will perceive. Consistent with this prediction, we found that large groups using ARS had fewer perceived negative status effects than large, verbally interacting groups (H5).

Using lean media to diminish status effects is of great practical importance—especially in large groups where status effects, such as evaluation apprehension, intimidation, dominance, and so forth, can be even stronger than in smaller groups. Such decreases in status effects create enhanced group member experiences that lead to increased satisfaction and decreased negative behaviors that diminish group performance, such as conformance pressure, cognitive inertia, cognitive interference, production blocking, advocacy effects, and so on.

Another practical contribution is our explanation of anonymity as a key factor determining the level of social presence and subsequent status effects in ULIM groups. Verbal interaction alone in very large groups can be very intimidating; in mixing verbal interaction with ULIM interaction, we saw fewer status effects due to diminished social presence.

## Limitations and Future Research

Despite the contributions of this research, there are several limitations and future research opportunities. First, the ARS we employed uses a multiple-choice question format. Although this method works well for assessing basic conceptual understanding, it is harder to implement for questions that require a higher order of reasoning and integration. Such questions could cause pacing problems: more integrative questions take more time to answer, and if the facilitator waits for everyone to respond, there can be considerable delays. Future research should devise tasks that maximize the benefits of ARS. Similarly, we are not certain we had the ideal mix of verbal interaction and ARS interaction. Our sessions did not replace all verbal interaction with ARS interaction—participants could still use both. Our study cannot prescribe the ideal mix of ARS and verbal interaction.

This study has made a strong theoretical and empirical case that ARS can provide increased interactivity though parallelism and decreased status effects through anonymity. However, we did not control these features individually—a group either used both or neither. It might be useful for future research to see how each individually affects interactivity and status effects. For example, researchers could conduct a laboratory experiment that varies social presence to study the importance of anonymity with an ARS.

The large groups that we studied were in large lecture auditoriums, whereas many opportunities exist to test CMCIM with other kinds of groups. CMCIM could be tested for the potential to extend ULIM to many industry and government applications, such as large-scale consulting engagements, company meetings, executive strategy development sessions, focus groups, and customer feedback sessions. Increased interactivity, along with the associated increase in participation by large-group members, would likely improve decision-making results, but no clear empirical evidence exists to support this assertion. ULIM may also have promise in involving large groups of users and developers in large-scale software development in requirements gathering and enterprise resource planning (ERP) software implementation. Other research could examine the generalizability of CMCIM in other group contexts, such as medium or small groups using richer CMC technologies.

In our study, we focused on how PS is a function of the degree to which users' expectations of CQ are confirmed or disconfirmed. Future research could examine how CQ may be applied to the yield shift theory [12]. For example, CQ may influence PS by increasing the utility people ascribe to their goals, changing the goals that comprise their active goal set, or increasing the likelihood people ascribe to achieving their goals. In addition to providing a more comprehensive explanation of satisfaction effects, this research could provide valuable insights on other important managerial factors such as how CQ can increase confidence in, and dedication to, team decisions, both of which could possibly be theoretically explained by the three yield shifts described by Briggs et al. [12].

Finally, recent research by Brown et al. [13] indicates that in utilitarian decision-making contexts, EDT may not be the best explanation for predicting satisfaction. Brown et al. tested three different models for explaining satisfaction—the disconfirmation, experiences-only, and ideal-point models. EDT accounts for both the disconfirmation- and experiences-only models. In addition to predicting that a positive expectations disconfirmation yields satisfaction, EDT predicts performance has a direct and independent influence on satisfaction. However, Brown et al. showed that in a utilitarian software adoption context, expectations disconfirmation is not nearly as important in determining satisfaction as is good performance. We did not directly measure expectations disconfirmation, so future research should consider whether both constructs contribute to increased PS, or whether communication performance alone leads to greater PS.

## Conclusion

This study proposes and provides initial support for CMCIM, which explains and predicts how interactivity, CQ, and status effects impact PS in groups. We studied CMCIM in large groups because they are especially prone to interactivity, CQ, and status effect problems. Our results dramatically reveal that groups using ULIM had higher perceived interactivity than face-to-face groups. In addition, perceived interactivity improved perceived CQ. We found that large groups using ULIM had fewer status effects and greater PS than face-to-face groups. Since ULIM is inexpensive and requires little training and support, these results may aid the continuance and success of large, global work teams involved in projects such as software development, systems implementation, product development, strategy development, and other important decision-making projects in which status effects and communication issues are likely.

*Acknowledgments:* The authors acknowledge funding from the Information Systems Department at Brigham Young University. They also appreciate the technical support of California State Polytechnic University, Pomona, and eInstruction Inc., and the feedback from Hawaii International Conference on System Sciences (HICSS) conference reviewers and workshop participants at Oklahoma State University. The authors received substantial help from Detmar Straub with the statistical analysis and interpretation. Finally, they appreciate extensive reviews and edits from Robert Briggs, Marvin Gardner, Sarah Phelps, Taylor Wells, Trent Spaulding, Gunilla A. Sundstrom, Jordan Barlow, Kevin Brinkerhoff, Laura Rawlins, and the anonymous referees.

## Notes

1. Bhattacherjee [9] and some others call the associated theory "expectation confirmation theory"; McKinney et al. [69] call the associated theory the "expectation-disconfirmation paradigm." These are all variants of the expectation disconfirmation model, which we will use to refer to our baseline theory.

2. Expectations are cognitive beliefs a person has about the attributes or performance of his or her experience at some time in the future—the likelihood that an experience is associated with certain attributes, benefits, and outcomes that are likely oriented on the future and are relatively malleable [96].

3. A priori power analysis determined that to achieve a medium effect size and power of 0.80, the minimum sample size for testing this model was 79 and the minimum sample size for small effect size was 207. This analysis was conducted using GPower version 2.0 by Franz Paul and Edgar Erdfelder, Bonn University, Department of Psychology. We used Cohen's guidelines on effect sizes: a small effect is 0.1, a medium effect is 0.3, and a large effect is 0.5.

4. Should researchers make a default assumption that all constructs are reflective, they risk invalidating the results of the factorial validity tests. A high percentage of the recent research in *MIS Quarterly* and *Information Systems Research* misspecifies constructs as reflective when they are actually formative, leading to problems in empirical results and theoretical interpretations, including the potential increase in both Type I and Type II errors [79]. There are four unique aspects of formative indicators, which are not shared by reflective indicators: (1) changes in the

indicators cause changes in the construct, (2) indicators do not have to be similar/interchangeable, (3) indicators do not need to covary, and (4) indicators do not necessarily have the same antecedents and consequences.

5. However, a researcher must rely on theory first to deal with any discrepancies.

6. "Standardizing or centering indicators helps avoid computational errors by lowering the correlations between the product indicators and their individual components" [11, pp. 198–199]. Standardizing is used if it is thought that the indicators measure their constructs equally well. Because we had no theoretical reason to believe that there were unequal differences in the specific indicators, standardizing was our methodological choice.

7. To be conservative, we only consider the change in $R^2$, shown in the $f^2$ statistic, to be equivalent to effect size. This is because regression changes in $\beta$ are a less accurate indicator of effect size especially if multicollinearity exists [18]. Since PLS and regression share similarities in how $\beta$ is calculated, we also do not consider changes in $\beta$ to be equivalent to effect size. We calculate $f^2$ as $[R^2(\text{interaction model}) - R^2(\text{main effects model})] / [1 - R^2(\text{main effects model})]$.

8. "A variable functions as a mediator when it meets the following conditions: variations in levels of the independent variable significantly account for variations in the presumed mediator (i.e., Path a), variations in the mediator significantly account for variations in the dependent variable (i.e., Path b), and when paths a and b are controlled, a previously significant relation between the independent and dependent variables is no longer significant, with the strongest demonstration of mediation occurring when Path c is zero" [5, p. 1176].



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## Appendix: Measures Used in This Research

| Latent variable (type) | Items | Measure notes |
|---|---|---|
| Interactivity (second-order) | Subconstruct: control (reflective):<br>Ctnl1: I felt that I had a great deal of control over my communication in this group.<br>Ctnl2: While I was involved in this group, I could choose freely what I wanted to hear/read and say/contribute.<br>Ctnl3: While involved in this group, I had absolutely no control over my communication.*<br>Ctnl4: While involved in this group, my actions determined the kind of experiences I had.<br>Subconstruct: two-way communication (reflective):<br>Two1: The facilitator effectively gathered group members' feedback.<br>Two2: The group environment facilitated two-way communication between group members and the facilitator.<br>Two3: It was difficult to offer feedback to the facilitator.*<br>Two4: The facilitator made me feel he or she wanted to listen to the group members.<br>Two5: The facilitator did not at all encourage group members to communicate.*<br>Two6: The group environment gave group members the opportunity to communicate. | We adapted original measures from Liu [59] to make them consistently in past tense and more general to a group interaction (not a Web site interaction). |

*(continues)*

Appendix. Continued

| Latent variable (type) | Items | Measure notes |
|---|---|---|
| | Subconstruct: synchronicity (reflective):<br>Synch1: The facilitator processed my input very quickly.<br>Synch 2: Getting information from the facilitator was very fast.<br>Synch 3: In the group environment, I was able to obtain the information I wanted without any delay.<br>Synch4: When I communicated with the facilitator, I felt I received instantaneous information.<br>Synch 5: The facilitator was very slow in responding to my requests.* (dropped) * | |
| Discussion efficiency (reflective) | Eff1: To what extent would you agree that this group interaction was result oriented?<br>Eff2: The time spent in the group interaction was efficiently used.<br>Eff3: Issues raised in the group interaction were discussed thoroughly. | Original from Davison [25]. Did not use Eff4 “What percentage of group interaction time do you think was spent on serious interaction? ___%.” Expanded from a five-point scale to a seven-point scale (strongly agree to strongly disagree). In Eff1 changed *say* to *agree.* Used “course” language for course scenario. Changed *meeting* to *group.* |
| Task discussion effectiveness (formative) | Taskd1: The discussions were ineffective.*<br>Taskd2: The context of the discussions was carelessly developed.*<br>Taskd3: Issues were examined effectively.<br>Taskd4: Participation in the discussions was unevenly distributed.*<br>Taskd5: Ideas in the discussions were uncritically examined.*<br>Taskd6: The amount of information exchanged was sufficient. | Instrument application: used as is to measure communication task discussion effectiveness on the group level for the posttest. Original from Burgoon et al. [14]; used all original items except 1 and 3, as these overlap with discussion quality. Changed original anchors to the degree of agreement on seven-point Likert-type scale. |

| | | |
|---|---|---|
| Process satisfaction (formative) | Satp1: Our group discussion process was efficient.<br>Satp2: Our group discussion process was uncoordinated.*<br>Satp3: Our group discussion process was unfair.*<br>Satp4: Our group discussion process was understandable.<br>Satp5: Our group discussion process was satisfying. | Original from Tan et al. [102]. Reanchored on a seven-point scale from five-point scale. Original anchors were inefficient/efficient, uncoordinated/coordinated, unfair/fair, confusing/understandable, dissatisfying/satisfying; changed to only using first part of anchor with respondent indicating how strongly they agreed or disagreed (made items 1, 4, 5 positive). For classroom use, "decision-making" was termed "discussion process." |
| Openness (reflective) | Open1: It was easy to communicate openly to all members of this group.<br>Open2: Communication in this group was very open.<br>Open3: When people communicated to each other in this group, there was a great deal of understanding.<br>Open4: It was easy to ask advice from any member of this group.<br>Open5: We needed to adapt our style of communication to effectively communicate.* | Adapted from Roberts and O'Reilly [88]; changed to past tense. Changed Open5 from "talk" to "style of communication." Removed original item 3 because it theoretically deals more with enjoyment. |
| Status effects (reflective) | Stat1: Some group members tried to intimidate others, e.g., by talking loudly, using aggressive gestures, making threats, etc.<br>Stat2: Some group members tried to use their influence, status, or power so as to force issues on the other group members.<br>Stat3: I felt inhibited from participating in the interaction because of the behavior of other group members.<br>Stat4: I experienced pressure, either to conform to a particular viewpoint or to not contradict others. | Original from Davison [25]. Expanded from a five-point scale to a point-point scale (strongly agree to strongly disagree). In Stat3, changed *meeting* to *group* and *discussions* to *interactions*. In Stat3 and Stat4, changed *you* to *I*. |

*Notes:* All items use a seven-point Likert-type scale anchored on "strongly disagree/strongly agree." * = reverse coded.