
The Effects of Gender Interaction Patterns on Student Participation in Computer-Supported Collaborative Argumentation

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In this study we examined response patterns in exchanges between males and females and their effects on gender participation in five online debates. Students classified messages into arguments, evidence, critiques, and elaborations while posting messages to the debates to facilitate argumentation and the sequential analysis of message-response sequences. The findings revealed no differences in number of critiques posted in response to arguments because females were just as likely as males to critique messages from both males and females, and because females responded to males with critiques at a higher than expected frequency. Posthoc analysis revealed strong indications that females posted fewer rebuttals to the critiques of females than males, and males posted more rebuttals to the critiques of females than females. The methods used in this study illustrate a process-oriented approach to explain and predict gender differences in participation and serve as a framework for future research on gender participation, group interaction, and strategies for facilitating collaborative argumentation and problem solving.

Keywords: computer-mediated communication, gender interaction, collaborative argumentation

□ A growing body of research has been conducted on gender differences in computer-mediated communication (CMC) to examine the relationships between gender, communication styles, and conditions that affect female and male participation in CMC. The significance of this research has grown with the increased use of networked computers in education and the workplace.

With the increased use of CMC is the assumption that CMC reduces the gender-influenced inequalities often observed in face-to-face communication by diminishing the salience of physical and social cues that reveal the gender of participants (Wojahn, 1994). Given this assumption, CMC enables both male and female participants to openly share, confront, and discuss differing viewpoints—a key ingredient to engaging students in deeper discussions and critical discourse (Johnson & Johnson, 1992). However, the research findings have been mixed, suggesting that the social constraints manifested by gender differences continue to place a significant influence on gender behavior and participation in CMC.

For example, studies on gender participation in CMC have found that males tend to post more and longer messages than females in mixed gender discussions (Herring, 1993; McConnell, 1997; Ross, 1996; Vanfossen, 1996). Although females have been found to participate less than males, females have been found to be less disadvantaged in online discussions than in face-to-face discussions (McConnell, 1997). In contrast, other studies found that females posted more messages than males (Davidson-Shivers, Muilenburg, & Tanner, 2000, 2001; Herring, 1999; Savicki, Kelly, & Ammon, 2002) and females posted more substantive comments in both threaded discussions and chats in small groups. At the same time, studies have also found no significant differences between genders (Allen, 1995; Wojhan, 1994), and that the comments posted by males and females have been found to be similar in type and frequency in large group discussions and chats (Davidson-Shivers, Morris, & Sriwongkol, 2003). These mixed findings could be attributed to differences in group-task (e.g., information sharing, argumentation, problem solving), task structure (e.g., graded participation, minimum required postings, assignment of roles or teams), and methods used to measure participation (e.g., message frequency vs. message-response frequencies).

Although the findings on gender participation are mixed, studies have found clear gender differences in communication styles in CMC. Men tend to assert opinions strongly as facts and place more value on presenting information using an expository style; are more likely to use crude language, violate online rules of conduct, and engage in more adversarial exchanges; and sometimes terminate exchanges when there are disagreements (Blum, 1999; Fahy, 2002a, 2002b; Herring, 1993, 1999; Mahoney & Knupfer, 1997; Savicki, Lingenfelter, & Kelley, 1996; Vrooman, 2001). In contrast, females tend to hedge, qualify and justify their assertions (using such words as *maybe*, *possibly*, and *perhaps*), express support of others, make apologies, and in general, manifest a more consensus-making orientation and epistolary style. Females are also more upset by violations of politeness and more likely to challenge participants who violate rules of conduct (Smith, McLaughlin, & Osborne, 1997). At

the same time, students in discussion groups have also been found to modify their communication styles in the direction of the majority gender (Baym, 1996; Herring, 1996).

These differences in communication styles have the potential to affect how males and females exchange messages and responses with one another. Although Fahy (2002a) found that females were more likely to respond to messages addressed to them and were more likely to make contact with a greater number of participants in discussions, studies have yet to examine how males and females exchange messages with one another and how the patterns of exchange affect the extent to which males and females contribute messages that support critical discourse, critical thinking, argumentation, and group problem solving. For example, studies are needed to determine (a) whether females are more likely to challenge and question the claims of males than the claims of other females; (b) whether females are more likely to explain, justify, or clarify their claims in response to challenges from males than challenges from other females; and (c) how the patterns of interaction support or inhibit the ability of males and females to effectively participate in critical discourse and collaborative problem solving.

The absence of studies on the patterns of interaction between males and females can be attributed, in part, to limitations in the theories and assumptions used to frame current research in CMC (Dillenbourg, Baker, Blaye, & O'Malley, 1996). Theories are needed to help researchers formulate (a) a framework for predicting possible patterns in male-female exchanges and the effects of these patterns on participation, and (b) an operational definition of *group interaction*. Group interaction is a construct that has not been operationalized to the extent where researchers are able to measure and identify patterns in the interactions between participants in online discussions (Garrison, 2000; Rourke, Anderson, Garrison, & Archer, 2001). To operationalize and measure patterns in student exchanges, studies must examine specific message-response sequences framed within discourse structures associated with specific collaborative tasks (Mandl & Renkl, 1992). At the same time, new computer tools and software are needed to assist researchers in measuring, identifying, and analyzing interaction patterns in online discussions (Pilkington, 1999).

THEORETICAL FRAMEWORK

In this study, the rationale for analyzing patterns in messages exchanged between males and females was based on two assumptions of the dialogic theory of language (Bakhtin, 1981; Koschmann, 1999). The first assumption is that

social dialogue must be viewed as part of a social context in which all possible meanings of a word interact, possibly conflict, and affect future meanings. As a result, conflict and meaning are produced not by the message alone, but by examining the relationship and juxtaposition of alternative viewpoints presented in the message and responses to the message. The second assumption is that meaning is renegotiated and reconstructed as a result of conflict generated in social interactions (cognitive conflict, not interpersonal conflict), and that conflict and the consideration of both sides of an issue are needed to drive further inquiry, reflection, and articulation of individual viewpoints and underlying assumptions to achieve deeper understanding (Johnson & Johnson, 1992; Wiley & Voss, 1999).

These assumptions imply that messages in online discussions should not be analyzed in isolation, as in previous studies, by reporting only the frequency of messages posted by gender (Blum, 1999; Fahy, 2002b, 2003; Herring, 1993, 1999; Savicki et al., 1996). Message frequencies alone cannot explain how males and females exchange messages and responses and how the patterns affect male and female participation. As a result, the theoretical framework used in this study demands a process-oriented and microanalytical approach that examines the relationships or sequencing of messages and responses exchanged between genders in terms of their functional roles during collaborative argumentation. The types of exchange of most interest in this study were those that produced conflict, because conflict was believed to drive discussion and student participation.

INSTRUCTIONAL CONTEXT AND COLLABORATIVE TASK

To identify interaction patterns between males and females, we designed a study to examine male and female exchanges and participation in online debates, where students engaged in collaborative argumentation. Argumentation engages students in the use of transactive reasoning (including justification, criticism, elaboration, clarification, and elaboration of ideas) to test out uncertainties, to extract meaning, and to achieve deeper understanding (McAlister, 2001). Argumentation is also used to investigate and evaluate evidence and alternative arguments (Kruger, 1993). To participate in argumentation, students must be presented with opportunities to discuss, examine, and question controversial issues and complex problems. To acquire the skills of argumentation, students must practice the skills in discussion and in written scholarship (Lipman, 1991). As a result, online debate is believed to help students develop these skills, because it requires students to formulate their thoughts in writing as they participate in discussions (Baker, 1999).

However, the efficacy of this collaborative argumentation rests on the assumption that controversy is the force that drives inquiry and the construction of knowledge and meaning, which in turn drives discussion and student participation. This assumption also serves as the dividing line that differentiates the communication styles of males and females. As a result, predictions can be made on how communication styles affect the way males and females exchange messages, and how specific patterns of interaction affect gender participation in argumentative discourse. Furthermore, gender differences in participation are most likely to appear in discussions of this nature (Herring, 2000), particularly when the topic of discussion is contentious in nature (Savicki et al., 1996).

Finally, argumentation is a task that has clearly established processes and discourse structures (Toulmin, 1958) that can facilitate the process of operationalizing and measuring interaction patterns in online discussions—a major challenge that has not yet been adequately addressed in previous CMC research (Garrison, 2000; Rourke et al., 2001). Essentially, the discourse structures of argumentation help to narrow the scope of analysis to specific speech acts and sequences of speech acts often observed during argumentation, therefore making the systematic study of group interaction possible (Mandl & Renkl, 1992).

PURPOSE OF STUDY

The purpose of this study was to identify interaction patterns between males and females, and to examine how these patterns influence the way males and females participate in online debates. As a result, we examined in this study what may be commonly held and possibly inaccurate assumptions about gender participation and gender interactions in online discussions based on current, but limited, knowledge of gender differences in communication style. Based on the assumptions of the dialogic theory and previous findings on gender differences in communication styles, we specifically examined the following hypotheses:

1. (a) *Male messages elicit more challenges from males than from females.*
(b) *Female messages elicit more challenges from males than from females.*

These hypotheses were based on previous studies that show males are more likely than females to engage in argumentative discourse (Fahy, 2002a & 2002b; Herring, 1993, 1999; Tannen, 1990, 1994); the assumption that participants will engage in discussion with others who share similar communication styles; and the perception that females who engage in confrontational exchanges are often

negatively seen by others as dominating, bossy, or emotional (Butler & Geis, 1990) and thus, their contributions are less accepted by others in the group (Flanagin, Tiyaamornwong, O'Connor, & Seibold, 2002).

2. *Male and female critiques elicit more personal rebuttals from males than from females.* This hypothesis was based on the assumptions that rebuttals are likely to prolong and possibly increase the level of emotional intensity between discussants; a female who prolongs a confrontation further increases the likelihood of being perceived by others as dominating, bossy, or emotional (Butler & Geis, 1990); and males are more likely to persist in confrontational engagements given their preference for argumentative styles of communication.
3. The types of messages posted by males and females will differ in frequency, with males posting more critiques and elaborations than do females. Males were predicted to post more critiques because previous research shows that males are more likely than females to challenge others (Tannen, 1990, 1994), and Hypothesis 1 predicted that male messages elicit more challenges from males than from females, and female messages elicit more challenges from males than from females. Males were predicted to post more elaborations than were females, based on the Hypothesis 2 prediction that challenges elicit more personal rebuttals (or elaborations) from males than from females.

METHOD

Participants

The participants ($n = 19$) were graduate students from a major university in the Southeast region of the United States. They consisted of 8 female and 11 male students, ranging from 20 to 40 years in age. The students were enrolled in a 16-week online graduate course on theories of learning and cognition as required to complete a master's program in instructional systems with a major in distance learning. The gender of each student was determined at the beginning of the online course through personal introductions and posted biographies. All students in the course agreed to participate in this study.

Debate Procedures

Students participated in a series of five weekly debates that critically examined the assumptions of particular theories of learning and cognition studied in the

course. For example, students debated position statements such as “Knowledge cannot be instructed or transmitted by a teacher—it can only be constructed by the learner” to study the cognitive versus constructivist paradigms. Students were instructed to support or refute presented claims by posting arguments, evidence, explanations, critiques, evaluations of arguments, and messages for group maintenance.

Each debate was conducted in a threaded discussion forum in Blackboard, a Web-based course management system. The debates were highly structured:

- Student participation in the weekly debates and discussions in the course contributed to 20% of the course grade.
- Prior to each debate, students were randomly assigned to one of two teams (but balanced by gender) to either support or oppose a given position.
- Students were required to post a minimum of four messages to receive full credit for each debate.
- Immediately following each debate, student votes were used to determine which team won the debate.

Online Debate Messages and Message Labels

In the debates, students were restricted to posting specific types of messages to serve specific functions. Students were presented a list of nine response categories during each debate (see Figure 1) based on Toulmin’s (1958) model of argumentation and the content analysis of online debates from a previous study (Jeong, 2003). Students were required to classify each posted message by category by inserting the corresponding label into the subject headings of each message, and limit the content of each message to address one, and only one, category at a time. Included with the message labels were tags to identify team membership—*o* for opposing and *s* for supporting team (e.g., ARGs [argument, supporting], ARGo). These labels were intended to help students locate exchanges between opposing team members (e.g., ARGs → CRITo [critique, opposing]) and respond to those exchanges to advance the discussion. The labels were also intended to make the interrelationships between messages and responses explicit so that students could better visualize and monitor the structure and status of each argument. No participation points were awarded for a given debate if students failed to properly label their messages. The experimenter occasionally checked for errors in the message labels and allowed students to return to previous messages to correct for errors in their labels.

An example discussion thread is illustrated in Table 1. For illustrative pur-

Figure 1 □ Illustration of an online debate with the nine presented response categories and the student-labeled messages posted within the Blackboard discussion forum.

The screenshot shows a web browser window displaying a Blackboard discussion forum. The interface includes a navigation bar at the top with options like 'Back', 'Forward', 'Reload', and 'Home'. Below this is a search bar and a toolbar with icons for actions such as 'SELECT ALL', 'UNSELECT', 'INVERT', 'READ', 'UNREAD', 'COLLECT', 'LOCK', 'UNLOCK', and 'REMOVE'. The main content area is a list of messages, each with a checkbox, a subject line, a sender name, a timestamp, and a 'New' status indicator. The messages are organized into a hierarchical structure with expandable/collapsible icons. A legend on the left side of the page defines response categories: POS (Simple statement of position), ARG (Main argument or assertion), EVID (Support argument with evidence), CRIT (Critique, test/question validity), QUES (Ask question for clarification), ELAB (Elaborate/clarify without defending/challenging), EVAL (Evaluate, review, compare), JUDG (State a judgment to refute or accept), and OTH (Other comments regarding process, procedures, jokes, acknowledgements, etc.).

Category	Message Subject	Sender	Timestamp	Status
	Read Instructions carefully	Instructor	Mon Feb 11 2002 12:32 pm	
	POSo - Agreement	Student10	Mon Feb 11 2002 9:20 pm	New
	ARGo Learning vs Knowledge	Student14	Mon Feb 12 2002 12:53 pm	New
	EVIDs Learning vs Kno...	Student10	Tue Feb 12 2002 9:42 pm	New
	QUESo	Student03	Wed Feb 13 2002 9:32 pm	New
	OTHs	Student15	Sat Feb 16 2002 1:52 pm	New
	OTHs: Learning vs ...	Student18	Sun Feb 17 2002 10:10 am	New
	EVIDs - I agree with you	Student09	Fri Feb 15 2002 6:49 pm	New
	POSo - Flawed statement	Student04	Mon Feb 11 2002 7:44 pm	New
	EVIDo Re: POS - Flawed sta...	Student11	Mon Feb 11 2002 8:53 pm	New
	OTHo Re: EVID(O) Re:...	Student04	Tue Feb 12 2002 6:37 pm	New
	CRITs Instruction vs Learn...	Student12	Wed Feb 13 2002 12:10 pm	New
	EVIDs	Student13	Thu Feb 14 2002 6:39 pm	New
	POSo Teacher guides experience	Student08	Mon Feb 11 2002 9:16 pm	New
	CRITs Guidance is not Know...	Student10	Mon Feb 11 2002 9:24 pm	New
	POSo Literal Interpretat...	Student15	Sat Feb 16 2002 2:03 pm	New
	POSo Re: POSo Teacher guid...	Student04	Wed Feb 13 2002 11:28 am	New
	CRITs Self-teaching	Student13	Thu Feb 14 2002 7:20 pm	New
	ARGo Re: CRITs Self...	Student04	Thu Feb 14 2002 7:37 pm	New
	ELABs complex lear...	Student13	Sat Feb 16 2002 4:31 pm	New
	OTHo Re: ELAB...	Student04	Sat Feb 16 2002 7:36 pm	New
	EVIDs Invention	Student12	Sat Feb 16 2002 12:33 am	New
	CRITs Instructional Mistruths	Student09	Fri Feb 15 2002 7:16 pm	New
	ARGo learning, right or ...	Student16	Sat Feb 16 2002 11:14 am	New
	POSo Somewhere in ...	Student14	Sat Feb 16 2002 5:05 pm	New
	OTHs Seeing Both ...	Student10	Sun Feb 17 2002 8:05 pm	New

Note: The students' names were present during the discussions, but they are not presented in the figure above in order to protect the identity of the participants in this study.

poses, the actual text has been paraphrased and abbreviated, and gender tags have been added to the labels. The message-response sequences were determined by referring to the hierarchical structure of the threaded messages. For example, Message 1 (ARGm) received two responses in Message 2 (ARGf) and Message 6 (CRITm). Message 6 (CRITm) received two responses from Message 7 (CRITm) and Message 10 (ARGf).

Message labeling was used for the primary purpose of establishing each message as the unit of analysis so that specific message-response sequences (e.g., ARG → CRIT, CRIT → ELAB [elaboration]) could be clearly identified and counted to determine their relative frequencies. Examining message-response sequences has been found to be a major challenge in previous studies on group interaction in CMC (Gunawardena, Lowe, & Anderson, 1997; Newman, Johnson, Cochrane, & Webb, 1996) because messages often address multiple functions at the same time. As a result, producing an accurate map of the

Table 1 □ Example discussion thread with student-labeled messages.

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1. **ARGm:** To say that “knowledge cannot be instructed or transmitted aby a teacher, but can only be constructed by the learner” is an overgeneralization. It would make teachers obsolete.
 2. **ARGf:** Excellent argument. It is the symbiotic relationship between teacher and student that enables learning to take place. The teacher must provide guidance to the learner.
 3. . . . **EVALm:** This is a well-reasoned commentary. I agree with these contentions, but I believe that what has not been explained is how a learner constructs new ideas stemming from new theories or perspectives. Although I side with the opposition, I believe there must be a middle ground that recognizes that learners can construct knowledge.
 4. **ELABf:** A self-taught person can only construct new ideas until they have learned the prerequisite information and skills needed to construct the new knowledge.
 5. **OTHm:** Very well stated about the conditions of self-taught individuals. I thought that was a good comeback.
 6. **CRITm:** What teachers transmit is not knowledge, but accumulated *information*. We use this information as tools to construct new knowledge. By analogy, we need access to tools and materials to construct a house. The transmission and access to tools and information simply facilitates the construction of a house.
 7. . . . **CRITm:** But I would argue that teachers can and do transmit knowledge or information. What you are saying instead is that *NEW* knowledge (or building an architecturally unique house) cannot be instructed by a teacher and must be constructed by the learner. And that is an entirely different argument.
 8. **CRITf:** But not all learned knowledge is instructed. I learned how to build houses by mainly watching my father build houses and learned through practice. I never received any formal instruction.
 9. **.EVALm:** From what has been said thus far, some learning result from instruction and some do not. From an epistemological standpoint, this is consistent with Constructivists’ acceptance and synthesis of cognitive learning theories and principles.
 10. . . . **ARGf:** Although there is truth to what you say, most of the skills and tools used to build a house is passed down from one generation to the next through and are not reconstructed. In other words, we generally try to avoid the mistake of always trying to “recreate the wheel”.
 11. **EVIDm:** Your ideas are consistent with what Driscoll states in Chapter 3 of the textbook. Teacher input is important and so is their assessment of the learner’s performance in order to ensure performance is to established standards.
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relationships between messages and responses has been found to be a task that is extremely difficult if not impossible to accomplish. Although message labeling may appear to be artificial and perhaps intrusive, this method has been implemented in a number of computer-supported collaborative argumentation systems to scaffold and teach the processes of argumentation and prob-

lem solving (Carr & Anderson, 2001; Cho & Jonassen, 2002; McAlister, 2003; Sloffer, Dueber, & Duffy, 1999; Veerman, Andriessen, & Kanselaar, 1999). Nevertheless, message labeling could significantly alter patterns of interaction between males and females compared to the patterns produced without the use of message labeling. The precise effects of message labeling on group interaction patterns in general has not yet been fully investigated and preliminary findings are not yet conclusive (Jeong & Juong, in press).

Data Analysis

Data preparation. Computer software was written by the principal author to download, tabulate, and compile the student-labeled messages from the Blackboard discussion forums into Microsoft Excel®. All messages with the label *judgment* were reassigned with the *evaluation* label because few judgment messages were observed and because they were indistinguishable from evaluation messages. The Question and Critique categories were also combined for the same reasons. Messages that were assigned the *position* label were reassigned with the *argument* label because all position statements posted by students included a supporting argument.

The experimenter tagged each label with *f* for female and *m* for male (e.g., ARGf, CRITm), based on the gender of its author. The gender of each participant was established at the beginning of the course, and therefore, the gender of each message could be identified by referring to the student names displayed with each message posted to the discussion forums. The tags *o* and *s* used to identify team membership were not used in this study in order to reduce the total number of possible message categories from 24 (6 Categories \times 2 Teams \times 2 Genders = 24) to 12 (6 Categories \times 2 Genders), minimize the total number of possible message-response exchanges from 576 (24 \times 24) to 144 (12 \times 12), and maximize the cell frequencies for each observed message-response exchange. The 12 response categories were ARGf, EVIDf (supporting evidence, female), CRITf, ELABf, EVALf (evaluation, female), OTHf (other process comments, female), and ARGm, EVIDm, CRITm, ELABm, EVALm, OTHm.

Interrater reliability. A total of 570 messages were observed in the five online debates. Table 2 shows the number of messages posted per student across each message category. A total of 236 messages from the second and fourth debates were coded by the experimenter. Cohen's kappa (0.60) was calculated to reveal good interrater reliability (Bakeman & Gottman, 1997, p.66) between the message labels assigned by the students versus the labels assigned by the experimenter. Among the messages that were labeled as critiques (the one

message category from which all three research hypotheses were grounded), the percent of agreement was 95%.

Statistical analysis. To control for experiment-wise Type I error, each of the four hypotheses was tested against the Bonferroni adjusted alpha value of $p = .05/4 = .0125$. Hypothesis 1, parts (a) and (b), were tested by using two independent sample *t* tests. In the first *t* test, the dependent variable was the mean number of critiques posted by males and females in response to messages from males. In the second *t* test, the dependent variable was the mean number of critiques posted by males and females in response to messages from females. The gender of the participant that received the critique served as the independent vari-

Table 2 □ Frequency of messages posted per student across all message categories.

<i>Gender</i>	<i>ARG</i>	<i>EVID</i>	<i>CRIT</i>	<i>ELAB</i>	<i>EVAL</i>	<i>OTH</i>	<i>n</i>
f	12	4	0	0	2	7	25
f	10	1	8	1	4	2	26
f	2	0	0	1	0	1	4
f	6	5	12	3	1	2	29
f	6	6	8	5	5	3	33
f	12	2	4	4	5	3	30
f	2	1	2	6	7	7	25
f	7	13	3	5	9	5	42
m	11	10	7	7	5	5	45
m	2	4	8	11	7	1	33
m	10	3	5	10	2	2	32
m	22	3	3	7	4	11	50
m	9	0	1	2	1	2	15
m	8	3	7	4	1	0	23
m	3	2	2	1	3	3	14
m	2	2	0	3	7	7	21
m	15	8	10	1	10	15	59
m	9	6	9	2	5	2	33
m	4	4	1	12	7	3	31
152	77	90	85	85	81	570	

Note: ARG = argument, EVID = supporting evidence, CRIT = critique, ELAB = elaboration, EVAL = evaluation, OTH = other process comments.

able. In Hypothesis 2, a one-way analysis of variance (ANOVA) was used to test for differences in the mean number of personal rebuttals posted by males in response to male critiques, by males in response to female critiques, by females in response to male critiques, and by females in response to female critiques. In this case, the independent variable was type of gender exchange (e.g., male-to-male—MM, female-to-male—FM, male-to-female—MF, and female-to-female—FF). In Hypothesis 3, a 2 (Gender) \times 6 (Message Category) univariate ANOVA was used to test for gender differences in the mean number of arguments, evidence, critiques, elaborations, evaluations, and other comments (dependent variable) posted by males and females (independent variable).

Exploratory analysis. Sequential analysis (Bakeman & Gottman, 1997) was used to explore and identify other patterns of interaction between genders by determining (a) the frequency of specific response types to specific message types, based on the observed frequencies, (b) the transitional probabilities between messages and responses that reflect how likely specific types of messages elicit specific types of responses; and (c) the transitional probabilities that are higher and lower than the frequencies that might be expected if the responses had been randomly distributed across message categories based on z-score tests formulated by Bakeman and Gottman (pp. 108–111). This method has been used extensively in human communications research to study, for example, communication patterns between spousal partners (Bakeman & Gottman, pp. 184–193; Gottman, 1979), children at play (Bakeman & Brownlee, 1982), mother and infant (Stern, 1974), and humans and computers (Olson, Herbsleb, & Rueter, 1994).

The discussion analysis tool (DAT; Jeong, 2005), was developed in previous studies (Jeong, 2003, 2004) and used to compute the transitional probabilities between messages and responses. Figure 2 displays an excerpt from one online debate that illustrates how the transitional probabilities were computed. For example, CRIT_m (Message 6) elicited two direct responses in Message 7 (CRIT_m) and Message 10 (ARG_f). The CRIT_m in Message 7 elicited one direct response in Message 8 (CRIT_f). As a result, CRIT_m messages elicited a total of three responses (CRIT_m, ARG_f, and CRIT_f), resulting in a total of three response types each occurring once in frequency. As a result, 33% of responses to CRIT_m were CRIT_m, 33% were ARG_f, and 33% were CRIT_f. A transitional probability matrix consisting of 144 (12 \times 12) cells was produced by DAT to show the transitional probabilities for every possible pairing of messages and responses. Subsets of the transitional probabilities were selected and converted by DAT into transitional state diagrams to provide a means to visually identify potential differences in response patterns between MM versus FF

exchanges and the types of responses most likely to follow specific message-response exchanges (e.g., ARG → CRIT → ELAB).

RESULTS

Responding to Messages with Critiques

The results did not support the hypothesis that male messages are more likely to elicit challenges from males than from females. In the gender comparison of the mean number of critical responses to male messages, males ($M = 3.0$, $SD = 2.43$, $n = 11$) did not differ significantly from females ($M = 3.0$, $SD = 3.25$, $n = 8$), $t(17) = 0.07$, $p = .94$, effect size = 0. Thus, females were just as likely as males to challenge the claims of males.

The findings did not support the hypothesis that female messages are more likely to elicit challenges from males than from females. In the gender comparison of the mean number of critical responses to female messages, males ($M = 1.73$, $SD = 1.35$, $n = 11$) did not differ significantly from females ($M = 1.63$, $SD = 1.41$, $n = 8$), $t(17) = 0.16$, $p = .87$, effect size = 0.04. Thus, females were just as likely as males to challenge the claims of females.

Although males outnumbered females 11 to 8 and, thus, more male than female critiques were anticipated, the mean number of critical responses to male and female messages posted by males and females were still not statistically significant. Nevertheless, the observed means were tested against the expected means in a posthoc analysis to confirm the findings above. To compute the expected mean number of male critiques posted in response to male messages, for example, the total number of critiques posted by males ($n = 53$) was divided by the total number of males in debates ($n = 11$). This product was multiplied by the percentage of the total messages posted by males (354 of 570 = 62%) to arrive at the expected mean of 3.01. This was compared to the observed mean of 3.00 using a one-sample t test at alpha $p = .01$. The posthoc tests revealed no significant differences between the observed and expected mean number of critical responses within each of the four possible message-critique exchanges between genders—MM, MF, FM, and FF (see Table 3). This posthoc test confirmed that there were no discernible differences in the way male and female messages elicited male and female critiques while controlling for differences in the number of males and females participating in the debates.

Responding to Critiques with Personal Rebuttals

The one-way ANOVA yielded no significant gender differences in the mean number of personal rebuttals elicited by FF, MM, MF, and FM exchanges, $F(3,85) = 1.29$, $p = .28$. Per female critique, the mean number of female rebuttals

Table 3 □ Comparison of observed versus expected number of critiques posted in response to messages across gender exchanges.

	<i>M</i>	<i>SD</i>	<i>n</i>	<i>exp value</i>	<i>t value</i>	<i>df</i>	<i>p</i>	<i>effect size</i>
M-Mcrit	3.09	2.43	11	3.01	.111	10	.91	+0.03
F-Mcrit	1.73	1.35	11	1.81	-.203	10	.84	-0.06
M-Fcrit	3.00	3.25	8	2.89	.096	7	.93	+0.03
F-Fcrit	1.63	1.41	8	1.74	-.231	7	.82	-0.08

Note: M-Mcrit = Male critique of a male's message, F-Mcrit = Male critique of a female's message, M-Fcrit = Female critique of a male's message, F-Fcrit = Female critique of a female's message. The expected mean number of male critiques posted in response to male messages = (the total number of critiques posted by males, $n = 53$) divided by (the total number of males in debates, $n = 11$) multiplied by the percentage of the total messages posted by males, 354 of 570 or $62\% = 3.01$.

elicited was .08 ($SD = .28$, $n = 13$) versus .38 ($SD = .49$, $n = 24$) for males. Per male critique, the mean number of female rebuttals elicited was .28 ($SD = .46$, $n = 18$) compared to .32 ($SD = .47$, $n = 34$) for males.

However, a closer examination of the results revealed that the mean numbers of rebuttals to critiques were very similar between the MM, MF, and FM exchanges, but were substantially lower in the FF exchanges. The similarities in mean scores between the MM, MF, and FM exchanges could have contributed to the no significant differences found in the one-way ANOVA. As a result, exploratory posthoc comparisons were conducted to specifically compare the mean number of rebuttals generated between MM versus FF, MF versus FF, and FM versus FF exchanges. The posthoc comparisons revealed that FF exchanges elicited four times fewer rebuttals than MM exchanges, $t(45) = -1.75$, $p = .086$, effect size = -0.63 ; FF exchanges elicited almost five times fewer rebuttals than the MF exchanges, $t(35) = -2.0$, $p = .053$, effect size = -0.74 ; and FF exchanges elicited 3.5 times fewer rebuttals than the FM exchanges, $t(29) = -1.39$, $p = .17$, effect size = -0.53 .

Differences in Message Types Posted by Males and Females

The 2×6 univariate ANOVA (Gender \times Message Categories) revealed no significant main effect for gender, $F(1, 102) = 1.60$, $p = .20$. Thus, no evidence was found to support the hypothesis that the frequency of posted arguments, evidence, critiques, elaborations, evaluations and other statements differs

between males versus females (see Table 4). We found that females posted an average of 4.63 critiques and males posted an average of 4.82 critiques. Furthermore, females posted an average of 4.0 messages with supporting evidence and males posted an average of 4.09 messages with supporting evidence. Although no significant differences were found in the response frequencies between genders overall, the results in Table 4 still suggest a male tendency to post more elaborative messages (5.45) than females (3.13).

The main effect across message category in the ANOVA revealed significant differences between the mean number of messages posted across message categories, $F(5, 102) = 2.62, p = .028$. Tukey's posthoc test was used to compare pair-wise differences between message categories. The mean number of arguments posted per student (male and female together) was significantly greater than the mean number of messages posted as evidence ($p = .024$) and other comments ($p = .038$). Differences approaching statistical significance were found between the mean number of arguments and the mean number of critiques ($p = .06$) and elaborations ($p = .06$) posted per student.

The interaction between gender and message category was not found to be significant, $F(5, 102) = .22, p = .95$, suggesting that the distribution of message categories posted in the debates did not significantly differ between males and females.

Table 4 □ Mean number of postings by gender across message categories.

Gender	Statistic	Message Category						Overall
		ARG	EVID	CRIT	ELAB	EVAL	OTH	
Female	<i>M</i>	7.13	4.00	4.63	3.13	4.13	3.75	26.75
	<i>STD</i>	3.98	4.21	4.31	2.23	3.04	2.31	10.77
	<i>n</i>	8	8	8	8	8	8	48
Male	<i>M</i>	8.64	4.09	4.82	5.45	4.73	4.64	32.36
	<i>STD</i>	6.07	2.88	3.57	4.13	2.87	4.63	14.28
	<i>n</i>	11	11	11	11	11	11	66
Total	<i>M</i>	7.88	4.05	4.72	4.29	4.43	4.19	4.93
	<i>STD</i>	5.22	3.39	3.78	3.58	2.87	3.77	12.90
	<i>n</i>	19	19	19	19	19	19	114

ARG = argument, EVID = evidence, CRIT = critique, ELAB = elaboration, EVAL = evaluation, OTH = other process comments.

Exploratory Analysis of Interaction Patterns Between Genders

To identify other patterns in gender exchanges that might help to explain some of the observed similarities and differences in gender participation, sequential analysis was used to produce the transitional probability matrix in Table 5, which shows how often given types of messages elicited given types of responses based on gender along with the transitional probabilities that were higher and lower than the expected frequencies. This analysis revealed higher than expected frequencies (or response patterns) in seven areas: (a) female responses to male arguments with critiques; (b) male responses to female arguments with supporting evidence; (c) male responses to male critiques with counter critiques; (d) male responses to other male elaborations with more elaboration; (e) male responses to other male evaluations with more evaluations; (f) male responses to other statements of females with other statements; and (g) female responses to other statements of males with other statements.

Using an experimental technique formulated by the principal experimenter, the observed frequencies in the lower-right quadrant of the transitional probability matrix (in Table 5) were examined in isolation in order to gain insight into what might happen if the debates had been conducted in an all-male group. These frequencies alone were then used to recompute the transitional probabilities and z scores, and to generate the state diagram at the top of Figure 2 representing the interactions produced between males only. Using the same procedure, the observed frequencies in the upper-left quadrant of the matrix were used to generate the bottom state diagram in Figure 2 to examine the interactions produced between females only. A visual comparison of the diagrams suggests that male-only exchanges produced a more diverse range of responses to arguments and critiques. In comparison, female-only exchanges tended to exhibit a more structured pattern of responses to arguments and critiques—arguments tending to elicit mostly critiques and evidence, and critiques tending to elicit mostly counter critiques, supporting evidence, and counterarguments.

A closer examination of the diagrams reveals response patterns to suggest that when females chose to respond to a female's argument, the females were more likely to respond with critiques (41% of all female responses to female arguments) than with any other type of response (e.g., 24% of responses with evidence, and 18% with counterarguments). In contrast, only 20% of the responses elicited by male arguments were male critiques, which is half the probability of eliciting female critiques from female arguments. These differences in response patterns suggest that an all-female debate might produce more argument-critique exchanges than an all-male debate and that females might produce more critiques than males if participants were required to

respond to all arguments. Given that 8 of the 19 participants in this study were female, these response patterns altogether would help to explain why in this study no significant differences were found in the mean number of critiques posted by males and females. Furthermore, the diagrams indicate that male elaborations were elicited in 19% of the responses to male critiques, whereas female elaborations were elicited in only 9% of responses to female critiques. These response patterns would suggest that an all-female debate would not only produce fewer personal rebuttals to critiques (as found in this study), but would also produce fewer elaborative messages compared to the number of elaborative messages that might be produced in an all-male debate.

These response patterns provide some clues to how females might perform in all-female debates and how males might perform in all-male debates. However, these findings are speculative at this point because it is not yet known how patterns in FF exchanges differ when females have the option of responding or not responding to messages from males, and vice versa. As a result, the findings from this exploratory analysis will need to be verified in a controlled experimental study to determine if this particular technique of partitioning process data by gender can generate findings that are consistent with findings produced under controlled conditions (e.g., comparing all-female to all-male groups) and, as a result, be used in single-group studies (as opposed to controlled studies) to study group interaction and gender participation.

DISCUSSION

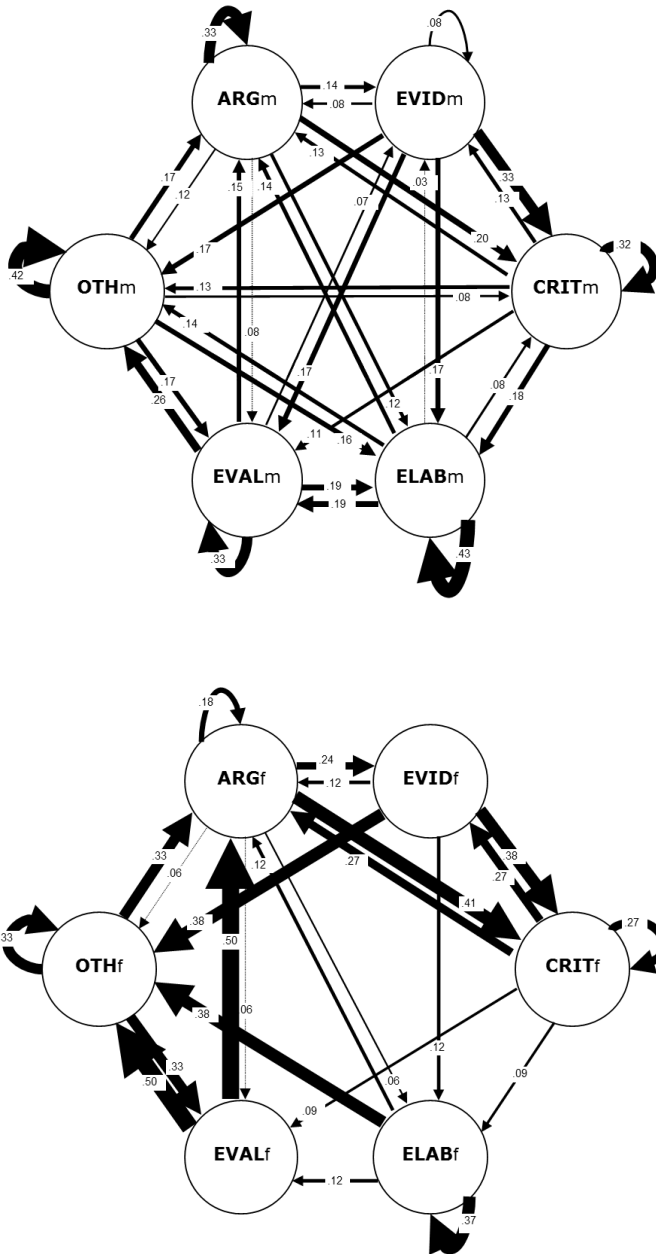
The purpose of this study was to examine how males and females participate and interact when asynchronous discussion forums are used in combination with message labeling to facilitate collaborative argumentation. Based on the assumptions that males are more likely than females to engage in argumentative discourse, that social interaction is required to produce conflict, and that conflict is what drives further inquiry, we hypothesized that (Hypothesis 1a) male messages elicit more challenges from males than from females; (Hypothesis 1b) female messages elicit more challenges from males than from females; (Hypothesis 2) male and female critiques elicit more personal rebuttals from males than from females; and (Hypothesis 3) the types of messages posted by males and females will differ in frequency, with males posting more critiques and elaborations than females post. However, the findings in this study (although not conclusive) did not support our hypotheses, which suggests that our assumptions on how males and females participate and interact online during critical discourse may not be entirely accurate. The females in this study were just as likely as males to respond to males *and* females with

Table 5 □ The transitional probability matrix produced by the discussion analysis tool (DAT).

	ARGf	EVIDf	CRITf	ELABf	ELABf	VALf	OTHf	ARGm	EVIDm	CRITm	ELABm	ELABm	VALm	OTHm	Replies	No Replies	Given	Reply Rate—%
ARGf	.05	.06	.11	.02	.02	.02	.02	.16	.20	.19	.11	.05	.03	.64	14	57	75	
EVIDf	.04	.00	.12	.04	.00	.16	.16	.12	.16	.12	.08	.04	.12	.25	15	32	53	
CRITf	.09	.09	.09	.03	.03	.00	.00	.18	.12	.06	.09	.15	.09	.34	10	37	73	
ELABf	.05	.00	.00	.15	.05	.15	.15	.05	.10	.05	.10	.10	.20	.20	9	25	64	
VALf	.06	.00	.00	.00	.00	.06	.06	.18	.06	.06	.18	.24	.18	.17	17	33	48	
OTHf	.09	.00	.00	.00	.09	.09	.09	.09	.00	.00	.00	.27	.36	.11	20	30	33	
ARGm	.10	.05	.15	.05	.06	.06	.00	.20	.09	.12	.07	.05	.07	.82	36	95	62	
EVIDm	.05	.05	.11	.03	.13	.00	.00	.05	.05	.21	.11	.11	.11	.38	20	45	56	
CRITm	.05	.07	.05	.04	.04	.05	.05	.11	.09	.21	.13	.07	.09	.56	15	53	72	
ELABm	.02	.05	.07	.10	.10	.02	.02	.09	.02	.05	.28	.12	.09	.58	21	60	65	
VALm	.03	.00	.00	.08	.08	.13	.13	.10	.05	.00	.13	.23	.18	.39	22	52	58	
OTHm	.04	.00	.04	.00	.04	.38	.38	.08	.00	.04	.08	.08	.21	.24	29	51	43	
n =	26	20	37	22	26	28	28	59	41	53	57	48	51	468	228	570	59	

Note: ARG = argument, EVID = supporting evidence, CRIT = critique, ELAB = elaboration, EVAL = evaluation, OTH = other process comments, f = female, m = male. Replies = observed number of replies posted to each message type; No Replies = number of messages that did not receive a reply; Given = number of messages observed; Reply Rate = percentage of messages that elicited at least one reply. The transitional probabilities in bold font and underlined were significantly greater than the expected probability (1/12 categories = .083) based on z score tests with $p > .01$. Values in bold and in parenthesis were significantly less than the expected probability.

Figure 2 □ Transitional state diagram of the male-only and female-only exchanges.



challenges. Although there were strong indications that FF exchanges elicited fewer rebuttals than MM, MF, and FM exchanges, these differences were not statistically significant. Furthermore, no differences were found in the number of arguments, supporting evidence, critiques, elaborations, and evaluations posted by males and females.

No Differences in Responding to Messages with Critiques

A number of factors might explain why the females in this study were just as likely as males to challenge other participants. Some of the possible factors are the small sample size observed in the study, the specific procedures used during the debates to encourage argumentation (e.g., message labeling, dividing students into opposing teams, using the debate format, requiring minimum postings), and the high MF ratio in the discussion groups. Given that the majority of the participants in this study were male, it is possible that the females modified their communication styles in the direction of the majority gender (Baym, 1996; Herring, 1996). This type of behavior in theory could have been facilitated by the use of message labels because the labels could have attuned the participants to how other participants were behaving in the debates. These factors might explain why the females in this study challenged the arguments of males at much higher than expected frequency, and why the females were just as likely as males to challenge any participant in the debates (male or female). Nevertheless, more research is needed to verify our findings and their underlying causes.

Potential Differences in Responding to Critiques with Personal Rebuttals

Although the differences were not statistically significant, there were nevertheless strong indications that FF exchanges tended to elicit fewer personal rebuttals than MM, MF, and FM exchanges. In particular, we found in the posthoc analysis that the FF exchanges elicited four times fewer rebuttals than MM exchanges, and five times fewer rebuttals than the MF exchanges (with moderate effect sizes and *p* values approaching significance). One plausible explanation for the low number of rebuttals following the FF exchanges is that the females may have felt less inclined than males to rebut a challenge because a rebuttal might prolong a confrontation, lead others to perceive them as dominating and emotional, and affect how their contributions are accepted by others (Butler & Geis, 1990). More data and a larger student sample will be needed to verify these observed patterns of interaction between males and females, and their underlying causes. Nevertheless, these findings (although not con-

clusive) are consistent with the findings of previous studies that show that males possess a stronger preference than females to engage and persist in argumentative dialogue (Fahy, 2002a; Herring, 1993; Tannen, 1994). At the same time, however, these findings also suggest that the assumption that conflict drives further inquiry is less applicable in FF exchanges than in other gender exchanges.

No Differences in Messages Types Posted by Males and Females

In this study, we predicted that males would post more critiques and elaborative statements than females because the findings of previous studies show that males exhibit a greater tendency to engage and persist in confrontational exchanges than females (Fahy, 2002a; Herring, 1993; Tannen, 1994). However, our findings showed no such differences between genders. Some possible explanations for this finding come from the response patterns found in this study. No gender differences were found because:

- Females exhibited a stronger than expected tendency to critique the arguments of males.
- When females chose to respond to female arguments, their responses were twice as likely to be critiques than the male responses to male arguments.
- Females posted rebuttals to the critiques of males nearly as often as did the males.
- Males exhibited a stronger than expected tendency to respond to female arguments with supporting evidence.

These response patterns may have contributed to the similarities, rather than to the differences, in the number of critiques, supporting evidence, and elaborations posted by males and females.

Instructional Implications

Overall, a comparison of the findings from this study and previous studies highlights some important implications regarding the strategies and procedures used to facilitate critical discourse. It is important to note that any variation in the number or combination of strategies used to structure critical discourse can have a broad range of effects on gender participation and interaction patterns. As a result, the strategies used to structure discourse must be carefully considered when interpreting findings reported in past and future studies on gender participation. Secondly, strategies should be selected based on their ability to foster patterns of interaction that minimize gender differ-

ences in participation (e.g., frequency of posted critiques). Otherwise, strategies can be selected primarily to improve the overall performance of the group (e.g., minimize the number of arguments and critiques left unchallenged and unsupported) rather than the performance of individuals (male or female). Group performance can be improved, for example, by assigning specific roles to individuals (e.g., information provider, the critique, etc.) based on the individual's gender, preferred communication style, and the desired types of interactions he or she is likely to produce as a result of assigning individuals to specific roles.

Although no significant differences were found overall in the number of rebuttals posted by males and females in this study, the posthoc analysis revealed that females posted fewer rebuttals to the critiques of females than did males, and males posted more rebuttals to the critiques of females than did females. These types of interaction patterns, if not appropriately addressed, could have broad implications on group performance (particularly in all-female groups) because the process of explaining and justifying arguments is an important process in effective problem solving (Johnson & Johnson, 1992). As a result, appropriate strategies are needed to ensure that all participants are able to fully engage in the key processes that advance critical discourse. For example, students can be required to respond personally to challenges and use supportive language when presenting critiques (e.g., greetings, I-agree-but, acknowledgments, thank yous, reply invitations) in order to convey their receptiveness to alternative viewpoints and to encourage others to reciprocate responses (Fahy, 2003; Jeong, 2006).

Implications for Future Research

The findings in this study provide insight into some of the processes and nuances of group interaction in online discussions and, further, insight into how gender can affect the processes of critical discourse. Nevertheless, our findings are not conclusive because of limitations in the design and scope of the study. Future research will need to examine interaction patterns across a larger sample of students, control for variations in male-female ratios, examine multiple discussion groups to prevent the idiosyncrasies of any one group from skewing the findings, replicate the findings across multiple topics and domains, test for gender differences in other message-response sequences (e.g., ARG → EVID, ARG → ELAB) using new or more refined message categories (e.g., CRIT with supportive language → ELAB), identify the patterns that inhibit critical discourse (e.g., +ARG → -ARG), improve the message labeling procedures to increase interrater reliability, and interview students to determine how their perception of other participants affects how they respond

to messages. Most of all, future studies will need to control for the effects of different strategies used to facilitate discourse to determine to what extent each strategy when used alone produces patterns of interaction that facilitate critical discourse and how particular interaction patterns ultimately affect group performance in decision making, problem solving, and learning outcomes.

In terms of the broader implications on future research, the methods and tools demonstrated in this study serve as a guide to conducting future research on other variables that might be associated or influenced by gender, such as anonymous participation, use of supportive language and expressions, use of qualifying versus intensifying terms when stating claims, and analytical versus intuitive thinking. In addition to examining the effects of what or why messages are posted (e.g., argument, critiques) and who posts the messages (e.g., male vs. female), the methods demonstrated in this study can also be used to examine the combined effects of how (e.g., use of supportive language) and when (e.g., response latencies associated with analytical vs. intuitive thinking) messages are posted to create more precise models of group interaction. We hope the methods and software tools presented in this study will help lay the groundwork to building computational models and intelligent discourse environments capable of measuring, detecting, and responding to deficiencies in group interaction patterns. Regardless of whether or not observed patterns of interaction can be generalized to the larger population, the ability to precisely measure and identify interaction patterns as they emerge in a given situation may one day enable us to implement more strategic interventions to optimize individual and group performance in computer-supported environments. □

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