This study examined the effects of computer network technologies on teacher-student and student-student interactions in a writing course emphasizing multiple drafts and collaboration. Two sections used traditional modes of communication (face-to-face, paper, and phone); two other sections, in addition to using traditional modes, used electronic modes (electronic mail, bulletin boards, and so on). Patterns of social interaction were measured at two times: 6 weeks into the semester and at the end of the semester. Results indicate that teachers in the networked sections interacted more with their students than did teachers in the regular sections. In addition, it was found that teachers communicated more electronically with less able students than with more able students and that less able students communicated more electronically with other students.

Patterns of Social Interaction and Learning to Write

Some Effects of Network Technologies

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In 1981, Emig challenged the dominant educational model in the schools, a model that viewed writing as "exclusively a silent and

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solitary activity," and called on teachers to view writing as an activity that "can be enhanced by working in, and with, a group of other writers, perhaps especially a teacher, who give vital response, including advice" (p. 27). A decade later, teachers who adopted collaborative approaches to writing no longer lecture exclusively but also talk with students to monitor what they are learning and to understand how best to structure collaborative activities. In practice, however, learning to write in collaboration with others is difficult. In the traditional writing classroom, time constraints and routines can work against collaboration. For example, a group of teachers who were named as outstanding teachers of writing reported that student conferencing is extremely valuable but difficult to arrange with any frequency (Freedman, 1987). The teacher in a traditional classroom is constrained because logistically it is easier to have everyone on the same time clock. Everyone turns in papers at the same time and receives comments at the same time. It is also hard to arrange for students to give and receive comments from their classmates. It is expensive to reproduce papers for circulation and time consuming to coordinate the sharing of papers.

In the past, these problems plagued collaborative writing programs. But a new technology, word processing plus computer-mediated communication, may help to alleviate some of them. Computer-mediated communication is a text-based tool (e.g., electronic mail and bulletin boards) that can be synchronous or, more frequently, is asynchronous. Unlike computer-based tools for writing that allow an author to check or improve his or her work by interacting only with computer programs or data bases (such as text analyzers or dictionaries), this technology is entirely devoted to letting people communicate with one another. Several characteristics make it uniquely suited to increasing interaction and to expediting collaboration among teachers and students. First, both synchronous and asynchronous computer-mediated communication overcome physical barriers. Teacher and students do not have to be in the same place (e.g., the teacher's office, the classroom, or a dormitory room) to communicate. Of course, the telephone also permits interaction over space—but not over time. More-

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over, people cannot read over the telephone, and providing detailed comments over the telephone is difficult, particularly when only one person has a physical copy of the paper, as is often the case. Second, asynchronous computer-mediated communication is convenient. Senders and receivers do not have to coordinate their communications jointly. Students do not have to wait for a class meeting or an arranged appointment to offer a paper for feedback or to ask questions. Responses from classmates and teachers can be requested when they are most needed. Third, computer-mediated communication, particularly electronic mail, greatly reduces social context cues, even when participants do not use pseudonyms (Dubrovsky, Kiesler, & Sethna, in press; Sproull & Kiesler, 1986). It reduces static social cues, such as clothing and furniture, that remind people of social definitions and social distinctions. It reduces dynamic social cues, such as smiling, frowning, and hesitating, that remind people they are being evaluated. Students who might be anxious or shy about going to the teacher's office or contacting a classmate might feel more confident communicating electronically (Finholt, Kiesler, & Sproull, 1986). Finally, group computer communication tools, such as electronic bulletin boards and distributive mail lists, make it easy to communicate with many people simultaneously over distance, thus providing students with opportunities to communicate in real contexts to a wider audience than just the teacher, both locally within a classroom or school (Rubin & Bruce, 1986), and globally throughout the country or world (Cohen & Riel, 1989; Levin, Riel, Boruta, & Rowe, 1984).

Increased interest in using collaborative activities to teach writing (Bruffee, 1973, 1985; Gere, 1987), increased use of computers to prepare text, and increased access to computer-mediated communication tools have led to the use of asynchronous electronic bulletin boards and electronic mail to extend the writing classroom (Hiltz, 1986; Payne, 1987) and to the use of synchronous electronic communication to give real-time writing feedback (Batson, 1988). However, our understanding of how computer-mediated communication affects patterns of interaction in writing classes is limited (Sheingold, Hawkins, & Char, 1984). The primary goal of the field experiment reported here was to begin exploring this process by comparing interaction in writing classes that had access to networked communication tools with interaction in classes that used traditional modes of communication.

HYPOTHESES

We examined the following general hypothesis:

H1. When the technology is easily accessible and sanctioned, teachers will communicate more with students and students will communicate more with each other because computer-mediated communication may increase opportunities for interaction and decrease its costs. In other words, we expected total communication to increase with the availability and teacher sanctioning of networked communication tools; we did not expect communication via traditional modes to decrease as electronic communication increased.

In addition to examining the overall effects of the availability of computer-mediated communication on interaction, we examined the role of several potential mediating variables—in particular, variables relating to performance, ability, anxiety, and behavioral consistency. While the present study is not designed as a test of any theory of social interaction in learning to write, we used ideas from models of motivational and structuring processes and their effects on social interaction (Turner, 1988) to hypothesize the following consequences of computer-mediated communication for individual students:

H2a. Less able or poorer performing students will be the primary beneficiaries of increased opportunities for communication. On one hand, the classroom ecology literature suggests that brighter, better performing students dominate traditional modes of communication, such as face-to-face interaction, by choosing the front and center classroom seats where interaction is greatest (e.g., Adams & Biddle, 1970; Becker, Sommer, Bee, & Oxley, 1973; Breed & Colaiuta, 1974; Sommer, 1967; see Montello, 1988, for a review). Perhaps these students would dominate these new ways to communicate as well. However, we expected network communication tools to provide less able or poorer performing students with communication opportunities that they might not have in the regular classroom because of efforts to maintain self-esteem, shyness, or slower reaction times.

H2b. Students with higher writing anxiety will interact less about their writing with their teachers and other students via traditional modes of communication than students with lower anxiety. Although a definite cause of writing anxiety has not been established, it seems likely that anxiety over evaluation plays a role (Hillocks, 1986) and, if this is the case, we would expect high-anxiety students to avoid situations in

which their writing may be evaluated. In addition, this negative relationship between anxiety and interaction will be less for communication via computer-mediated modes because it takes place without an exchange of nonverbal cues and social context information that (a) reminds students that they are being evaluated and (b) makes it easier for students to manage self-presentation.

H2c. Students with higher computer anxiety will interact less about their writing via computer-mediated communication modes than students with lower computer anxiety. In an experimental setting, high levels of computer anxiety were shown to be related to poorer task performance, greater state anxiety, self-reported physiological arousal, and debilitative thoughts (Heinssen, Glass, & Knight, 1987). Hence, we expect high levels of computer anxiety to lead to avoidance of using computers.

H2d. Students who communicate more with their teacher and other students at the beginning of the semester will communicate more with their teacher and other students at the end of the semester. The fact that social interactions are repeated across time gives rise to structuring in social interactions. This is a hypothesis of simple behavioral consistency or "routinization" as a predictor of amount of interaction (cf. Turner, 1988).

Finally, and somewhat speculatively, we hypothesized the following about individual teachers:

H2e. More experienced teachers and their students will use electronic communication modes more than less experienced teachers. New computer technologies do not, in and of themselves, create educational improvements; instead, they create opportunities for improvements. Realizing such opportunities typically requires teachers and students to reconceptualize ways of teaching and learning in order to exploit the technology's potential for enhancing classroom goals. As Rubin & Bruce (1990) observed, "in general, teachers and students create *new practices* that reflect complex and situation-specific combinations of old and new approaches" (p. 2). If realizing a technological innovation is a complex problem-solving process in which teachers and their students must reason about the potential of the new technology in order to create practices that meet classroom goals, then we might expect that experienced teachers will be more effective in realizing the potential of new technologies. Research suggests that experienced teachers have more developed knowledge structure about learning, teaching, and students that allow them to reason more effectively about classroom events than do inexperienced teachers, who seem to lack the conceptual structures or seem to have simple, undifferentiated structures (cf. Clark & Peterson, 1986).

We explored these hypotheses in a field experiment that compared two types of collaborative writing classes: one in which students and teachers used traditional modes of communication and computer word processing, and the other in which teachers and students used, in addition, a distributed computer network having special applications for collaborative work, a document "comments program," for simultaneous discussion via computer, electronic bulletin boards, and electronic mail.

METHOD

The data for this study were collected from four sections of a freshman writing course at Carnegie Mellon University (CMU) in the spring of 1988. The course is a universitywide core requirement for all students who do not qualify for an exemption based on SAT and AP scores. (In the academic year 1987-1988, approximately 12% of the freshman were exempt.) All sections emphasized collaborative approaches to writing. Two sections used network communication tools in their writing tasks. Each networked section met in a computer laboratory once a week and in the regular classroom twice a week. When the networked sections met in the computer laboratory, students and teachers used traditional modes of communication (e.g., face-to-face) as well as electronic modes. The two regular sections met three times a week in a regular classroom. Although the networked sections met in the computer laboratory only once a week, students and teachers in the networked sections (and in the regular classrooms as well) had access to the electronic modes of communication outside the classroom at any time. Thus the primary difference between the networked sections and the regular sections was that in the networked sections, teachers sanctioned the use of electronic modes of communication by meeting in the computer laboratory once a week and encouraging—and on some occasions, requiring—students to use the electronic modes outside the classroom.

Participants

Students were randomly assigned to the sections, subject only to constraints of scheduling and achieving a mix of majors in each

section. Both the networked and regular sections contained a balance of fine arts students (architecture and art) and science and engineering students. (Freshmen liberal arts students take this course in the fall.) There were no significant differences in average SAT verbal scores across sections, as indicated by a one-way ANOVA, $F(3, 70) = .29$, n.s. Of the 81 students who participated, 37 were placed in the networked sections, and 44 were assigned to the regular sections. All entering CMU students take a Computer Skills Workshop (CSW) that teaches three computer systems, including the system on which the networked writing tools are implemented. In CSW, students learn to use electronic mail and bulletin boards. All students in the networked sections and all but 3 students in the regular sections had completed the workshop prior to beginning the writing class. All sections were told that the English Department was studying collaboration in writing.

The two teachers in the networked sections were interested in teaching networked sections of the course.[1] One was a beginning teacher with only several semesters of part-time experience, while the other had several years of full-time experience in teaching, administration, and tutoring. The teachers in the regular sections were targeted for recruitment into the study on the basis of teaching experience comparable with that of teachers interested in teaching the networked sections. This targeted recruitment resulted in one teacher being a beginner with one semester's prior experience; the other had several years of full-time prior experience in teaching, administration, and tutoring. All teachers were recruited on the basis of their interest in collaborative approaches to writing and were randomly assigned to their sections. All teachers used word-processing regularly and were at least acquainted with using the campus-wide network. The teachers using the computer network to support collaborative writing in their sections were also given computer technical support.

Course Structure and Writing Assignments

The writing course emphasized the process of writing, strategies for producing particular types of writing, discussions, feedback, and revision. Each student in this course wrote and revised three papers during the semester. The three writing assignments were (a) the statement of a problem and an analysis of its aspects, (b) defining a

thesis and supporting it, and (c) a proposal with a problem-solution structure. Students also examined how each of these three kinds of writing functions in its academic, public, and professional contexts. Because of course constraints, the assignments were not counterbalanced and are thus treated separately in subsequent analyses.

The instructors followed a common course outline with identical writing assignments, but specific activities in their individual classes were left to their discretion. Each pair of instructors (networked vs. regular) had weekly meetings with a supervisor to discuss collaborative approaches to writing. Collaborative activities discussed included all aspects of the composing process: monitoring and orchestrating writing processes; representing the writing task, purpose, and audience; acquiring knowledge; generating ideas; setting goals; and so forth. The instructors reported a similar mix of activities and requirements across the four sections. All four teachers required students to attend one face-to-face conference about their first paper, and all were available for optional conferences for the remainder of the semester. As students planned each paper, they engaged in interactions and group exercises both inside and outside the classroom. In addition, students typically wrote at least one draft on which the teacher and classmates commented before writing a final draft. Although students collaborated on many writing processes, students drafted their papers individually and were assigned individual grades.

Network Tools

While all four sections engaged in traditional (e.g., face-to-face) collaborative activities, the networked sections also used the following network communication tools for collaborative communication: *Comments* (Neuwirth, Kaufer, Keim, & Gillespie, 1988) and *Talk* (Neuwirth, Palmquist, & Gillespie, 1988a, 1988b), electronic bulletin boards, and electronic mail. *Comments* is a menu-driven computer program that permits authors to send electronic versions of papers for comment to an unlimited number of respondents (see Figure 1). The author of a paper notifies a recipient by an electronic mail message that he or she would like the recipient to comment on the paper. The recipient can read the paper online or print a hard copy but, except to add comments, normally cannot change the electronic copy sent by the author. *Comments* provides a special window in which the reader

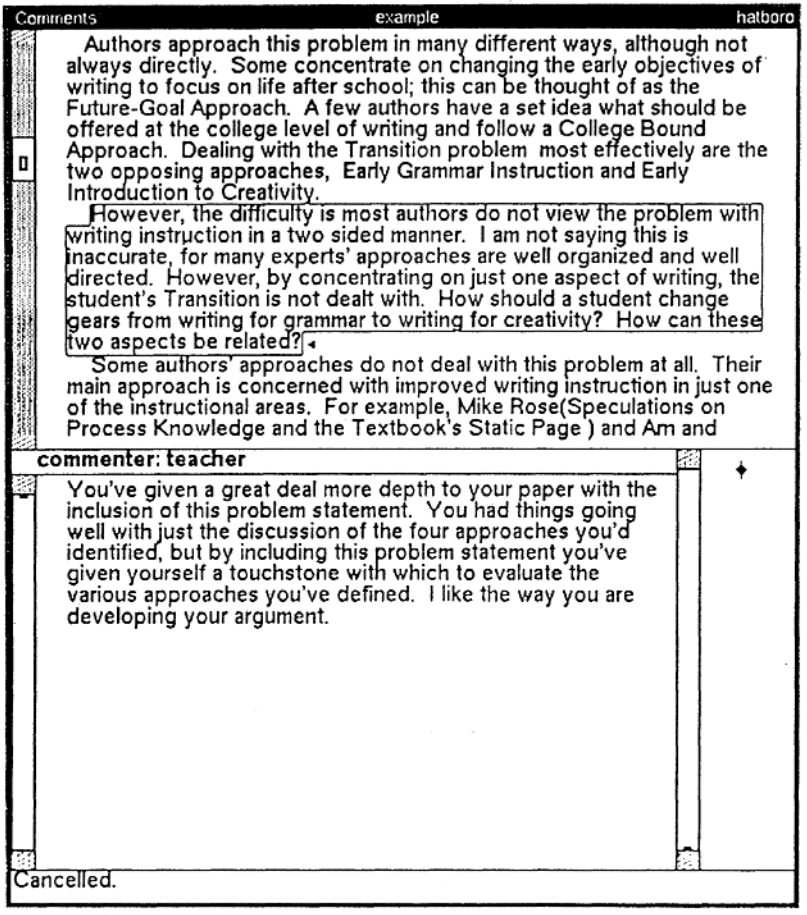


Figure 1: Comments Program Screen With a Student's Text in the Upper Panel and a Teacher's Comment in the Lower Panel

writes comments, much as the reviewer of a paper document might write comments in the margin of that document. To make a comment, the reader uses a mouse to point to a location in the text or selects a region of text and chooses *Make Comment* from a menu. An icon appears in the text marking the region the reader is commenting on.

The reader can make as many comments as desired. He or she may also have access to comments written by others (perhaps by the author or other readers) and can comment on those observations by pointing to the location within the comment and again choosing *Make Comment*. When the reader is done, he or she notifies the author that the paper is available by an electronic mail message. At that point, if the author does not understand a comment or disagrees with it, the author can ask for elaboration by sending the paper back to the commenter, continuing a dialog. The *Comments* program is similar to other text annotation programs that support collaborative writing (Edwards, Levine, & Kurland, 1986; Fish, Kraut, Leland, & Cohen, 1988), but it is integrated with the CMU campuswide distributed personal computing network that allows students and teachers to access their files from any work station on campus.[2] Students in the networked sections were introduced to this program during the first weeks of the semester and could access it in the computer laboratory and at other locations on campus at any time. That is, students' use of the *Comments* program was not limited to the one day they met in the laboratory; students could access all electronic communication modes 24 hours a day, 7 days a week. They were sometimes assigned tasks that required them to use the program to comment on each other's writing and to "hand in" intermediate and final drafts to their teachers. They were encouraged to use the program to contact their teachers if they had a "quick question" about their intermediate drafts while composing. Students often used *Comments* outside the classroom.

The networked writing students also used *Talk*, a communication program designed for synchronous conversation and brainstorming. *Talk* puts a window on a workstation screen for each participant in the conversation. It splits each window into panels, one for each participant. Each participant can compose and read messages in his or her own panel and can read the messages of other participants in all the other panels. Participants do not need to wait to read other messages before composing and sending their own. All messages are sent character by character the instant participants type them. *Talk* also stores on the disk a record of the conversation that students could access or print. *Talk* was used primarily during the class session held in the computer laboratory for required activities structured by the instructor (e.g., brainstorming or role-playing types of readers), though like *Comments*, students could access it from any workstation on campus and occasionally used it outside the classroom.

Students in the networked sections were also assigned tasks to be posted on the section's electronic bulletin board (b-board) and were encouraged to comment on other students' posts. Electronic mail was also available. While electronic mail (as well as the other network tools) is accessible to everyone at CMU at all times, students in the networked sections were explicitly encouraged to use electronic mail to contact instructors and other students about writing assignments in the course.

Students and teachers did not used pseudonyms in any of their communications via electronic modes. Each of the tools identifies the originator of the communication through the person's unique user identification, coupled with his or her name.

Measures

We posited the computer-mediated communication would increase the amount of communication. In this study, we operationalized "amount of communication" by measuring students' frequency of interaction about their writing with their teachers and with each other. We measured frequency of interaction by asking students how frequently they received comments on their writing tasks, including the paper they had just turned in. Students were asked to rate on 7-point Likert-type scales how often their instructors and other students had communicated with them via various modes of communication. We also asked students to rate how helpful the comments were "for becoming a better writer," in order to obtain one indicator of the quality of the interactions that took place via the various modes. Questions were asked about three traditional modes of communication (paper, face-to-face, and telephone) and four electronic modes of communication (the *Comments* program, the *Talk* program, electronic mail, and electronic bulletin boards). The relevant questions from the questionnaire are provided in the appendix.

We hypothesized that less able or poorer performing students would be the primary beneficiaries of increased opportunities for communication. We used verbal SAT as a general indicator of ability. We collected two measures of students' writing performance. The first was the grade assigned by the instructors to the papers. Since grades are known to teachers and the students who receive them, this measure can be expected to be relevant to students' efforts to maintain

self-esteem. Grades ranged from D– to A+ and were translated into a simple 12-point variable (i.e., D– = 1, D = 2, D+ = 3, C– = 4, and so on). In theory, this measure should reflect only the quality of writing, but because teachers interact with students in many ways other than by reading their writing assignments, it is possible that factors in addition to the quality of the written assignment partially determined the grades. Moreover, students in the different sections were graded by different instructors, making it difficult to compare grades of students across sections.

Therefore, the second measure of students' writing performance was holistic scores assessed by four independent sets of judges who did not know the students. The judges were asked to perform holistic evaluations based on assignment-specific course criteria. Judges were trained on a set of practice papers following the procedures outlined by Jacobs, Zinkgraf, Wormugh, Harfiel, and Hughey (1981). Two sets of judges consisted of three doctoral students in English, two of which acted as primary judges and one as a "tiebreaker." The other two sets of judges consisted of five doctoral students each. The judges' assessments were made in two stages. First, one set of two judges made rough evaluations of the first papers by placing them into four quartiles with the third judge acting as a "tiebreaker" to insure that papers were distributed equally into the four quartiles. The reliability of the first two judges (Spearman's correlation) was .61. The other set of three judges did the same for the last papers (Spearman's correlation for the two primary judges = .48). Second, one set of five judges read all of the first papers within each quartile and ranked them from best to worst. The average of the rankings of the five judges was used to generate one rank per paper. The reliability of this summary measure (Cronbach's alpha) was .63. Thus, when the rankings were combined, the entire set of first papers was ranked from the best to the worst. The same procedure was followed by the other set of five judges for the last papers (Cronbach's alpha = .56).[3] Although the interrater reliability scores were on the low side, the reliability of the resulting summary measures and hence their empirical validity (i.e., the correlation between them and another observed variable) may be higher than what was indicated by the interrater reliability scores (Bohrnstedt, 1983).[4]

We hypothesized that writing anxiety and computer anxiety would mediate students' interactions. We operationalized writing anxiety with the Daly-Miller writing apprehension scale (Daly & Miller,

1975) and computer anxiety with the Computer Anxiety Rating Scale (Heinssen et al., 1987).

Finally, we hypothesized that teacher experience would affect interaction in electronic modes. We assessed teachers' experience through an examination of their departmental records and interviews.

Procedures and Analyses

We collected data using two questionnaires. The first asked about high school writing experience and prior computing experience, and it included the Daly-Miller writing apprehension scale and the Computer Anxiety Rating Scale. It was administered during the initial week of classes.

The second questionnaire assessed students' perceptions of frequency of interaction via three distinct traditional modes of communication and four distinct electronic modes of communication as well as the helpfulness of the various modes. Because we were primarily concerned with change in use of the different modes of communication across the semester, the second questionnaire was administered two times: after students had turned in their first paper and had received a grade for it about 6 weeks into the semester, and again when the students turned in their last paper but before they had received a grade at the very end of the semester.[5]

To evaluate the first hypothesis—(when the technology is easily accessible and sanctioned, teachers will communicate more with students and students will communicate more with each other)—we used a repeated-measures ANOVA to examine the frequency of interaction data across the different types of classrooms via the two modes at two times. When we turned to individual differences in the use of the different modes of communication and examined the mediating relationships postulated in the second hypothesis, we began with simple correlations to examine teachers' use of communication modes at Time 2 and the two performance measures, grade and holistic scores. To further explore the relationship in hypothesis two in the light of other mediating variables (writing anxiety, computer anxiety, behavioral consistency, and teacher experience), we used multiple regression analysis to assess the independent effects of students' general ability and writing performance on interaction at Time 2 while controlling for the mediating variables.

Table 1
Analysis of Variance: Student-Teacher Interaction

Effect	df	F	p
Type of classroom (C)	1, 73	22.49	.001
Mode of communication (M)	1, 73	118.05	.001
Time (T)	1, 73	4.27	.042
C × M	1, 73	90.13	.001
C × T	1, 73	1.97	.164
M × T	1, 73	2.89	.094
C × M × T	1, 73	19.71	.001

RESULTS

Students' Interaction With Their Teachers

Our first analysis examined differences in students' ratings of their frequency of interaction with their teachers in the two types of sections —networked and regular—and for two communication modes: traditional and electronic. To insure greater reliability, we defined the two communication modes by adding together students' ratings of their interaction frequencies for the following individual modes: paper, face-to-face, and telephone (traditional); electronic mail, bulletin boards, and *Comments* and *Talk* programs (electronic). There are two times: Time 1, immediately after students turned in their first paper (the early part of the semester, approximately 6 weeks), and Time 2, immediately after students turned in the third and last paper (at the end of the semester). We analyzed the data with a 2 (networked vs. regular sections) × 2 (traditional vs. electronic modes of communication) × (Time 1 vs. Time 2) repeated measures ANOVA, with the first factor between subjects and the last two factors within subjects. All three main effects were significant. Over all subjects, there was more total interaction in the networked than the regular classes, $F(1, 73) = 22.49$, $p < .001$ (see Table 1 and the top panel of Figure 2),[6] more use of the traditional modes of communication than the electronic modes, $F(1, 73) = 118.05$, $p < .001$ (compare the bottom left panel of Figure 2 to the bottom right panel), and slightly more interaction at Time 2 than at Time 1, $F(1, 73) = 4.27$, $p < .05$.

All of these main effects are qualified by a highly significant three-way interaction, $F(1, 73) = 19.71$, $p < .001$. The nature of this interaction

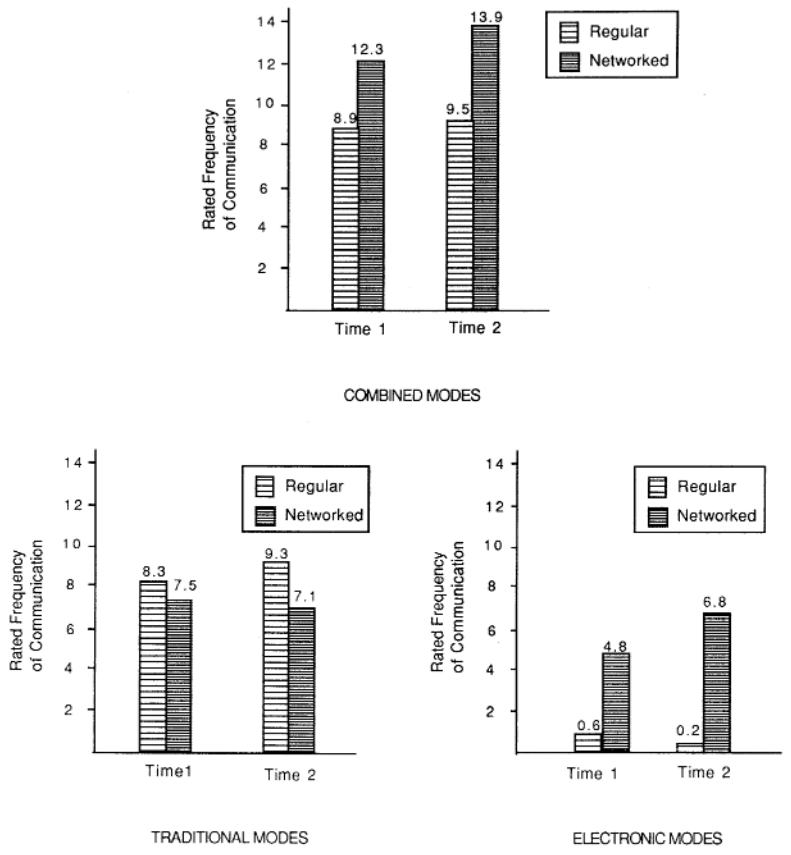


Figure 2: Students' Ratings of Frequency of Communication With Their Teachers at Time 1 (Sixth Week) and Time 2 (End of Semester) in Regular and Networked Classrooms for Combined, Traditional, and Electronic Modes.

is seen clearly in the bottom two panels of Figure 2. During the early part of the semester, at Time 1, there was no significant difference in the frequency with which the teachers in the networked and regular sections used traditional communication modes to provide writing feedback (means of 7.5 and 8.3, respectively). Over time, however, there was a slight (though nonsignificant) decrease in the networked teachers' use of the traditional modes (from 7.5 to 7.1), while teachers

in the regular sections marginally increased their use of traditional communication modes over time (from 8.3 to 9.3). Thus by Time 2, the end of the semester, teachers in the regular sections were using the traditional communication modes more than teachers in the networked sections (9.3 vs 7.1).

The picture is very different for electronic communication (bottom right, Figure 2). Teachers in the networked sections substantially increased their use of electronic communication over time (from 4.8 to 6.8). This increase in electronic communication did not come at the expense of traditional communication, however, because the networked teachers did not significantly change their use of traditional communication modes over the course of the semester. Thus the data suggest that teachers in the networked sections maintained most communication via traditional modes and added to their repertoire of tools for communication by using electronic communication modes to give feedback on writing. On the other hand, teachers in the regular sections rarely used the electronic modes to communicate with students at any time during the semester.[7]

Table 2 presents a more detailed view of the data just discussed. The means and standard deviations for the seven individual modes that compose the traditional and electronic summary scales are displayed. Early in the semester, paper and face-to-face interaction were the most frequently used communication modes, even for the teachers in the networked sections. This pattern was sustained over time by the teachers in the regular sections. This pattern was broken, however, by the teachers in the networked sections who later in the semester used the *Comments* program as frequently as face-to-face interaction and paper to provide feedback on students' writing.

Students' Interaction With Other Students

Whereas Figure 2 shows how students communicated with teachers, Figure 3 shows how students communicated with *each other* over the course of the semester. It displays summary measures of students' ratings of the frequency with which they interacted with other students about their writing, using traditional and electronic communication. Again, these interaction rates were analyzed with a 2 (networked vs. regular sections) × 2 (traditional vs. electronic modes of communication) × 2 (Time 1 vs. Times 2) repeated measures ANOVA (see Table 3). There were two significant main effects. As with teacher-

Table 2
Students' Ratings of Teachers' Use of Different Modes in Detail

Networked (n = 36)			*Regular (n = 39)*		
Mode	*Use*	*(SD)*	*Mode*	*Use*	*(SD)*
Time 1					
Paper	5.0	(1.6)	Paper	5.5	(1.6)
Face-to-face	4.5	(1.3)			
			Face-to-face	4.7	(1.7)
Electronic mail	3.0	(1.9)			
Bulletin board	2.7	(1.8)	*Comments* program	1.5	(1.3)
			Telephone	1.3	(0.7)
Comments program	1.7	(1.2)	Electronic mail	1.1	(0.4)
Talk program	1.4	(1.2)	Bulletin board	1.1	(0.6)
Telephone	1.1	(0.5)	*Talk* program	1.0	(0.2)
Time 2					
Face-to-face	4.8	(1.3)	Paper	5.4	(1.9)
Comments program	4.5	(1.8)	Face-to-face	5.2	(1.1)
Paper	4.0	(1.5)			
			Telephone	1.7	(1.0)
Bulletin board	2.4	(1.7)	*Comments* program	1.1	(0.7)
Electronic mail	2.3	(1.6)	Bulletin board	1.1	(0.5)
			Electronic mail	1.0	(0.2)
Talk program	1.8	(1.3)	*Talk* program	1.0	(0.0)
Telephone	1.3	(0.8)			

Note. Blank spaces between modes indicate that students' ratings of teachers' use of modes were significantly different ($p < .05$), using selected paired comparisons.

student interaction, total student-student interaction was greater in the networked sections both at Time 1 (12.9 vs. 8.2) and Time 2 (13.8 vs. 9.1), $F(1, 73) = 30.75$, $p < .001$. Likewise, there was more student-student interaction via the traditional modes than the electronic modes, $F(1, 73) = 44.80$, $p < .001$ (compare the bottom left panel of Figure 3 to the bottom right panel).

Once again, these main effects must be qualified by a highly significant three-way interaction, $F(1, 73) = 11.84$, $p < .001$. Students in the networked sections, like their teachers, increased their electronic communication with each other over the course of the semester (from 6.8 to 8.6). In contrast to their teachers, however, students seem to have *substituted* electronic communication for the traditional modes, as use

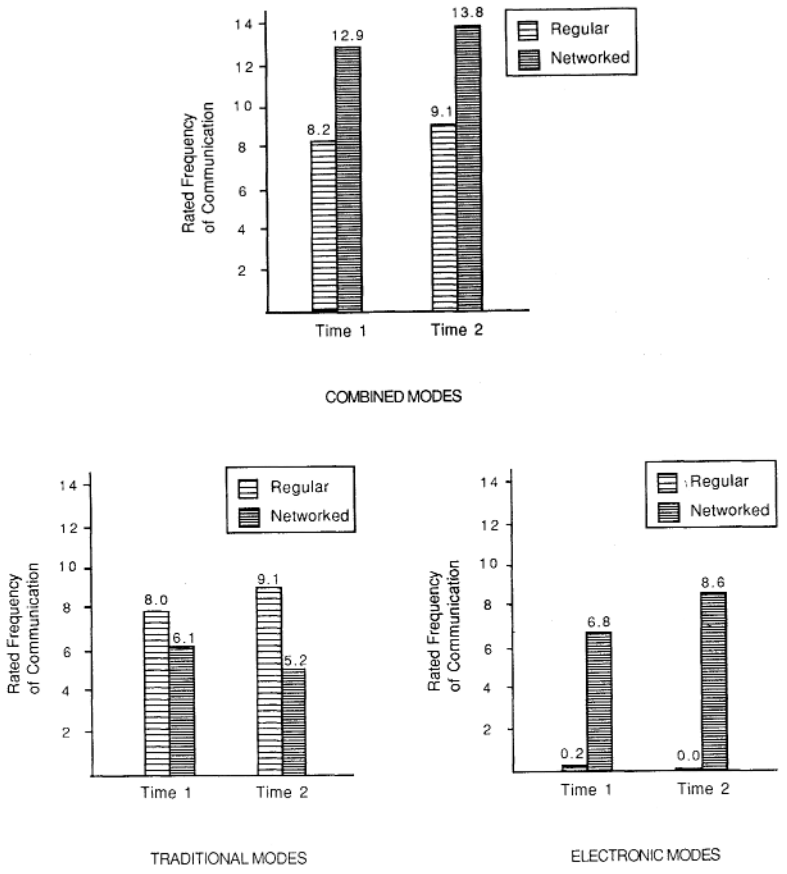


Figure 3: Students' Ratings of Frequency of Communication With Other Students at Time 1 (Sixth Week) and Time 2 (End of Semester) in Regular and Networked Classrooms for Combined, Traditional, and Electronic Modes

of the traditional modes decreased about as much as use of the electronic communication modes increased (from 6.1 to 5.2). In particular, the networked students used paper less frequently to provide feedback to other students and increased their use of the *Comments* and *Talk* programs (see Table 4). In the regular sections, on the other hand, students used traditional communication almost exclusively

Table 3
Analysis of Variance: Student-Student Interaction

Effect	df	F	p
Type of classroom (C)	1, 73	30.75	.001
Mode of communication (M)	1, 73	44.80	.001
Time (T)	1, 73	1.35	.249
C x M	1, 73	270.99	.001
C x T	1, 73	.12	.733
M x T	1, 73	2.87	.094
C x M x T	1, 73	11.84	.001

Table 4
Students' Ratings of Classmates' Use of Different Modes in Detail

	Networked (n = 36)			*Regular (n = 39)*	
Mode	*Use*	*(SD)*	*Mode*	*Use*	*(SD)*
Time 1					
Face-to-face	4.2	(1.6)	Face-to-face	5.5	(1.5)
Comments program	3.7	(1.7)	Paper	4.1	(2.3)
Paper	3.6	(1.8)			
			Telephone	1.5	(1.2)
Electronic mail	2.5	(1.7)	*Comments* program	1.1	(0.5)
Bulletin board	2.5	(1.7)	Electronic mail	1.0	(0.2)
Talk program	2.2	(1.6)	Bulletin board	1.0	(0.2)
			Talk program	1.0	(0.2)
Telephone	1.3	(0.8)			
Time 2					
Face-to-face	4.3	(1.5)	Face-to-face	5.7	(1.4)
Comments program	4.2	(1.6)			
Talk program	4.1	(1.8)	Paper	4.1	(2.2)
Paper	2.4	(1.4)	Telephone	2.1	(1.7)
Bulletin board	2.3	(1.7)			
Electronic mail	2.0	(1.4)	*Comments* program	1.0	(0.0)
			Electronic mail	1.0	(0.0)
Telephone	1.6	(0.9)	Bulletin board	1.0	(0.0)
			Talk program	1.0	(0.0)

Note. Blank spaces between modes indicate that students' ratings of classmates' use of modes were significantly different ($p < .05$), using selected paired comparisons.

and significantly more frequently than did students in the networked sections, both at Time 1 (8.0 vs. 6.1) and Time 2 (9.1 vs. 5.2).

Students' Perceptions of Helpfulness

We also assessed students' perceptions of the helpfulness of the comments they received via each of the traditional and electronic communication modes. General questions were posed about the helpfulness of the comments communicated via the various modes without reference to whether the comments were from teachers or from classmates. Traditional communication was perceived as fairly helpful (mean = 5.0 on a 7-point scale averaging across all the traditional modes). There was no difference over time or across sections in perceived helpfulness of traditional communication. But students in the networked sections rated the electronic communication modes, on average, as significantly less helpful than the traditional communication modes. This difference was significant at both Time 1, $t(35) = 6.10$ $p < .001$ and at Time 2, $t(36) = 3.56$ $p < .001$. Students generally rated feedback on writing received face-to-face and from paper as most helpful (see Table 5). By the end of the semester, however, after students in the networked sections had more experience with the *Comments* program, they rated it as helpful as face-to-face interaction and paper.

In sum, the availability of electronic modes of communication increased total student-teacher interaction but not total student-student interaction. Students in the networked sections seemed to prefer face-to-face and paper modes initially but shifted over time to include the *Comments* program among their preferred modes. However, these results do not address whether electronic communication aided certain types of students or teachers and not others.

Individual Differences

We hypothesized that teachers would use different modes to communicate with students who had performed less well and that these students would use different modes to communicate with each other. We first examined the simple correlations between the teachers' use of different individual communication modes at Time 2, the end of the semester, and student performance as measured by teacher grades and by the holistic rankings assigned to the first and last papers (see

Table 5
Students' Ratings of Helpfulness of Different Modes in Detail

Networked				*Regular*			
Mode	*Use*	*(SD)*	n	*Mode*	*Use*	*(SD)*	n
Time 1							
Face-to-face	5.5	(1.4)	35	Face-to-face	5.9	(1.3)	39
Paper	5.0	(1.4)	36	Paper	5.2	(1.7)	38
Electronic mail	3.8	(1.7)	21	Telephone	3.0	(2.0)	14
Comments program	3.6	(1.6)	33				
Bulletin board	3.3	(1.5)	22	*Comments* program	2.2	(2.0)	10
Talk program	3.0	(1.6)	21				
Telephone	2.7	(1.9)	9	Electronic mail	1.0	(0.0)	7
				Bulletin board	1.0	(0.0)	7
				Talk program	1.0	(0.0)	6
Time 2							
Face-to-face	5.8	(1.4)	35	Face-to-face	5.7	(1.6)	39
Comments program	5.0	(1.5)	36	Paper	5.6	(1.6)	37
Paper	4.6	(1.1)	34	Telephone	3.3	(2.3)	25
Talk program	3.8	(1.5)	33	Electronic mail	1.1	(0.7)	17
Electronic mail	2.7	(1.7)	22	*Comments* program	1.0	(0.0)	16
Telephone	2.6	(1.6)	20	Bulletin board	1.0	(0.0)	16
Bulletin board	2.2	(1.4)	23	*Talk* program	1.0	(0.0)	16

Note. Blank spaces between modes indicate that students' ratings of helpfulness of modes were significantly different ($p < .05$), using selected paired comparisons.

Table 6).[8] The pattern of correlations for the teachers in the regular sections is overwhelmingly positive, suggesting either that these teachers communicated more with students who had performed well or that students who performed well sought out their teachers more often. The pattern of correlations displayed in the left column of Table 6 (11 of 12 positive) is significantly different from chance according to a binomial test, $p < .003$.[9]

The pattern of correlations for the networked sections includes many more negative correlations (9 of 16), significantly more than the regular sections, $\chi^2(1) = 6.86$, $p < .01$. That is, teachers in the networked

Table 6
Associations Between Students' Frequency of Communication With Their Teachers at Time 2 and Measures of Students' Writing Performance

	Regular Sections Modes at Time 2			*Networked Sections Modes at Time 2*			
Writing Performance	*Face-to-Face*	*Paper*	*Telephone*	*Face-to-Face*	*Paper*	*Telephone*	*Comments*
First paper (Time 1)							
Teacher's grade	.49**	.15	.17	.19	−.28*	−.03	−.06
Holistic ranking	−.02	.36**	.11	.20	−.22	.18	−.43***
Third paper (Time 2)							
Teacher's grade	.47**	.18	.31*	.09	−.43***	.27	−.08
Holistic ranking	.19	.19	.27*	.002	−.40**	.51***	−.21

Note. Table entries are Pearson correlations.
*$p < .10$; **$p < .05$; ***$p < .01$.

sections communicated more with lower performing students as defined by the teachers' grades and by scores of the independent judges. This pattern is strongest when communication was by paper and through the *Comments* program. We cannot know from these data if teachers in the networked sections sought out lower-performing students or if lower-performing students sought out the teacher. It is clear that teacher-student interaction patterns in the networked sections differed from teacher-student interaction patterns in the regular sections.

Notice that the association in the regular sections is strongest between teacher face-to-face communication and the students who were given high grades by the teacher. The association is much weaker between teacher face-to-face communication and the holistic rankings. The different magnitudes of correlations observed between the teacher's grade and holistic ranking in the regular sections for face-to-face communication and the absence of such differences for face-to-face communication in the networked sections suggest that processes of self-esteem maintenance and social influence may be operating in teacher's assignment of grades: Students who know that they have

performed well at Time 1 experience a reduction in evaluation anxiety and interact more than students who received a low grade, possibly appearing more interested in class. Teachers reward this increased interaction with higher grades, especially if the student is perceived as sincere (Bean & Kuh, 1984).

The negative associations displayed in Table 6 between student writing performance and interaction with the teacher in the networked sections ran counter to the pattern of teacher-student interaction reported in the literature. Such zero-order correlations, however, preclude drawing strong inferences because many possible "third variables" confound the relationships reported in Table 6. Therefore, to assess the independent effects of student performance and teacher experience on interaction (controlling for several plausible mediating variables), we regressed summary scales of the students' ratings of their frequency of interaction with teachers via the electronic and traditional modes at Time 2—the end of the semester—on grade on the first paper, SAT verbal score, the writing anxiety scale, the computer anxiety scale, frequency of interaction at Time 1—the sixth week—and teacher experience. We included grade on the first paper as the measure of performance (which was known to the teachers and students at Time 1) and SAT verbal score as a measure of general ability. With both of these variables included in the regression equation, we could look at the independent effects of performance and ability on interaction, at least as these concepts were operationalized here. We expected students with higher levels of writing anxiety compared to those with lower levels to interact less with their teachers via traditional communication modes. We expected this negative relationship to be weaker for communication via the electronic modes because cues that remind us we are being evaluated, such as smiling and frowning, are missing in computer-mediated communication. Additionally, we predicted that higher levels of computer anxiety would have a detrimental effect on electronic communication. Because we were interested in changes in interaction over time, we also needed to include interaction behavior at Time 1 as a predictor. Finally, we included teacher experience in the regression equation because we thought that teachers defined as more or less experienced might differ in how they communicated with their students. We also wondered whether the teachers differed in the extent to which they encouraged their students to interact with each other via the various communication modes. Hence we conducted these same analyses on the sum-

Table 7
Factors Predicting Students' Frequency of Interaction With Their Teachers and With Other Students at Time 2

Factor	Regular Sections	Networked Sections	
	Traditional Modes	Traditional Modes	Electronic Modes
Student-teacher interaction			
SAT verbal	−.12	−.29	−.48***
Teacher experience	.02	.22	.37**
Writing anxiety	−.04	−.35**	−.27*
Computer anxiety	−.28*	−.13	−.27*
Time 1 interaction	.27	.30	.27
Grade on paper 1	.30*	−.01	.03
n	37	36	36
Adjusted R^2	.22	.18	.42
Student-student interaction			
SAT verbal	−.17	−.03	−.41**
Teacher experience	−.10	.10	.63***
Writing anxiety	−.27	−.36**	−.06
Computer anxiety	.04	.02	−.18
Time 1 interaction	.30*	.43***	−.06
Grade on paper 1	−.14	.12	.22
n	37	36	36
Adjusted R^2	.05	.25	.32

Note. Table entries are standardized regression weights.
*$p < .10$; **$p < .05$; ***$p < .01$

mary scales of students' ratings of their frequency of interaction between classmates. Results of the analyses are displayed in Table 7.

Several aspects of the data are notable. First, holding other variables constant, the SAT verbal score was a significant predictor of electronic communication. The lower the students' SAT verbal scores, the more they interacted electronically with teachers and classmates. Second, the teacher who was defined as more experienced in the networked sections differed in how he communicated writing feedback. The more experienced teacher communicated more often electronically. Indeed, this more experienced teacher communicated more frequently in all modes, but the effect was strongest for the electronic

media. Also, this teacher's students communicated more often with each other electronically.

We expected writing anxiety to be more strongly related to use of traditional communication modes than to use of electronic communication. This pattern was observed for students in the networked sections, although the difference in the regression weights was not significant. The higher their writing anxiety, the less students in the networked sections communicated with their teacher and classmates via the traditional modes. Writing anxiety was also negatively related to teacher-student interaction via the electronic modes. As expected, this relationship was weaker than the relationship of writing anxiety to traditional communication. Computer anxiety was also a significant predictor of electronic teacher-student interaction. The higher their computer anxiety, the less frequently the networked students communicated electronically. Unexpectedly, computer anxiety was also negatively associated with traditional communication in the regular and networked sections.

In general, interaction at the sixth week (Time 1) was positively associated with interaction at the end of the semester (Time 2), although this effect reached conventional levels of significance only for traditional student-student communication. The effect of simple behavioral consistency, which usually is the most important predictor in any longitudinal study, was weaker than expected. Certainly, styles of collaboration and of interaction with classmates and teachers about writing are much less habitual than many other behaviors performed in school. Thus the relative novelty of the activity, particularly in the networked sections, helps explain the low coefficients for prior behavior.

Finally, the pattern of correlations between student performance and teacher-student interaction reported in Table 6 is also evident in the regressions. A student's grade on the first paper was significantly associated with communication via the traditional modes in the regular sections, even after the effects of all the other variables in the equation were controlled ($p < .09$). Its effect was positive, and it is the most important predictor in the equation. Grade on the first paper was unrelated to teacher-student interaction in the networked sections, but the negative relationships noted in Table 6 were picked up by SAT verbal scores in the regressions. As already discussed, this relationship was highly significant for use of the electronic modes and approached significance ($p < .17$) for the traditional modes.

DISCUSSION

The social effects of computing are contingent not only on the particular computer system (e.g., a network and its associated tools) but on its social context: Characteristics of individuals, user groups, the larger organizational and social structure in which the technology is embedded all play a role (Kling, 1980; Markus, 1983). We took care to describe characteristics of the social context that previous theory and research suggest are relevant: The teachers and students were relatively computer literate, the teachers worked actively to find ways in which network technology could enhance their course objectives and communicated their goals and the reasons for using particular methods to achieve them to students, and teachers and students had easy access to network tools because of the campus-wide network. We believe these results will transfer to similar social contexts. Although many schools do not yet have such sophisticated campus-wide networks, such networks and their associated tools are clearly valuable and becoming increasingly widespread.

This study examined the use and effects of computer-mediated communication in a context in which it may prove to be most helpful: a classroom in which collaborative learning is encouraged. In such a classroom, working together is valued, not penalized. Network technology and collaborative writing tools support student efforts to become better writers by providing opportunities for practice and for receiving feedback from an audience that includes both teachers and classmates. Because computer-mediated communication crosses space and time, the teacher is no longer a scarce resource for students when the technology is available. Critics of the use of electronic communication tools in education worry that highly valued aspects of the teacher-student relationship will be eliminated. In particular, they fear that face-to-face interaction will decrease as more "impersonal" modes of interaction, such as networked communication, increase. This was not the case in our study. We found that using network communication tools to support collaborative learning and writing did not replace traditional forms of communication with teachers, but, in fact, total teacher-student communication about writing increased. In particular, face-to-face communication between student and teacher increased over the course of the semester whether students and teacher were networked or not.

The most important practical implications of our findings have to do with the effect that computer-mediated communication had on the

distribution of teachers' attention in the classroom. We know from the educational literature that better students are more likely to volunteer answers and comments than poorer students (Brophy, 1983) and that they tend to sit in the area of the classroom that captures teacher attention and interaction opportunities. We suggested that network technology might modify this pattern, providing poorer students and their teachers with psychologically and physically low-cost alternative communication modes not found in the regular classroom. We found that less able students communicated more with teachers and classmates electronically than more able students. The availability of electronic communication, in a sense, allowed a more equitable distribution of attention, especially from the more experienced teacher. Interestingly, research in organizational communication suggests similar effects. Computer-mediated communication permits peripheral members of organizations more access to work and social activities. As a result, such people feel more central to the organization and more committed to it (Eveland & Bikson, 1988; Huff, Sproull, & Kiesler, 1989; Sproull & Kiesler, 1990).

Because the data reported here are correlational, we do not know if the changes in focus of attention that we observed were due to the networked teachers and students seeking out less able students or if less able students initiated more contacts. Most likely, this relationship is bidirectional. Less able students probably feel anxious about interactions concerning their writing skills and therefore can benefit from electronic communication, which reduces the social cues that remind them they are being evaluated. Thus, less able students might feel more comfortable interacting electronically with others about their writing than they feel in person. Likewise, teachers are probably more anxious about interactions that convey criticism, albeit constructive, and they might feel more comfortable delivering their feedback electronically to students.

One striking result of this study was the strong relationship between teacher experience and the use of electronic communication. The more experienced teacher in the networked condition communicated electronically with students and encouraged students to communicate with each other electronically. This finding highlights a limitation of this study that can be redressed in future research. Teacher experience was not manipulated. Obviously, for ethical reasons, we cannot deliberately assign students to less experienced teachers (or manipulate levels of writing anxiety and computer anxiety).

But we would have more confidence in our finding if we had studied more teachers. With only two teachers in the networked sections, we do not know if the results say something representative of more and less experienced teachers (and electronic communication) or if the results are idiosyncratic to the individuals involved. A replication of this finding with as many teachers as possible is clearly warranted to assess the generalizability of the teacher experience effect that we found in this study.

In the study reported here, we operationalized "amount of communication" as students' ratings of their frequency of interaction. Given that we found effects with this measure, it seems reasonable to carry out further research using more expensive, direct observation measures.[10] Although much of our knowledge about people's behavior is based on such verbal self-reports (Schwarz, 1990), direct observation measures could provide us not only with an additional measure of the frequency of interaction but with information that can shed light on important questions about duration (e.g., Did teachers in the networked sections spend more time on classes than teachers in the regular sections?) and form of the interactions (e.g., What did the electronic modes of interaction with low-ability students look like?). Such information is, of course, crucial in creating independent judgments about the interaction process itself and the quality of interaction. Both kinds of judgments are needed to form a more complete model of the effects of network technologies on social interactions and learning to write. In the absence of such information, we focused on the processes of social interaction rather than on performance outcomes. Although clearly such outcomes are of ultimate interest, we believe that in the absence of a more detailed model, such a focus is likely to generate more heat than light.

CONCLUSION

Educational theory and research suggest that students learn through active participation in tasks that closely represent the real-world situation in which they are embedded (Brown, Collins, & Duguid, 1989; Cohen, 1972). Computer-mediated communication can facilitate these processes. It provides students who are learning to be better writers increased opportunities for interaction with the heterogeneous audience that they are likely to encounter in the real world.

It may change interaction patterns and patterns of attention in the classroom. Because less able students are often the most disenfranchised members of the classroom, a technology that redistributes teacher and classmate attention so that these less able students can become more active participants may ultimately have a profound impact on learning outcomes. We have no evidence that more able students will suffer any less attention as a result. In our study, there was more teacher-student communication in the networked sections throughout the semester. Computer-mediated communication did not just redistribute shares of a constant pie, it actually increased the size of the pie.

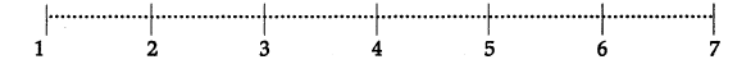
APPENDIX
Selected Questions from the Second Questionnaire

This questionnaire asks you about your experience in the class so far this semester. Many of the questions ask you about "your writing" for the class. By "your writing," we mean *all of your writing assignments and activities* in the class, including but not limited to problem statements, purpose of audience analyses, writing process descriptions, paper plans, sketches, as well as intermediate and final drafts. We are interested in UNIT I,[1] from the beginning of the semester to your problem analysis paper. Please read and answer all of the questions carefully. Your instructor will not see your answers which will be kept completely confidential. Thank you for your participation.

Writing Experience

Instructor Activities

The following questions ask about the role your instructor played in the production of your writing. For each question, fill in the blank(s) with a number from the following scale:

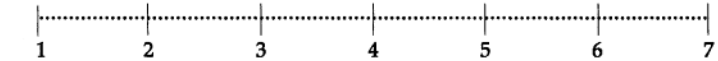


Q. For the comments you received from your instructor, how frequently did your instructor use each of the following means of communication to give you comments?

Written via paper	———	Face-to-face	———
Written via e-mail	———	Over the phone	———
Written via b-boards	———	Interactively via computer	
Written via *Comments* program	———	(talk or co-op programs)	———

Classmates' and Friends' Activities

The following questions ask about the role your classmates and friends played in the production of your writing. For each question, fill in the blank(s) with a number from the following scale:



1 2 3 4 5 6 7

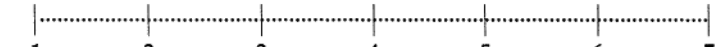
Never Sometimes Very Frequently

Q. For the comments you did receive from your classmates, how frequently did your classmates use each of the following means of communication to give you comments?

Written via paper	———	Face-to-face	———
Written via e-mail	———	Over the phone	———
Written via b-boards	———	Interactively via computer	
Written via *Comments* program	———	(talk or co-op programs)	———

Helpfulness of Activities and Feedback

The next section asks about how *helpful* various activities were for becoming a better writer. For each question, fill in the blank with a number from the following scale.



1 2 3 4 5 6 7

Not helpful Somewhat Helpful Very Helpful

NOTE: Put a "0" in the blank if the question is not applicable to you, for example, if you never engaged in that activity.

Q. How helpful were the following means of communication?

Written via paper	———	Face-to-face	———
Written via e-mail	———	Over the phone	———
Written via b-boards	———	Interactively via computer	
Written via *Comments* program	———	(talk or co-op programs)	———

1. When the questionnaire was administered the second time, it referred to UNIT III.

NOTES

1. The English department typically runs networked sections on the basis of teacher interest.

2. CMU's campuswide network is based on a distributed personal computing environment of advanced function workstations called *Andrew* (Morris et al., 1986).

3. Only four of the five judges' rankings were used in forming the summary measure for the last set of papers. Preliminary analyses indicated that the rankings of the fifth judge correlated negatively with those of each of the other four judges. This discrepancy may be due to the judge having made an error in data recording (accidentally reversing the scales) or to the judge using different criteria than the other four judges (and to the criteria that the judge had used in the training session). Because a large amount of time had elapsed between the collection of the ranking data and the preliminary analyses, it was not feasible to obtain additional evidence concerning the issue by asking the judge. Had we retained this discrepant judge's rankings in the summary measure, the reliability coefficient would have been near zero.

4. This is because the measures are a summative composite of the judges' individual rankings and, while each of the judges' individual rankings may deviate from the "true" ranking, some deviations from the true ranking are likely to be positive, others are likely to be negative, and the total will tend to cancel. Thus, in such a summative composite, the reliability is partially a function of the number of individual judges used and Cronbach's alpha is a lower bound to its reliability. Moreover, in a study that examines relationships among variables, high reliability is important in reducing false negative error (i.e., failing to find a relationship when one is there) but has less relevance to reducing false positive errors. If a significant relationship *is* found between a measure and another variable, the fact that the reliability of the measure is only moderate does not automatically invalidate the finding provided that the correlation can be interpreted as indicating that the measure has criterion-related validity.

5. The fact that students responded to the questionnaire *after* receiving a grade on the first essay but *prior* to receiving a grade on the third essay is likely to have introduced a response bias (Bradburn, 1983). For example, students who were expecting to receive a higher grade on the third essay than they actually received may have rated the modes of interaction more helpful than if they had rated the modes after receiving a grade. However, since students rated the modes in relationship to each other, it is likely that any such response bias would affect students' ratings of all the modes—that is, it would affect the students' rating of traditional as well as electronic modes. In the same way, students in regular and networked sections would be affected equally by any such bias. Thus it is unlikely that any response bias introduced by the procedure affected the results. Although undesirable, other things being equal, the difference in procedure was necessary because we wanted to administer the first questionnaire to all sections at the same time to avoid having students who had already completed it talking to students who had not. Since the sections were not on exactly the same schedules and teachers did not wish to delay giving students their grades, we waited until all students had received grades before administering the questionnaire the first time. It was impossible to duplicate the procedure on the second administration because students did not receive grades on the third paper until after the semester had ended and many of them would have already dispersed.

6. The numbers in Figures 2 and 3 reflect a recoding of the Likert-type scale variables (from 1 = never . . . 7 = very frequently to 0 = never . . . 6 = very frequently) so that the graphs in these figures would have origins at zero.

7. Only a few students reported any use of the electronic communication modes in the regular sections.

8. We also examined an analogous set of correlations for interactions between classmates, but no interesting pattern of correlations resulted.

9. Because the grade assigned by the teacher and the panel of experts' ranking score were based on the same paper, these two measures are not completely independent and therefore a binomial test based on both sets of correlations may not be appropriate. Looking only at the grades given by the teacher, all 6 correlations are positive. This pattern is significantly different from chance, $p < .02$. Considering only the holistic ranking, 5 of the 6 correlations are positive. This pattern is significantly different from chance $p < .10$.

10. While it is less expensive to gather direct observation information for the electronic communication modes, gathering *comparable* information is expensive for traditional modes.

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