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Abstract

Mentoring has long been recognized as an effective process to help students and young professionals develop new skills and attitudes. This study analyzed the content of message exchanges between five professional scientists and five minority college students who were paired as part of the E-mentoring program developed at the University of North Carolina at Chapel Hill. Interaction was assessed both quantitatively and qualitatively, with the goal of providing a better understanding of the connection between interactivity patterns and perceived success of a mentor-student relationship. Several factors were identified as contributing to successful interaction, including structure of the exchange; balance of discussion topics; mirroring in content and message length; and limited overt "managing" by mentors.

Headings:

Mentoring

Mentoring in education

Computer-mediated communication

MIRRORING AND MANAGING IN ELECTRONIC MENTORING: FACTORS IN INTERACTIVITY BETWEEN STUDENT-SCIENTIST PAIRS

by
Cara Bonnett

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Approved by:

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Introduction

Mentoring has long been recognized as an effective process to help students and young professionals grow and develop new skills and attitudes. However, time and distance constraints often prevent the development of such relationships. This is particularly true for science students in rural and lower socioeconomic areas, who rarely have the opportunity to interact with mentors face to face. Most corporate scientists are concentrated at research facilities in a few urban areas of the country and rarely have the leisure to travel to colleges and universities to interact with students there.

Computer-mediated communication (CMC), which includes synchronous and asynchronous systems such as computer conferencing and electronic mail, offers one way to support interaction between participants at remote locations, allowing them to interact at their own convenience, eliminating geographical restrictions and lessening scheduling constraints. Furthermore, e-mail and similar asynchronous text-based communication blend the informality of conversation with the benefits of written correspondence, encouraging reflection and providing an enduring record of the exchange.

CMC has been shown to both enhance and inhibit interaction. Students who are reluctant to speak, or are socially constrained, in traditional educational settings may find their "voice" in computer-mediated environments. Thus, electronic mentoring can create an environment where protégés feel more comfortable asking questions than they would in person. However, because CMC sacrifices much of the richness of face-to-face

interaction (body language, tone of voice, facial expressions, etc.), online exchanges can be impersonal.

Technological tools such as CMC have been used in schools, corporations and government agencies to extend or enhance individual capabilities in both work and study. Specifically in education, they have been used to facilitate teaching and learning. However, while research has tended to focus on computer-mediated interaction among groups in those settings, this study provides detailed information about one-on-one interaction in the mentoring context – a type of relationship that is increasingly popular in educational and corporate settings and indeed possible in any situation where two individuals correspond online.

This study's goal is to identify specific strategies that can be employed by participants to build successful relationships in all contexts where mentoring is possible. This research is particularly important in light of concerns about the widening "digital divide" between socioeconomic and racial groups that could limit minority students' ability to achieve academic and career success (Hoffman & Novak, 1998). Ensuring that information and communications technologies are available to underserved populations is only one factor; organizations also must encourage and support the most effective use of those technologies for connecting people in positive ways.

Relevant Literature

Two bodies of existing research are relevant to the current study of the interaction between students and scientist-mentors in an electronic environment. Studies of previous electronic mentoring programs offer broad insight into the types of discussions that tend to foster successful mentoring relationships but have not examined that interaction in a detailed fashion. CMC researchers have developed some useful strategies for analyzing interaction more systematically, and studies of CMC in educational settings (while typically oriented more toward the classroom and conferencing formats than one-on-one interaction) shed additional light on interactive learning in electronic environments. This review aims to highlight key themes in these bodies of research and examine the potential for synthesizing the strengths of each to develop a more specific understanding of interactivity in the particular context of e-mentoring.

Mentoring in a New Medium

Most research on electronic mentoring, or telementoring, has focused on informing the design of future programs and identifying general ingredients for success. For example, research suggests that initial training should clarify participant roles (O'Neill, Wagner, & Gomez, 1996) and should establish program goals and expectations (Muller, 1997). During the course of an e-mentoring program, according to Harris, O'Bryan and Rotenberg (1996), the development of successful mentoring relationships depends on:

- frequent, regular contact – what the researchers describe as a regular "rhythm" of message traffic;

- active, inquiry-based and student-centered communications; and
- "multidimensional communication utilizing intellect and emotion, balancing personal and scholastic information shared in the exchange" (Harris, O'Bryan, & Rotenberg, 1996, p. 56).

One study (Bennett, Tsikalas, Hupert, Meade, & Honey, 1998a) surveyed participants to find out which topics they had discussed online as part of the *Telementoring* project, aimed at connecting high school girls with women in science and technology-related fields. The study found that topics falling under the headings of "college" and "career" dominated the exchanges (with 62 percent of students saying they talked about college life and college courses with their mentors and 60 percent saying they had discussed career opportunities and their mentor's career), closely followed by "personal issues" such as confidence (45 percent), time management (48 percent), and balancing family and work (42 percent). Frequently, the study noted, personal interests unrelated to science were used as a springboard for discussing science. For example, one pair discovered a common passion for books, and the mentor described her own scientific inquiries as stories with characters, plots, conflicts, and suspense. While the program started with a focus on career mentoring, it became clear that "the young women's concerns about their personal lives were preeminent and integrally associated with any academic/career issues they might have" (Bennett et al., 1998a, p.22).

Interestingly, the researchers noticed a difference between mentors' and students' perceptions of their conversations. More than a quarter of mentors reported that they didn't feel they had provided any guidance because they communicated only minimally with their mentees or they believed they hadn't explored any substantive issues. The

authors concluded that the two groups differed on what they considered worthwhile conversation: Mentors expected more specific career-oriented conversations, and "what might have been regarded as casual chat by mentors was viewed as meaningful exchanges for students" (Bennett et al., 1998a, p. 17). These findings are similar to conclusions drawn in a study of traditional, face-to-face mentoring: Young and Perrewe (2000) looked at specific behaviors related to career and social support exhibited throughout the mentoring process and concluded that mentors value career-related behaviors exhibited by mentees, while mentees place more emphasis on social behaviors exhibited by mentors.

Another study that included both male and female participants noted gender differences in relation to discussion topics. Carlsen and Single (2000) found that half as many male mentors reported discussing their future career plans as did female mentors, and students with female mentors were more likely to report that they discussed "balancing career and life" than students with male mentors.

In an effort to develop a more detailed understanding of mentoring discussions, a few studies have attempted to categorize the messages exchanged by mentors and students. An early study (Murfin, 1994) used three measures to rate the "quality" of messages posted by African-American and female middle school students and scientist role models on a shared electronic bulletin board. Messages were coded according to tone (friendly, neutral, or unfriendly), content (science, no science mentioned), and type (managerial/administrative, career-related, or personal). Message maps were used to illustrate the distribution of messages, and several trends were noted: The number of personal messages showed a steady increase and managerial messages (i.e., messages used to coordinate or manage the communication process itself) seemed to decrease over

time, while the frequency of career-related messages did not change. Message tone also changed over time, becoming less neutral and more friendly.

O'Neill (1998) suggests that diversity in the types of assistance and support provided may itself be the defining characteristic of telementoring. Two studies have attempted to better define this diversity by categorizing messages in terms of functions or strategies employed by participants.

Harris and Jones (1999) identified 21 such functions in three basic classes ("reporting information," "requesting information," and "other," which included salutations, expressions of thanks, complaints, and apologies) but noted that a single message typically contained more than one perceived function. They observed that information of a personal nature was the most commonly reported type, followed closely by reporting of ideas/opinions/emotions, but emphasized the need for future researchers to look at more than the e-mail texts to better understand the context surrounding the exchanges.

Similarly, Tsikalas, McMillan-Culp, Friedman, and Honey (2000) identified about 30 strategies/functions exercised by students, mentors, and teachers in creating and maintaining project-based online mentoring relationships. They differentiated between "process" strategies, which made "explicit the phases of purpose, tone, or intensity that a conversation is expected to move through over time" (Tsikalas et al., 2000, p. 4) and community-building functions, which promoted a shared sense of purpose and the benefits of participation. In terms of process functions, they found:

- Students defined a specific role for their mentor; set expectations; asked good questions; built a personal relationship with the mentor; and actively managed communication.
- Mentors assessed and anticipated students' needs; focused and redirected students to more promising options; provided information; stimulated students to acquire new knowledge through questioning; directed action; extended students' vision; and exercised quality control.

Mentors also engaged in community-building strategies: They socialized students into particular cultures; treated students as colleagues; provided acceptance, support and encouragement; and referred students to others who might be able to assist and support them. Tsikalas et al. (2000) concluded that it is important to expand mentors' conceptions of their own roles and functions; and that students who were aware of their own needs for specific kinds of assistance and support, and who were proactive in seeking this assistance, had more successful e-mentoring relationships.

Thus, research on electronic mentoring has identified key factors in fostering successful interactions between students and mentors – in particular, message frequency, important discussion topics, and specific strategies to build relationships. However, a more detailed analysis of these factors and how they play out over the course of a relationship could prove useful in order to understand the dynamics of successful (and unsuccessful) mentoring experiences. Research on CMC, especially in educational settings, offers some specific tools for gaining a deeper understanding of interactivity in this context.

CMC and Interactivity

CMC has been found to both enhance and inhibit interaction. Because CMC sacrifices much of the richness of face-to-face interaction (body language, tone of voice, facial expressions, etc.), some early studies concluded that CMC fostered impersonal interaction. Walther and Ragoon (1992) cited the removal of visual communication cues as a particular disadvantage:

> Because the nonverbal codes are generally those that carry relational information, it is the loss of this particular information in written-only CMC that causes unemotional or undersocial communication (Walther & Ragoon, 1992, p. 57).

In an educational setting, students may detect less individuality in others if the teacher/moderator is unable to create a sense of "social presence," for example, through the use of "emoticons" or humor (Tu, 2000).

Conversational cohesion also can deteriorate in CMC. Interactive exchanges in a variety of CMC modes tend to be more disjointed than in face-to-face conversation. With e-mail in particular, responses often are separated from the messages to which they are responding, disrupting interaction coherence; and topics tend to decay quickly, which can create confusion (Herring, 1999).

However, CMC also offers unique advantages. Students using information and communications technology in educational settings express individual opinions with less fear of interruption (Cooper & Selfe, 1990) and tend to ignore socially constructed cues of class, race, and gender (Sproull & Kiesler, 1993). In addition, the online environment permits anyone to become an information provider for others, enabling students to take on a teaching role (Harasim, 1996).

While online interaction may begin as impersonal, Walther and Burgoon (1992) noted that computer-mediated groups develop and evolve in relationally positive directions; indeed, Walther (1996) later acknowledged the potential for "hyperpersonal communication," forms of computer-mediated contact that exceed the depth of interaction that can be achieved face to face. Walther (1996) concluded that students in CMC strive to develop similar social relationships to those found in face-to-face settings, but such relationships take longer to establish electronically. Yates (1996) noted that CMC is affected by the numerous social facets that surround and define the communication and advocates the study of specific social and cultural settings.

A variety of studies have explored interactivity as a key to understanding and evaluating CMC's effectiveness. Henri (1992) defines interactivity as a three-step process involving communication of information, a response to this information, and a reply to that first response. The presence or absence of these three-part chains of communications is an indicator of the degree of interactivity within a particular Web-based forum. In educational settings, Yacci (2000) defines interactivity in a similar fashion, as a message loop between participants. He identified message duration and lag time of response as key variables of interest and noted that the exchange of mutually coherent messages results in two outputs: content learning and affective benefits.

However, researchers have struggled to develop a framework to analyze interactivity that takes into account both the context (i.e., the structure of electronic interaction) and the content of electronic messages. Most attempts have focused on messages exchanged as part of computer conferences involving groups of people and have offered only limited insight.

Rafaeli and Sudweeks (1997), for example, contrasted interactive messages with purely reactive messages. They define interactivity as the dependence among messages in threads, the extent to which messages in a sequence relate to each other, and the extent to which later messages recount the relatedness of earlier messages. They concluded that messages categorized as interactive are more likely to contain agreement than disagreement, are significantly more humorous, and are more likely to contain personalizing content, in the form of self disclosure or an admission.

Herring (1996) analyzed electronic messages in terms of their internal structure and developed two schemes for analyzing interaction:

- The generalized interactive schema includes an opening epistolary convention, a link to previous discourse, a contentful message, a link to following discourse, and a closing epistolary convention.
- The electronic message schema includes a link to an earlier message, an expression of views, and an appeal to other participants.

She noted that women's messages tend to be aligned and supportive in orientation, while men's messages tend to oppose and criticize others.

One study of dyads looked at the decision-making interactions between pairs asked to complete tasks. Utterances were coded into three categories similar to Herring's scheme: orientation, suggestion and agreement (Condon & Cech, 1996).

Several more complex frameworks have been developed for analyzing different facets of electronic interaction. Henri (1992), for example, offers an overarching theoretical framework based on five dimensions of the learning process (Table 1). Messages were divided into "units of meaning," which then were categorized in each

dimension. Of key interest is the interactive dimension, which was broken down into three categories: explicit interaction (which included a direct response or commentary to a previous idea), implicit interaction (which included statements that responded to a previous comment without directly referring to it), and independent statement (which included statements related to the subject under discussion that were neither answers nor commentary).

Table 1: ***Henri's Analytical Framework (1992)***

Dimension	Definition	Indicators
Participative	Compilation of the number of messages or statements transmitted by one person	Number of messages Number of statements
Social	Statement or part of statement not related to formal content of subject matter	Self-introduction Verbal support "I'm feeling great…"
Interactive	Chain of connected messages	"As we said earlier…"
Cognitive	Statement exhibiting knowledge and skills related to the learning process	Asking questions Making inferences Formulating hypotheses
Metacognitive	Statement related to general knowledge and skills and showing awareness, self-control, and self-regulation of learning	"I understand…" "I wonder…"

Hara, Bonk and Angeli (1999) combined a variation of Henri's categorization scheme with a visual representation of message interaction developed by Howell-Richardson and Mellar (1996) to analyze electronic discourse in an online discussion. They sought to identify "social cues" within messages and to differentiate between surface-level cognitive processing and deeper processing. However, they noted the difficulty of coding and concluded that a reliable instrument for content analysis of CMC has yet to be developed. They suggested combining traditional quantitative methods with qualitative tools such as interviews, stating: "Since every computer conference will have

its own unique attributes, researchers may have to design electronic discussion group evaluation criteria on a case by case basis" (Hara, Bonk, & Angeli, 1999, p. 29).

One of the most useful frameworks was developed by Zhu (1998), who analyzed electronic discussion in a distance-learning course (Table 2). Interaction was categorized as vertical (with some participants concentrating on others' answers rather than contributing their own) or horizontal (with more equal participation). Participants typically began as wanderers (who seemed lost in the discussion and were floundering) or seekers (who recognized their own information deficit and need to gain more information), then became contributors and mentors.

Table 2: ***Message Categories, Participant Types and Interaction Types (Zhu, 1998)***

Category	Example	Participant type	Interaction type
Type 1 Question (Information seeking)	Ask for information or request an answer	Contributor Mentor Wanderer Seeker	Vertical
Type 2 Question (Discussion)	Start a dialogue	Contributor Mentor	Horizontal
Answer	Provide answers to information-seeking questions	Contributor Mentor	Horizontal
Information sharing	Share information	Contributor Mentor Wanderer	Horizontal
Discussion	Elaborate, exchange, express ideas or thoughts	Contributor Mentor	Horizontal
Comment	Judgmental	Contributor Mentor	Horizontal
Reflection	Evaluation, self-appraisal of learning	Contributor Mentor	Horizontal
Scaffolding	Provide guidance and suggestion to others	Contributor Mentor	Horizontal

Interestingly, many of these frameworks – as well as some of the strategies discussed in e-mentoring research – echo the categories developed as part of Bales' interaction process analysis. Bales (1950) proposed that the success of a group depends on two factors: how well it can solve the tasks facing it (the task function) and how well it

can keep its members satisfied with the group (integrative, or socio-emotional function). His method – which categorized interaction behavior as either social-emotional or task-oriented – has been commonly used in research on the interpersonal aspects of CMC, but the task-social dichotomy has been criticized for its rigidity and inability to account for multidimensional relational qualities (Walther, 1992).

Thus, none of the frameworks developed to date for analyzing CMC is without flaws. Simple categorization schemes prove too inflexible, while more complex schemes include unclear categories that often are not mutually exclusive. However, these frameworks offer a variety of useful concepts and tools for exploring interactivity in the specific context of electronic mentoring. This study aims to develop a more detailed picture of e-mentoring interaction, bridging the gap between the more general findings of previous e-mentoring studies and the specific tools developed by CMC researchers. Specifically, it addresses two research questions:

- What are the patterns of interactivity between minority college students and professional scientists who use computer-mediated communication in an educational setting (specifically, via messages exchanged as part of an electronic mentoring program)?
- Is there a relationship between interactivity patterns and perceived success of the mentor-student relationship?

Methods

The current analysis is based on two pilot studies on electronic mentoring designed and conducted by Drs. Diane Sonnenwald (project leader), Barbara Wildemuth, Goldie Byrd, Gary Harmon and Walter E. Bollenbacher, with the assistance of Cara Bonnett, Emily Brassell, Melissa Conley-Spencer, P. Brian Hilligoss, Victoria Kindon, Vikki Mercer, Monecia Samuel and Linwood Webster (Wildemuth, Sonnenwald, Bollenbacher, Byrd, & Harmon, 2001; Webster et al., 2000). These studies offer an opportunity to analyze interaction between corporate scientists and biology students from historically minority universities in North Carolina. The project involved two different groups of participants[1]:

- In Fall 1999, 11 undergraduate students from a rural university were paired with nine mentors who worked at a large corporation in the United States.
- In Spring 2000, nine graduate students from an urban university were paired with 12 mentors from a large corporation who worked in the United States or the United Kingdom.

Participants interacted using software developed on a Web-based platform that included private forums for each mentor-student pair. Messages between students and mentors were archived. In addition, each participant filled out a detailed questionnaire and was interviewed, both before and after their participation in the program.

Five student-mentor pairs were selected for in-depth qualitative analysis based on the patterns in topics discussed in the forum, overall participation, each individual's self-

[1] Participant names, including organizational names, are pseudonyms in order to protect the confidentiality of the participants.

assessment of the quality of the match, and the interactivity of each forum. The discussions between students and mentors in those pairs were analyzed with special attention paid to patterns in discussion topics and strategies employed in communication. Analysis of the message forums was supplemented by post-participation questionnaire data in order to compare interactivity patterns with pairs' perceptions of their relationships. The study methods are described in more detail below.

The current analysis of the mentor-student interactions was part of a larger research project that included an overall evaluation of the e-mentoring experience (Wildemuth et al., 2001) as well as examination of participants' information-seeking processes and the program's effect on students' information horizons (Sonnenwald, Wildemuth, & Harmon, 2001).

Participants

The first pilot study began with 12 students and 9 mentors. Of these participants, one student dropped out of college altogether and thus was not included in the pilot study. The second pilot study began with 12 students and 12 mentors; two students dropped the course and one student was deported during the semester. The general characteristics of the participants who completed the entire semester are summarized in Table 3.

Table 3: General Characteristics of Study Participants *(Wildemuth et al., 2001)*

		Students		Mentors	
		Rural Univ, Fall 99	Urban Univ, Spr 00	Company 1, Fall 99	Company 2, Spr 00
Number of participants		11	9	9	12
Age		20.9	25.3	43.4	36.7
Sex	Female	9	7	2	10
	Male	2	2	7	2
Race	White			9	9
	Asian/ Pacific Islander				3
	African-American/Black	10	9		
	African-American/Black, White	1			

Pilot study 1 (Fall 1999): The 11 Rural University students were junior and senior biology majors enrolled in an advanced course titled "Frontiers in Molecular Biology." Rural University enrolls about 1,900 students; 75 percent are African-American, and more than 30 percent come from its home county or adjacent counties. The Rural University students were paired with nine scientist mentors from Company 1, a health-care products and services firm with about 1,000 employees. The mentors were biologists and chemists, most working in research and development.

Pilot study 2 (Spring 2000): The 9 Urban University students were first- and second-year graduate (master's degree program) biology students enrolled in a course titled "Advanced Genetics Biology." Urban University enrolls about 5,600 students, 82 percent of whom are African-American. The Urban University students were paired with mentors from Company 2, a large, international research-based pharmaceutical and health-care company that has evolved as a result of several large corporate mergers over the past decade. At the time of the E-Mentoring program, the company had about 16,000 staff involved in biological and pharmaceutical R&D activities, at more than 20 sites

worldwide. The 12 mentors were employees from several divisions in the United States and United Kingdom; they had bachelor's, master's and Ph.D. degrees in a variety of fields including microbiology, molecular biology, genetics, biochemistry, and training and development.

Data Collection

Participants interacted using WebCT™, a Web-based distance education application package, with extensive customization to meet the project's needs (Webster et al., 2000). Each mentor-student pair had a private discussion forum containing threaded e-mail messages. During each pilot semester, all the messages posted to the forums were collected and archived for later analysis. These logs included the name of the person posting the message, the date and time at which it was posted, a subject line, and the text of the message. The subject line was automatically provided by the system (but could be edited) if the message was posted as a reply to an earlier message.

At the end of the semester, each participant responded to a survey, including questions concerning their reactions to their partners and the program as a whole.

Selection of Pairs for Detailed Analysis

Interaction between student-mentor pairs was compared using several measures; variation in all measures was sought. From the total participant group, five student-mentor pairs were selected for in-depth qualitative analysis based on four criteria:

- the patterns in topics discussed in the forum, specifically the presence (or absence) of four particular topics (academic, science, career and

social/interpersonal) and the occurrence of certain of those topics with other topics (for a more detailed explanation, see Appendix A);

- overall participation, as measured by frequency of postings in the forum;
- each individual's self-assessment of the quality of the match, as reported in the post-program questionnaire (see Appendix B); and
- the interactivity of each forum, analyzed using graphical methods developed by Henri (1992) to compare the pattern of postings that were in reply (explicit or implicit) to prior postings.

Based primarily on questionnaire responses, two pairs – one from each pilot study – were chosen as examples of "successful" forums. Three pairs – one from the first pilot and two from the second pilot – were chosen as examples of less successful forums.

Qualitative Data Analysis Methods

The discussions between the selected pairs of students and mentors were analyzed in greater detail to identify particular themes within and across pairs, with the message used as the basic unit of analysis. First, messages were coded for content using a classification scheme that categorized words as either academic, science-related, career-related, or social/interpersonal (see Appendix A for details). All forums then were reviewed to make sure the coding indeed represented general message content; of special interest were words that were not included in the coding list based on frequency but had been coded in particular categories and did in fact reflect those discussion topics.

Each forum then was carefully read in order to make comparisons and note differences between messages and across forums. Certain questions – for instance, "How is this message/forum different from the preceding one?" and "What kinds of things are

mentioned in both?" – proved useful in this stage to identify themes that represented the ways in which successful and unsuccessful pairs were either similar or different from each other.

Finally, the forums were examined from a more theoretical perspective, using the frameworks drawn from the literature of e-mentoring and computer-mediated communication. Specifically of interest were patterns in discussion topics and strategies employed in communication. For instance, forums were analyzed to determine how career- and science-related topics were integrated into the overall discussion. In addition, the forums were examined for topics that were missing from each discussion.

Throughout the process, messages or exchanges representing major themes were noted. Once an initial list of themes was identified, the forums were reviewed again to locate any conflicting evidence. Selected messages and exchanges then were culled, so that representative examples could be included in this report.

Results and Discussion

Pair Selection

A key factor in selecting pairs for qualitative analysis was each participant's self-assessment of the quality of the match as reported in the post-program questionnaire, compared to his or her respective peer group. All program participants reported that the quality of their match was at least "neutral" on a 5-point scale ranging from "very poor" to "excellent" (Wildemuth et al., 2001). The two pairs identified as successful had an average rating of 4.5 out of 5, while the unsuccessful pairs had an average rating of 3.2.

In addition, the message logs for each mentor-student pair were analyzed in various ways to better compare the activity levels and interactivity patterns within each forum. Because there were considerable differences between those activity levels and interactivity patterns in the Fall 1999 and Spring 2000 cohorts, individual pairs were compared to their peer group rather than to the group as a whole (Table 4).

Table 4: ***Comparison of Mentor-student Pairs***

	Fall 99		Spring 00			Average for all participants**	
	Pair 1*	Pair 2	Pair 3*	Pair 4	Pair 5	Fall 99	Spr 00
Number of messages per forum/pair	22	12	34	15	37	13.17	28.14
Number of messages sent by mentor (student)	11 (11)	5 (7)	20 (14)	9 (6)	16 (21)	8.88 (7.09)	19.91 (20.22)
Number of threads per forum/pair	8	6	10	6	7	4.58	8.50
Average number of messages per thread	2.75	2.00	3.40	2.50	5.29	3.01	3.57
Number of threads initiated by mentor	3	2	7	3	2		
Number of messages in longest thread	7	6	12	4	16	5.58	8.50
Number of single-message threads	1	4	6	2	2	1.25	3.21
Average number of words per message sent by mentor (student)	113.91 (106.63)	184.40 (105.42)	350.65 (214.92)	97.44 (54.33)	143.93 (56.09)	168.70 (100.65)	157.63 (96.88)
Rating of overall quality of mentor-student match by mentor (student)	4 (4)	4 (3)	5 (5)	3 (3)	3 (3)	3.50 (3.82)	3.64 (3.40)

* Pair was identified as successful

** From Wildemuth et al., 2001

To assess amount of activity, the frequency of posting in the forum by each participant was counted and the number of words in the messages was calculated.

Within each forum, interactivity was assessed by analyzing message threads. In a Web-based discussion forum, such as that used for this program, a thread is a set of connected messages, where one message is a reply to a previous message, analogous to a conversation in face-to-face communication. In this analysis, a message was interpreted as a "reply" based on the content of the message (i.e., the content of the message quotes

or otherwise responds to content in a previous message), rather than on the sender's use of the software-based reply function (i.e., the user clicks on the reply button to compose and post the message). Each posting was coded as one of the following (based on Henri, 1992):

Independent statement: a posting that initiates a thread; it does not explicitly or implicitly reply to any previous message;

Explicit reply: a posting that is directly linked to a previous message; this code was operationalized as any message that explicitly refers to a previous message, e.g., quotes from it, or any message that implicitly refers to a previous message and is posted via the software's reply function;

Implicit reply: a posting that implicitly refers to another person or message, and is not posted with the software's reply function.

In addition, an interactivity map was drawn for each forum to aid in visualizing the patterns of interaction.

For the program as a whole, there were more messages per forum, more threads per forum, more single-message threads, and longer message threads in Spring 2000 (Urban University/Company 2) than in Fall 1999 (Rural University/Company 1) (Wildemuth et al., 2001). Among the pairs chosen for this analysis, the number of messages per forum, the number of threads per forum, and the number of messages in the longest thread tended to be higher than average among pairs whose participants rated the match more highly.

However, this quantitative analysis provided only part of the rationale for pair selection. The final, most important component was an analysis of the mappings of topics discussed in the forum to detect patterns. Of key interest were the presence (or absence) of particular topics, the occurrence of certain topics with other topics, and the overall density of coded topic terms within a forum.

Using these criteria, five pairs were selected for qualitative analysis (Table 5). Two of those pairs – one from each study – were chosen as examples of successful forums. In the first study, student Dawn Kearns and mentor Dave Logan each rated the quality of the match as "good." Their exchange began with a combination of all four topics (academic, science, career and social/interpersonal) and continued with a high density of coded topic terms throughout. The forum included one long string of messages, along with several shorter strings. In the second study, student Simon Lewis and mentor Moira Thompson rated the quality of their match as "excellent." However, the structure of their exchange was somewhat different: They began with a combination of academic and social/interpersonal topics, later expanded to include science and career topics, and came full circle to close with academic and social/interpersonal topics. The overall density of coded topic terms was comparatively low. Their exchange included one long string of messages, several shorter strings, and several independent statements.

Table 5. ***Mentor-student Pairings***

Pair	Mentor alias	Student alias	Semester
1*	Dave Logan	Dawn Kearns	Fall 99
2	Elise Mason	Denise Bushnell	Fall 99
3*	Moira Thompson	Simon Lewis	Spring 00
4	Milly Pavlova	Sandra Forester	Spring 00
5	Meredith Yu	Sienna Johnson	Spring 00

* Pair was identified as successful

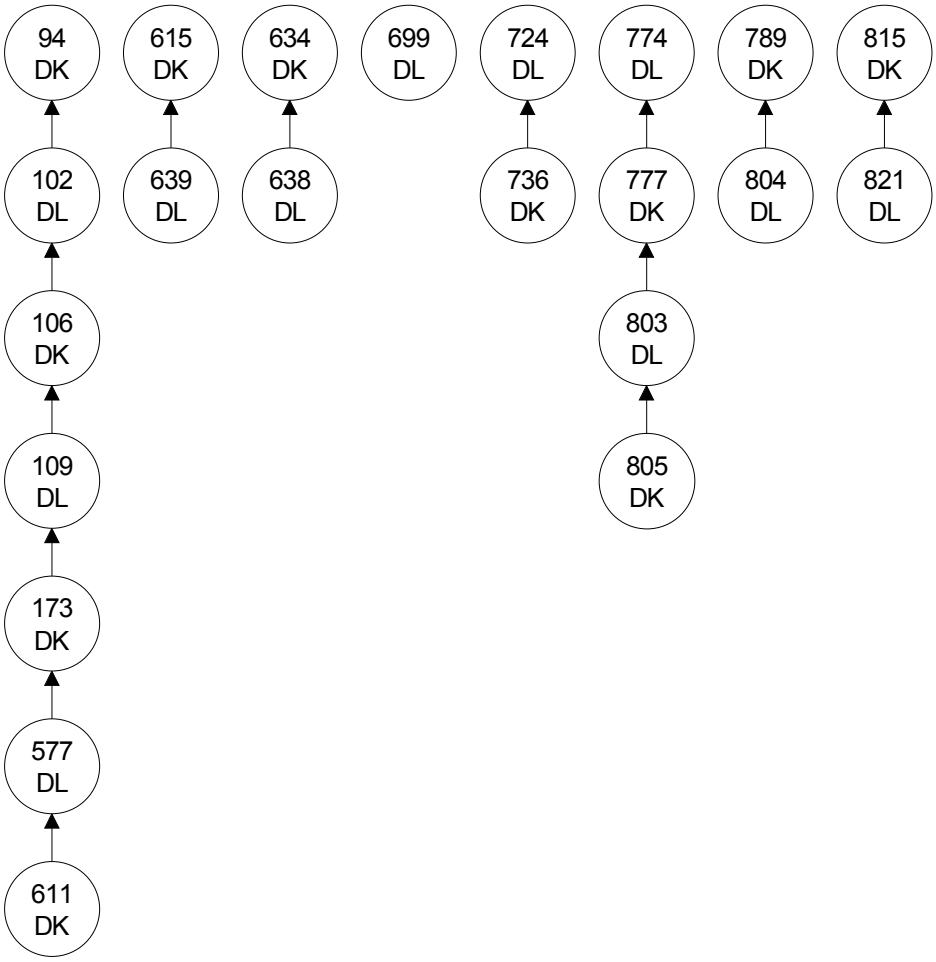
Three pairs – one from the first study and two from the second, larger study – were chosen as examples of less successful forums. In the first study, student Denise Bushnell and mentor Elise Mason rated the quality of their match as neutral and good, respectively. Their exchange began with academic and social/interpersonal topics but was heavily focused on science. It included one long string of messages and several independent statements. Student Sandra Forester and mentor Milly Pavlova each rated

the quality of their match as neutral. Their exchange was dominated by career topics and included several short message strings. Student Sienna Johnson and mentor Meredith Yu also rated the quality of their match as neutral. Their exchange got off to a comparatively slow start, dominated by social/interpersonal topics, but the density of coded topic terms increased throughout. Their forum was characterized by much more complex interactivity than most, with many strings that referred back to each other.

Pair-by-pair Analysis

A brief summary of each pair's exchange, along with a diagram of the structure of the exchange, is included to provide a basis for comparison among the pairs. In all figures, each numbered circle represents a single message; message identification numbers were automatically assigned by the system as each message was posted.

Figure 1. **Pair 1 (mentor Dave Logan and student Dawn Kearns)**



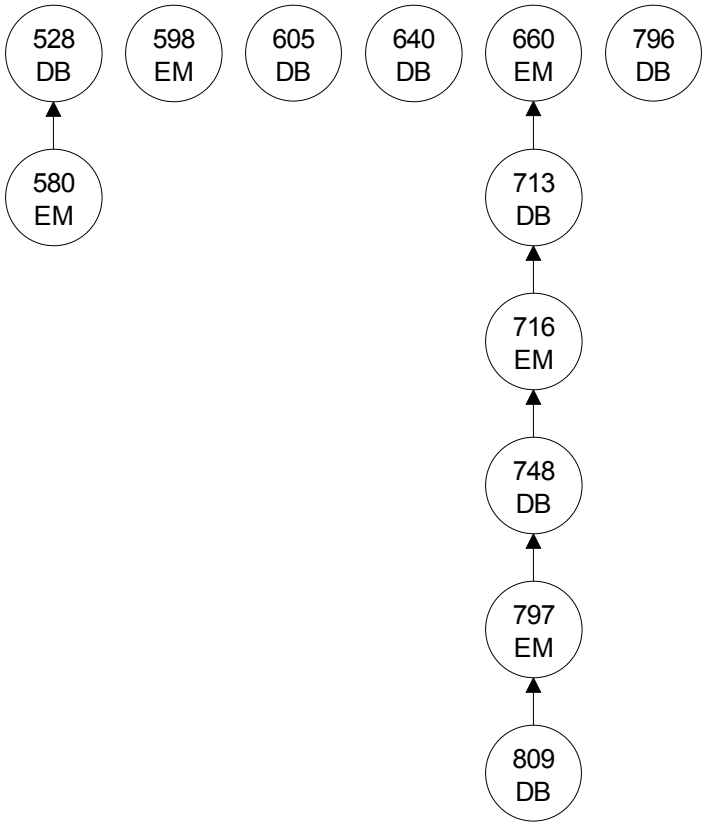
Pair 1 (Fall 1999 – successful)

The exchange began with brief social introductions that included several mentions by both Dawn and Dave of concerns about a possible hurricane in Dawn's area. Three messages into the exchange, Dawn asked Dave for advice on obtaining information about applying to hospital-based medical technology programs, and he suggested searching on the Internet or calling the hospitals directly. Subsequently, Dawn updated her mentor on her search for information and shared her career aspirations. Dawn then asked Dave whether she should observe in a clinical laboratory to get a better sense of the day-to-day doing of science and described her own research on plasmids; in this message, she called

her mentor by the nickname “Doc” for the first time. Six days passed, and Dawn noted the delay in her next message. She also talked about applying to colleges and mentioned that she had earned a B on a recent test and was preparing for midterms. Dave explained that he had been very busy, congratulated her on the test, commented on her career options, and wished her luck on her upcoming midterms. He also shared his experience with plasmids.

In his next two messages, Dave described his own work and asked how Dawn’s studies were going. Dawn explained that she had been busy with homecoming festivities and a play. Dave asked about Dawn’s course load and mentioned in passing that someone in his family had been ill. Dawn responded with a list of current and future classes and wished his family well. As the Thanksgiving break neared, Dave inquired about Dawn’s background in chemistry – his area of expertise – and she responded with a list of classes she had taken. As the exchange wound down, she told him she had submitted two applications to medical technology programs, and he wished her luck.

Figure 2. **Pair 2 (mentor Elise Mason and student Denise Bushnell)**



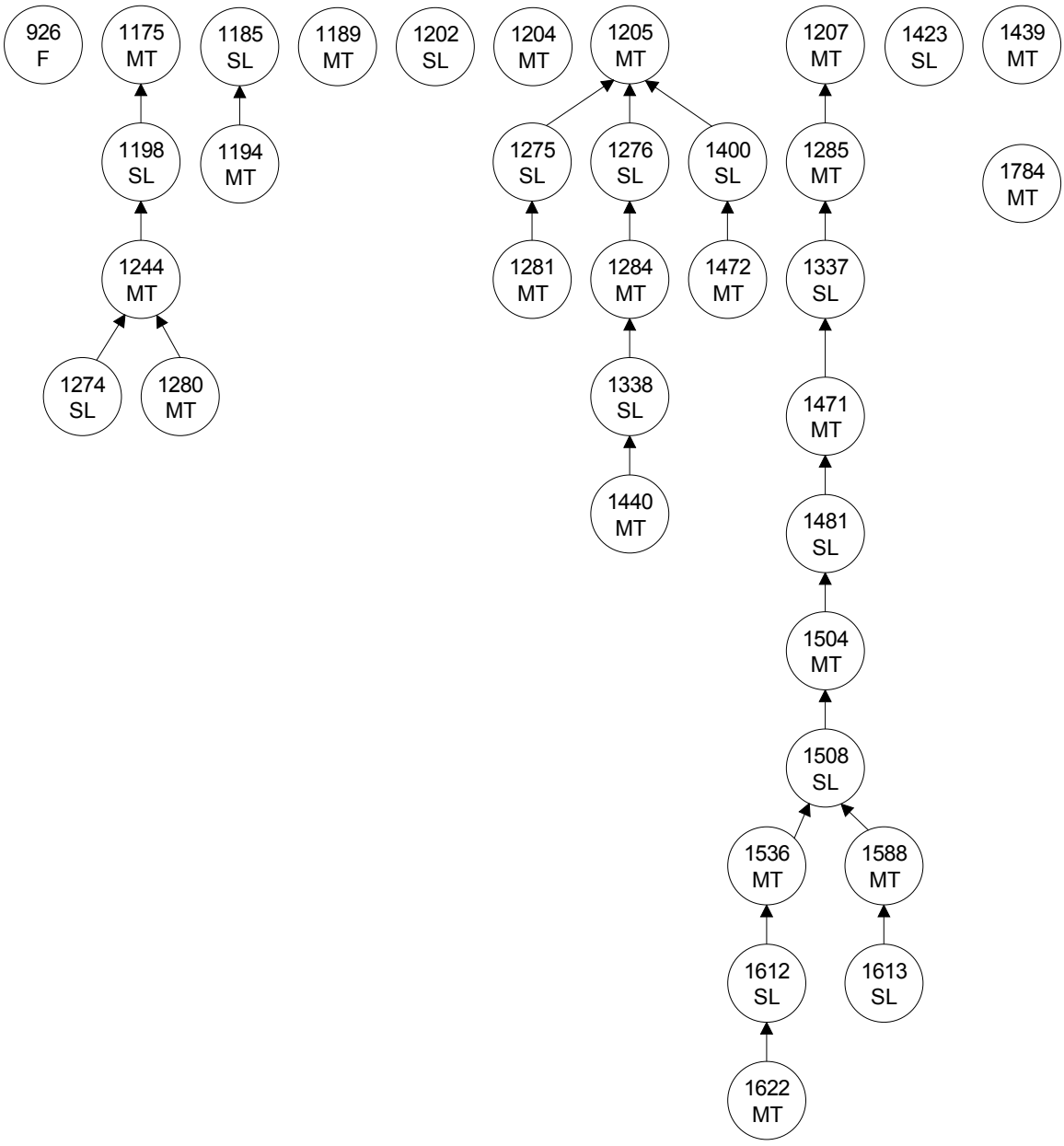
Pair 2 (Fall 1999 – unsuccessful)

Denise began by asking when might be a good time to talk, acknowledging that both were busy, and asked about the college Elise attended. Elise gave a brief description of her background and asked about Denise's courses. Denise described her research in the cell biology laboratory and listed her classes. Almost two weeks passed, and Denise sent a message to "check in." Elise apologized for the delay and described an antibody-related project she was working on; Denise commented that the project sounded interesting.

Elise again said she had been preoccupied recently with a presentation for work and asked what topics Denise wanted to discuss, such as goals, universities vs. industry,

and life as a scientist. Denise responded that she was interested in forensic science and would like to pursue a master's degree while working. Two weeks passed, and Elise apologized for her absence due to a death in the family. She suggested that companies might offer tuition reimbursement and asked about Denise's plans for Thanksgiving. Denise asked for advice on graduate school, then offered her condolences about Elise's loss and suggested that she "take one day at a time and try not to stress yourself about work."

Figure 3. **Pair 3 (mentor Moira Thompson and student Simon Lewis)**



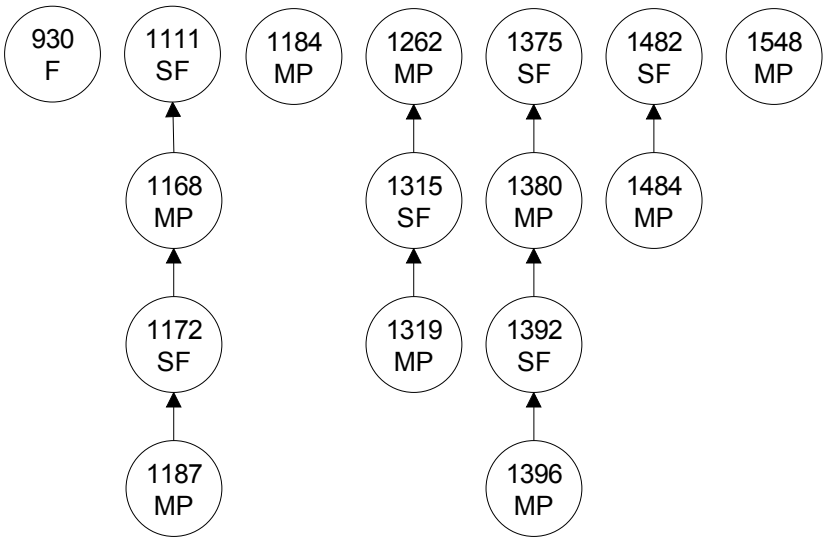
Pair 3 (Spring 2000 – successful)

Moira began by saying she wanted to talk about university life since her son was an undergraduate. Simon asked whether he should call her by her first name or "Dr." and suggested weekly conversations with her son. He went on to describe his own family, and Moira responded by talking about her sons. Moira then presented a list of topics for

possible discussion, organized in different message threads, and suggested that they discuss the logistics for chatting, since her job was rather busy. Simon asked for more details about her career and family, and she responded in detail. He said she sounded like a great parent and described his relationship with his own mother. Moira commented that science influenced the way she parents.

On an unrelated topic, Simon asked what Moira knew about grant writing, and she talked about her writing experience. She prefaced her next message by saying that she knew she was asking a lot of questions, then asked Simon several questions about why he was participating in the e-mentoring program. He answered in detail. Almost three weeks passed, and Moira returned with a lengthy message, first apologizing for the delay, then commenting on Simon's last message and finally describing her day. In his next message, Simon apologized for being brief, described his interest in microbiology, and said he wasn't sure what field he wanted to pursue for doctoral studies. Moira asked for his thoughts about various schools' programs, and he gave his opinions. Simon said he planned to go back through past messages and look for questions he hadn't yet answered. Moira inquired how Simon liked his labs and asked what he was currently studying and which sports he liked. He responded in detail. In her closing message, Moira said she ha enjoyed their correspondence and offered her phone number and e-mail address so they could keep in touch.

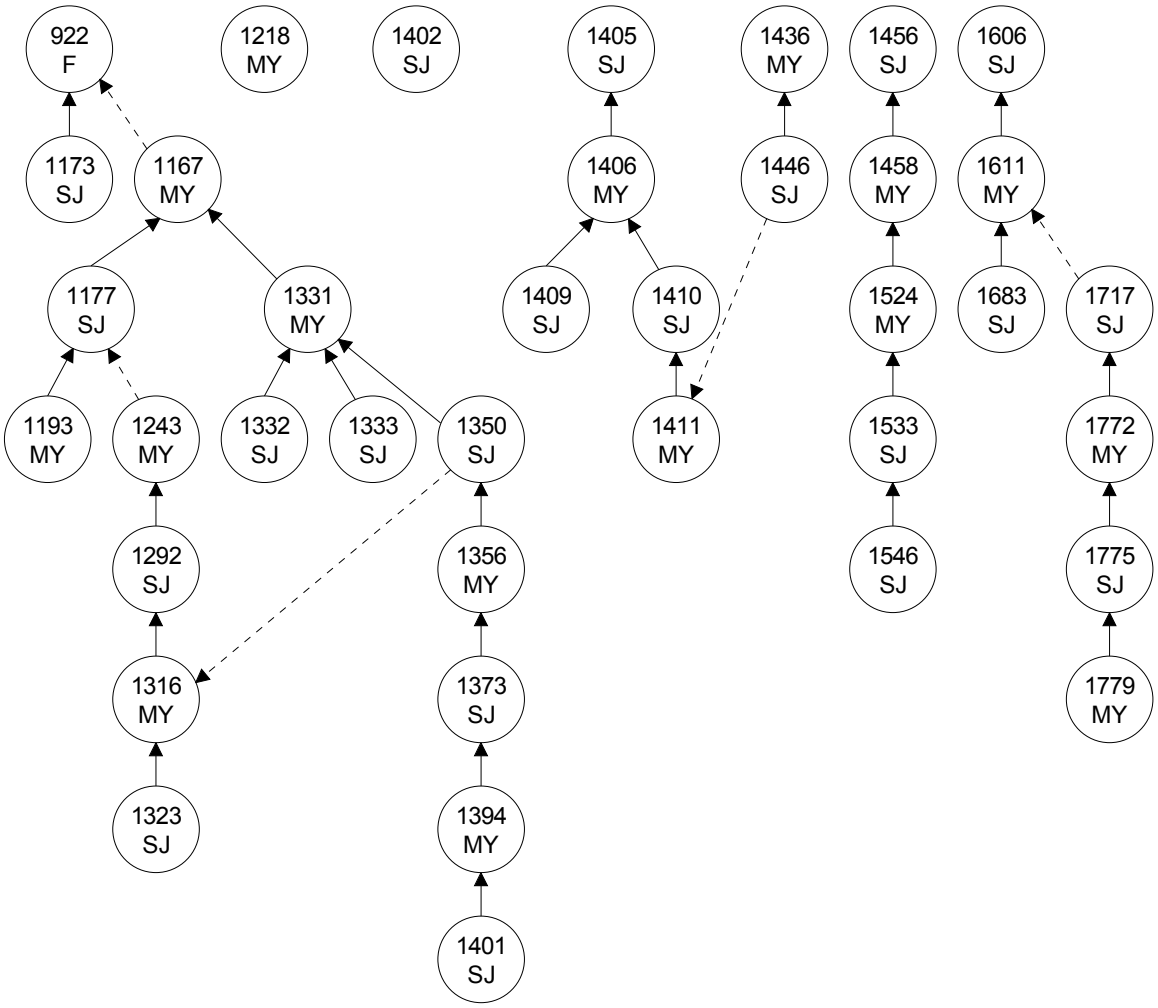
Figure 4. **Pair 4 (mentor Milly Pavlova and student Sandra Forester)**



Pair 4 (Spring 2000 – unsuccessful)

Sandra said she would like to communicate at least twice a week and asked for advice on her first graduate school interview, which was within the next few days. Milly suggested that she relax and wished her luck. Milly then described her own background. Sandra said her interview went well, asked whether Milly was working on any interesting projects at work, and said she had been spending a lot of time studying for her first biochemistry test. Milly remembered her own experiences studying biochemistry. Sandra then asked two specific questions about enzymes, which Milly tried to answer. On an unrelated topic, Sandra asked whether Milly's company had any summer positions available; Milly said no.

Figure 5. **Pair 5 (mentor Meredith Yu and student Sienna Johnson)**



Pair 5 (Spring 2000 – unsuccessful)

Sienna and Meredith dedicated the first 15 messages of their exchange to trying to set up a mutually convenient time for real-time chat and subsequently missing each other due to difficulties logging on. Meredith suggested a few possible topics, and then the two spent another eight messages trying to arrange a chat. Finally, Sienna suggested that they give up on real-time chat and described her personal background. Meredith responded by discussing a scientific meeting she just attended, describing her own research and

expressing interest in Sienna's background and research. Almost two weeks later, Meredith apologized for not keeping in touch and gave her own personal background. Sienna asked for information about jobs in academia vs. industry, but when she didn't get an immediate answer proceeded to apologize for asking so many questions. About a week later, Meredith again apologized for not writing and answered Sienna's question.

Sienna talked a little about her own research and asked for advice, then wished Meredith a nice Easter break. A week and a half later, Meredith apologized a third time for not keeping in touch and wished Sienna luck on her exams. In the last two messages, Sienna thanked Meredith, who suggested they keep in touch after the semester was over.

Thematic Analysis

Structure Within Interaction

Individual message structure. The internal structure of individual messages exchanged as part of the e-mentoring program was similar to the schema identified by Herring (1996), with an opening epistolary convention characterized by increasing use of social/interpersonal words, a contentful message, and a closing epistolary convention, again with increasing use of social words.

A typical e-mail from student Denise Bushnell to her mentor reveals a structure similar to that of a traditional letter, with academic and career-related content sandwiched in between a social greeting and social closing:

> Hi Elise, how are you? Fine, I hope. I haven't talked with you in a while, so I thought I would drop a few lines. I am anxious to graduate. After graduation I would like to attend Virginia Commonwealth University. I am really interested in Forensic Science. They offer a Master's Program in Forensic Science and I think it will be

> beneficial to me. Do you have a Doctorate degree? If so, where did you get it from? Can you give me any advice about graduate school? Well, I hope everything is going well for you and I will be waiting to hear from you. Denise[2]

Forum structure. Interestingly, at least one successful forum also appeared to have a similar metastructure, with more social words used at the beginning and the end of the exchange as a whole. The exchange between Moira Thompson and student Simon Lewis included a high percentage of social and academic topics in the first three e-mails and the last three e-mails of the exchange, while the middle messages included more career- and science-related discussion. Studies of online communities – participants in a distance learning class, for example – show that members exhibit behaviors that traditionally identify the presence of a community offline, such as building a common history, socially constructing rules and behaviors, and demonstrating signs of conscious disengagement from the online community when they leave (Haythornwaite, Kazmer, Robins, & Shoemaker, 2000). This metastructure could indicate an effort by one or both participants to create structure and a sense of closure for the relationship. However, because this phenomenon was observed in only one of the five pairs, more research – specifically of successful pairings – is necessary to confirm whether such a metastructure exists within other exchanges.

Branching structure. Within forums, threads can develop (or be organized) in a variety of ways, just as navigation menus can be organized in linear sequence, tree structure or cyclic network (Shneiderman, 1987). For example, the exchange between Dave Logan and Dawn Kearns is an example of a fairly simple linear structure (Figure 1),

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[2] While the original wording and tone of all e-mail messages has been preserved, misspellings were corrected to make this report easier to read.

while the exchange between Meredith Yu and Sienna Johnson (Figure 5) is more like a cyclic network, with responses referring back to other messages outside the linear path forcing users to jump around the nodes in an unpredictable fashion.

This study suggests that the simpler structure may prove more effective in electronic exchanges because complexity can hurt the flow of correspondence. More successful pairs were more likely to clearly organize their threads by content, while the conversation for at least one less successful pair (Meredith Yu and Sienna Johnson) appeared to suffer because its sequence and structure were more unpredictable and complex.

Regular "Rhythm" of Content-filled Messages

The importance of a quick beginning. This study suggests that mentor-student pairs should not waste time working out the details of correspondence at the beginning; more successful pairs jump right in with specific content, which accelerates the progression in message tone from neutral toward friendly.

One pair, for instance, had difficulty just managing to talk to one another due to technical problems: The server was down when both tried to log on, and these troubles prevented them from having any meaningful dialogue for quite a while. Mentor Meredith Yu and student Sienna Johnson exchanged 15 e-mails focused entirely on the details of when they should talk before engaging in any content-filled discussion. As a result, the tone of those early messages was comparatively neutral, with none of the sharing of personal detail that characterized more successful pairs.

In contrast, other pairs managed to avoid this trouble by immediately jumping into the exchange as if it were a conversation in progress, with content beyond basic

social pleasantries. For example, one student asked her mentor in the first e-mail which college she attended. Another student told her mentor in the first e-mail that she had her first interview for graduate school in a few days and asked the mentor for advice on how to handle it. Similarly, one mentor told her student she had a son in college and asked how he thought parents could best support students in coping with the pressures of university life. These questions launched these pairs into an immediate discussion of substantive issues that helped them move quickly from the neutral stage of just getting to know each other to a friendlier tone of interaction.

Successful management of time lags. A positive start doesn't necessarily ensure a successful relationship overall. Time lags in responding can hurt a pair's momentum if not properly managed. This study suggests that both participants should be sure to respond to all content in previous messages in order to minimize the negative effects of time delays in an electronic conversation. This helps to reestablish the flow of conversation after a delay.

The following exchange demonstrates a successful management approach by Dave Logan after a six-day lag in his conversation with his student:

> Hey Doc!!!
> Haven't heard from you lately. How are things going where you are? Things are okay here. I finally filled out applications to colleges in Georgia. I also requested an application to the Georgia Bureau of Investigation to work in the crime lab division. So I am just waiting to hear from people now. I did okay on my last test in Frontiers of Molecular Bio. class. I made a B. So I was happy. We have another test on Thursday and midterms on next Thursday, so if you don't hear from me in about two to three days, I am studying for midterms. I have to be on my way now, but take care of yourself and I hope to talk with you soon.
> Dawn

> Hi Dawn,
> You probably guessed it, the last 2 weeks have been very busy for me too! I am finally getting a breather. I will respond to each of your messages - I think I am now 3 behind, including this one.
> Great News on your test! That is excellent! Keep plugging away and the grades will come along for the ride. Remember that good things happen to good people.
> It sounds like you are really on the ball and very career motivated. As far as colleges, have you decided on a medical/healthcare based career? It also sounds like you are expanding your options with the application to the crime lab. There really are a lot of interesting choices out there to investigate.
> Oh well, that's all for now. I wish success on your midterms and I'll talk with you soon.
> Cheerio, Dave

In contrast, the following exchange reveals a disconnect between Meredith Yu and her student:

> I know you are already gone for the week, so this will just be posted for you Monday. …
> Well, I am starting to really get into my research. It's becoming kinda fun!!!!! It is funny how I have a totally different approach in tackling a research project than experienced researchers. I am learning how to lay out certain questions before even starting an experiment to assure I answer the right questions. I think I have a problem with trying to answer too many questions in one experiment, but I am learning. I just want to jump into everything..Ha!!Ha!! …
> If you have any advice to share with me, 'I am all ears.' I am just so bogged down with class and my research, I am not really thinking about issues to discuss. I am more interested in getting this degree and going to the next level. If there are mistakes that you have made in the past that may benefit my career path, please share them with me if you don't mind. There is only 2 weeks left in this semester, so I guess I will be disconnected from e-mentoring. I have final exams the week you come back from vacation. Maybe we can post a couple of messages to each other next week before you go on vacation.
> Sienna

> I'm sorry I didn't get back to you. Life has been hectic here. We moved … on 14th April, work was mad the following week and as you know I was on holiday last week.

> And you wanted advice from me on how to organise your time?!!!! I just keep writing lists of all the things I have to do. The lists never seem to get any shorter but it is satisfying when you can cross things off!
> Very best of luck with your exams. I don't envy you, but They're worth it for the good feeling when they're all done.
> I'm not sure whether or not we'll be disconnected at the end of your semester. We have a mentors' get-together next week (via phone) to chat about how it all went. It'll be interesting to see how everyone got on. It seems as though we're only just getting going really, but I think we could have been onto a good thing given more time! You're very welcome to mail me at work afterwards if that helps. My mail address is (meredith@company.com). …
> Hope everything goes well for you in the months/years ahead. You sound as though you know what you want to get out of life which is more than half the battle. Once you know what you want all you need is the confidence to go get it!
> Good luck (again)! Meredith

If one person asks a question or broaches a topic and that particular question or topic goes unaddressed, the question asker can be left to wonder whether his or her partner has even read the entire e-mail, leading to possible hurt feelings. In the above example, while the mentor makes an attempt to address all the topics raised by her student, she offers no advice on the student's research approach and does not offer any of her own personal experiences that might help in the student's career path.

The Four-topic Message as Invitation to Interactivity

While this analysis confirms previous studies' findings that it is important to balance intellect and emotion, it also reveals the importance of balancing specific discussion topics (in this case, academic, career, science and social/interpersonal content). A key indicator of this balance is the distribution of four-topic messages in the exchanges.

These four-topic messages need not be lengthy, as evidenced by a typical four-topic message from student Denise Bushnell to her mentor Elise Mason:

> Hi Elise!! How are you doing? Fine, I hope. My class schedule is not too bad, but I have several mtgs. to attend and research to do in the cell laboratory. I am taking Frontiers in Molecular Biology, Biochemistry, Genetics, Intro. to Business, & Biological Research. As of now I have had a genetics test (9/24), a biochemistry test (9/23) and I have a frontiers in Molecular biology test tomorrow. I am not having any difficulties right now. MWF I do research in the cell biology lab and TR I work at food lion so when I am not in any meetings I am relaxing. In my spare time I enjoy relaxing with my friends and just SLEEPING!! Well, I am getting ready to study so have a great day.
> Denise

While less successful pairs did not necessarily exchange fewer four-topic messages, their forums exhibited clear imbalances in the distribution of those messages. Specifically, mentors and students sent the same number of four-topic messages in the successful pairs (five each for Dave Logan-Dawn Kearns and four each for Moira Thompson-Simon Lewis), while there were significant imbalances among the less successful pairs. For example, Milly Pavlova sent five four-topic messages, while her student sent none. Meredith Yu sent four four-topic messages while her student sent only two, and Elise Mason sent one such message, while her student sent two.

The four-topic message allows variety and the ability to customize the conversation and the relationship overall: Unlike a conversation, which proceeds in a linear fashion, participants can take a nonlinear approach, responding first to those topics that especially interest them. It introduces a social dimension that might be impossible in a lab setting, where the focus is more on getting a job done. In electronic contexts, where science-based discussion can be more difficult, it allows mentors and students to discuss

other facets of "doing science," such as sharing new information resources including valuable web sites.

Mirroring as Indication of Successful Interaction

Content mirroring. Not surprisingly, this analysis revealed that messages on particular topics tend to elicit responses in those topics. For example, a message from student Simon Lewis inquiring about family, career and academic topics elicits his mentor's response in those categories:

> ***Simon Lewis:***
> Hello again..... Well I also want to know how difficult is it to have time to start a family? Did your start your family while in school? Are you married? If so where did you meet your husband? Was it hard to find a location to live that both of you liked? Feel free to tell me "NONE OF YOUR BUSINESS" I won't take it personal. I just want to know how to gain the things in life that are really important and the troubles that come along with it.
>
> ***Moira Thompson:***
> I can remember before I was married at how awful I thought it was that just at the point when you were having to make decisions about family... one is also making decisions about career. Everything seemed SO important! I guess the bottom line is the more you can figure out what you want... the easier those decisions become. For one, I knew that I WANTED to have a husband I loved, and I WANTED to have children, and I WANTED to have a job that I liked too. So, I tried to make decisions that balanced all three. Sometimes one took precedence over another, but I never let go of each basic wish. Obviously, when you are married... decisions become harder because some decisions will become joint decisions. Others will be yours or theirs. Sometimes you don't even know whose decision it is until It's already done. I firmly believe that only you can decide what you want... so be honest with yourself and learn to realize that you ARE the decision maker for your own life. This doesn't mean that you have control of everything. That is, opportunities and temptations will be presented to you, but as an adult, you must own up to being the person making choices. And sometimes it's those "little" choices, like whether to copy a car key. They all count. Most of the decisions are actually the small ones.

> Another is whether to do your homework each day when you are in middle school. I'm trying to teach my eighth grader about that one! Do I sound like I'm lecturing? If so, lecture right back whenever you feel like it.

Invitation to interact. To perpetuate successful interaction, a four-topic message should be viewed as an invitation to interactivity and should receive a four-topic response. Problems occur in pairs that do not provide these responses.

For example, student Denise Bushnell described her class schedule, upcoming tests and research in the cell biology lab in a four-topic message to her mentor, Elise Mason. When Elise didn't respond, she sent a follow-up message. Finally, Elise apologized for not answering sooner, but her message was a description of the project she was working on, with no acknowledgment of the student's earlier description of her own coursework. The student attempted to bring the conversation back:

> Hi Elise, your project sounds very interesting. I love doing research and just hanging around in the lab. Most people ask me how do you stay in the lab all of the time. Well, that is what I like to do.

However, that did not lead to any more questions about the student's academic concerns or research; instead, her mentor responded by talking about a work presentation she did and even noted, "scientists love to talk about what they do if they have a captive audience." The conversation ended four e-mails later, about two weeks before the semester's end.

In addition, interaction falters if one participant – either mentor or student – fails to follow up with a particular line of conversation, leading to a disruption in the conversational momentum. For instance, mentor Milly Pavlova described her own memories of learning biochemistry in response to her student's mention of an upcoming

biochemistry test. Her student, Sandra Forester, not only didn't respond but sent the conversation in a completely different direction:

> Congratulations on your interview!
> I completely understand how much time needs to be spent studying biochem... I must admit that was one of my LEAST favorite classes... I remember that my professor had us just memorizing biochemical pathways until we were blue in the face. I never felt like I was not learning the basis behind them, instead I was memorizing stuff that I could easily look-up in a chart if needed. Ugh.
> I work in the "physical mapping group" in the department of Molecular Genetics at GW. I am currently working on Adult-onset diabetes. My role is to do DNA fingerprinting. This is a new technique for me and I like it very much. There is lots of computer based assays and little bench work.
> Hope all is well. Milly
>
> Hi,
> How are things going? Our genetics professor presented a question for us to answer and it concerned enzymes which are not proteins. Do you have any ideas? Are you familiar with abzymes? If you have any information I would appreciate it. Thanks so much.
> Sandra

Mentor leadership and mirroring in message length. Among the total participant group, Wildemuth et al. (2001) noted that frequent postings by mentors led to more frequent postings by students and suggested that participants interpreted their partner's level of activity as representing his or her level of commitment to the exchange, a key relationship factor affecting willingness to engage in a mentoring relationship. They recommended that mentors be encouraged to post messages frequently, as it is likely that this will encourage students to post frequently.

The pairs selected for this study confirm that finding: In the pairs who rated themselves as more successful, the mentors posted more frequently than their students, while students in the less successful pairs posted more frequently than their mentors.

A second perspective on the mentor-student interactions is to examine who is initiating the discussions. By looking at the ratio of responses to independent statements for each group in each cohort, Wildemuth et al. (2001) noted that in the Fall 1999 program, the students initiated more of the threads, with the mentors responding, while in Spring 2000, the mentors initiated more threads and the students responded. They recommended that the mentor, as the more senior member of the pair, should take responsibility for initiating threads of discussion.

However, this study does not necessarily confirm that recommendation. Only one of the mentors initiated more threads than did her student (Pair 1, with mentor Moira Thompson initiating seven of 10 threads); in the rest of the pairs, the student initiated at least half – and as many as 70 percent – of the discussions. This suggests that allowing the student to set the discussion agenda may be a useful strategy.

One indication of successful interaction is that messages of a certain length tend to elicit messages of a similar length, with the mentor more likely to play a leadership role in this pattern. This pattern was especially noticeable among the two pairs who rated themselves as successful. For example, student Simon Lewis began his discussion with mentor Moira Thompson by sending comparatively short messages of less than 100 words. She responded with longer messages, often longer than 200 words, and over time, his responses became correspondingly longer (Table 6). At one point in the exchange, he even mentioned the issue of message length, writing, “I really don’t have much time to reply so please forgive me if I’m too brief.”

Table 6: ***Mirroring in Message Length (Pair 1)***

Order in forum	Message number	Word count	Sender	Receiver
1	1185	13 *	Simon	Moira
2	1175	112 *	Moira	Simon
3	1189	185 *	Moira	Simon
4	1194	150	Moira	Simon
5	1198	99	Simon	Moira
6	1202	17 *	Simon	Moira
7	1204	172 *	Moira	Simon
8	1205	28 *	Moira	Simon
9	1207	81 *	Moira	Simon
10	1244	372	Moira	Simon
11	1274	330	Simon	Moira
12	1275	30	Simon	Moira
13	1276	141	Simon	Moira
14	1280	200	Moira	Simon
15	1281	282	Moira	Simon
16	1284	786	Moira	Simon
17	1285	78	Moira	Simon
18	1337	347	Simon	Moira
19	1338	313	Simon	Moira
20	1400	131	Simon	Moira
21	1423	104 *	Simon	Moira
22	1439	108 *	Moira	Simon
23	1440	880	Moira	Simon
24	1471	1621	Moira	Simon
25	1472	581	Moira	Simon
26	1481	192	Simon	Moira
27	1504	168	Moira	Simon
28	1508	489	Simon	Moira
29	1536	638	Moira	Simon
30	1588	394	Moira	Simon
31	1612	260	Simon	Moira
32	1613	543	Simon	Moira
33	1622	136	Moira	Simon
34	1784	191 *	Moira	Simon

* Message coded as independent statement

Even among pairs who did not rate themselves as successful, mirroring occurs on occasion. For example, mentor Elise Mason's longest message to her student Denise Bushnell (273 words) elicited the student's longest message in response (243 words).

Unfortunately, this occurred near the end of the program, and their exchange ended soon after.

Horizontal Interaction That Emphasizes Community Building

The literature indicates that mentors should expand their conception of their own role and that students who know their own needs and seek assistance are more successful. This analysis suggests that pairs where both participants feel equally comfortable bringing up new topics and asking questions tend to rate the match more highly, while pairs in which the mentor acts as a "manager" tend to be rated as less successful. Thus, community-building functions are preferable to "process" strategies (Tsikalas et al., 2000), and horizontal interaction is preferable to vertical interaction, with the goal of moving a student from the seeker role into more of a contributor/mentor role in the exchange (based on Zhu's 1998 framework).

This analysis provided positive examples of successful horizontal interaction, as well as negative examples in which mentors acted more as teachers and managers and less as equal participants.

Moira Thompson and Simon Lewis offered one positive example of how mentors can invite their students to take on a teaching role. Rather early in the exchange, she issued this specific invitation:

> I would like for you to be very proactive about asking me specific questions on ANY topic. We are here to benefit each other. I think that students can mentor those who are older or further in their careers if we are willing to listen.

She immediately received a positive response:

> Hello, (Moira) I guess I do have a lot of questions....let me see let's start with you field, what do you do,why and how did you end up doing it?

However, a lack of such clear communication about roles and expectations can lead to confusion. For instance, student Sienna Johnson asked her mentor several questions about working in academic vs. industry, but when she received no immediate reply, she sent the following message:

> I did not mean to ask so many questions. These are just some issues we can incorporate into our messages. I hope your day has not been to busy, but what else could it be in the sciences (smile). Sienna

On a positive note, mentors who allowed a more horizontal relationship with their students opened the relationships up to positive developments. When one mentor shared with her student that there had been a death in her family, she received a comforting message in response:

> Hi Elise, How are you doing? I am sorry to hear about your grandmother, but just remember everything happens for a reason. Just take one day at a time and try not to stress yourself about work. I am going to Rocky Mount, NC for Thanksgiving and the day after Thanksgiving me and my mom will be heading to Williamsburg to do some shopping. Today I have a genetics test and tomorrow I have a biochemistry test. There is so much to know in biochemistry it really is stressful. Well, just thought I would respond back to you and take care of yourself.
> Denise

Thus, it is important to remind mentors that they need not know all the answers or always present a strong front; indeed, revealing their true situations and personalities can encourage a student not only to do the same but to grow.

In contrast, students who seemed to view their mentors in a more limited role tended to ask impersonal questions that did not help in developing the relationship. For example, Sandra Forrester's exchange with her mentor included comparatively little social/interpersonal discussion. Instead, the student seemed more comfortable asking

specific scientific questions, and as a result, the pair's messages tended to sound more like impersonal memos than friendly conversation:

> If you know any other enzymes which are not proteins that would be quite helpful, or just more general info on abzymes. Thank you again.
> Sandra

Dave Logan and Dawn Kearns provide an example of how students and mentors can move from specific questions into a more personal, horizontal interaction:

> Hi Dr. Logan
> I made it through the storm okay. I guess it was after the storm that was terrible. All streets were closed going to and coming from (the city). But everything turned out rather well.
> I have a question. Right now, I am looking to go into medical technology. I know I have to be certified before entering that field. But it is rather hard getting application information from hospital-based programs in North Carolina. How do I go about receiving applications and getting more information about programs that are done through and by the hospital?
> Have a blessed day.
>
> Good morning Dawn,
> I'm happy to hear you weathered the storm. I have seen clips from TV indicating that flooding appeared widespread and very damaging. I hope you weren't affected too much.
> I would try a few approaches to obtaining information from hospitals about their programs. Programs may vary from place to place and I would try contacting many different places. One approach would be to see if a number of them have websites, you might be able to screen out programs.
> Another approach would be to call the hospitals directly and ask to be directed to someone who could help you. In this case you will want to be prepared to state to them exactly what you are requesting of them.
> What has been your approach so far? You may want to Search for hospitals on the web outside of N.Carolina for literature and to get a feeling for what the requirements are.
> I hope this has helped, although I recognize it is rather vague. If you can provide me a little detail on you expectations I'm sure more things will come to mind.
> Have a nice Monday.

In this exchange, both participants framed the career-oriented discussion between a socially oriented greeting and a friendly, personal closing. The mentor, in particular, took care to avoid sounding abrupt in his response, inviting the student to ask further questions if she needed additional information. The overall tone of the exchange resembles that of a conversation between equals rather than a teacher or manager answering the question of a subordinate.

Summary and Conclusions

This research study analyzed the content of message exchanges between five professional scientists and five minority college students who were paired as part of an electronic mentoring program. Drawing from research in the published literature of both mentoring and computer-mediated communication, this study was formulated to bridge the gap between these bodies of research, offering detailed information about one-on-one interaction in a nontraditional educational setting. The study analyzed messages exchanged as part of two pilot studies on electronic mentoring, with the goal of providing a better understanding of the connection between interactivity patterns and perceived success of a mentor-student relationship.

It is evident from the results that there is no clear recipe for successful interaction; not only are there a variety of factors at play in developing an online relationship in this context, but mentor-student pairs can falter at various stages in the process and in various ways. Successful interaction seems to require a combination of factors, including:

*Linear structure of exchang*e**:** A linear exchange with threads organized by content is preferable to a more complex structure with responses referring back to other messages outside a linear path.

Importance of a quick, content-filled beginning and successful management of time lags: In order to kick-start the conversation and keep that momentum going, participants should jump right into specific content and should be sure to respond to all content in their partner's previous messages in order to minimize the negative effects of time delays.

Good balance of topics to stimulate interactivity: A balance of topics allows participants to customize the conversation and the relationship overall, introducing the potential for both social and task-related discussion and giving participants the choice of responding first to those topics that especially interest them.

Mirroring in content and message length: A message that includes a variety of topics is more likely to lead to a successful exchange if the receiver responds in kind, with a message addressing all the topics introduced. Problems tend to occur in pairs where one participant regularly ignores content introduced by the partner. It is important to note that either partner can take a leadership role in introducing new content; although mentors are the more senior partner in this particular context, it can be useful to allow the less senior participant to set the discussion agenda. Mirroring in message length is somewhat different: The pattern in successful pairs seems to indicate that mentors who send longer messages encourage their students to send longer messages in response, which encourages overall interactivity and builds stronger relationships.

Limited overt "managing" by mentors: Overall, the results would suggest that horizontal interaction, where both mentor and student interact as equal participants, is preferable to vertical interaction, where mentors act more as teachers and managers. In addition, "community-building" strategies, in which mentors and students interact as colleagues and provide mutual support and encouragement, are preferable to "process" strategies aimed at defining specific roles, setting expectations and actively managing communication.

Limitations and Directions For Future Research

Sample size. The fact that the participant sample represented a small, fairly specific group limits the extent to which these findings can be generalized to other electronic mentoring contexts. Nonetheless, the results do offer a depth of understanding that might not be available from a broader analysis of a larger participant group. Further studies utilizing other populations should test the robustness of the findings.

Applicability of study methods across domains. Although this particular content coding scheme has limited utility beyond the context of the current study, the process employed to create this scheme could be used to develop similar coding schemes in other domains that could then be used to analyze pair interaction in a similar fashion. For instance, a study of work-group pairs at different locations or student-student pairs in a distance-education class could use similar methods for reliably coding content, thus offering new insights into interaction in different contexts.

Collection of interview data concerning interactivity patterns. Interviews conducted for this project were focused on overall evaluation of the program and participants' use of information resources. In the future, interview questions could be more specifically targeted to issues of interactivity, for example, whether participants were aware of the "rhythm" of exchange, attempts by either participant to manage the exchange, or mirroring / metastructure in the exchange. It would be useful to know whether self-awareness of these phenomena help or hurt these exchanges.

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Appendix A

The content analysis of messages exchanged within student-mentor discussion forums was conducted in three stages: frequent words were identified; those words were classified into categories; and coding reliability was checked. Those steps are described in more detail below. The goal was to reliably classify message content. The classification methods used in earlier studies (Hara, Bonk, & Angeli, 1999; Zhu, 1998) did not confirm their reliability; the current methods were an attempt to overcome the problems of reliable classification.

Identification of Frequently Used Words

First, a word-frequency count of all the mentor-student forums was conducted using MonoConc Pro, a concordance creation program. Words with four or more occurrences were included, resulting in a list of 990 unique terms.

Classification into Topical Categories

Next, in order to identify patterns in discussion topics within the mentor-student forums, a framework for classifying terms was developed, based on key topics identified in the e-mentoring literature as well as types of interaction described in Bales' (1950) protocol. Four categories of important terms were identified (Table A-1).

Table A-1: ***Term Categories***

Category	Description
Academic	Any terms related to a student's current or future academic tasks and performance
Science-related	Any terms related to specific scientific topics in such areas as biology, chemistry, genetics, medicine, bioinformatics, biostatistics, molecular biology/biotechnology, bio-medical engineering, pharmacology, etc.
Career-related	Any terms related to professional employment, including: obtaining jobs or internships, career options, professional organizations, attending conferences, various career/job settings, etc.
Social/ Interpersonal	Any terms related to social or emotional interaction, including: greetings; offering or accepting assistance; indicating goodwill, praise, gratitude, admiration or approval; expressing condolence; indicating happiness or enjoyment; making a joke or trying to amuse; expressing agreement or compliance with a suggestion or request; confirming another's belief; expressing values, feelings or sentiments; expressing interest or comprehension; admitting an error or asking the other's pardon; or expressing frustration, dissatisfaction or disappointment
Other	Any terms that do not fit in the above four categories

Two coders were instructed to review the list of 990 terms and code each word into one of the five categories, with the expectation that most words would be categorized as "other." The two coders' lists were compared for intercoder reliability, revealing 310 disagreements. Those terms then were reviewed to see if a resolution could be reached. Several clusters of terms were ultimately excluded from the list because they could not be resolved into a single category. These included:

- Words with two senses, which would be impossible to code without seeing the word in context (such as "nature" and "degree").
- Proper names.
- Computer-related terms (such as "computer" and "firewall").
- Bibliographic terms (such as "literature," "text," and "author").

Some other terms resulted in an initial disagreement but were resolved to a particular category based on the consistent application of agreed-upon coding. For example, all family-related words (such as "husband," "wife," "babies," "children," "mother" and "parent") were ultimately coded into the social category because the word

"family" had been agreed upon as a social term. Similarly, all words containing "mentor" were coded into the academic category because the word "e-mentoring" had been agreed upon as an academic term. Medical terms proved the most difficult to code because they could fall into either the science or career category. As a result, each term was evaluated individually. "Med" was coded as a science term because "medicine" and "medical" had been coded as science terms, but "physician" and "hospital" were coded as career terms because they represented a possible job or job setting, and "md" was coded as an academic term because it represented an academic degree.

Selection of Terms for Further Analysis

The next step was to identify the 20 most frequently used words in each of the four main categories. To better evaluate term frequency, all terms were compared to see if any could be combined using simple stemming. Basic string matching, including verb variations and plurals, was employed. Because the distinction between categories relied on differentiating between an individual and his or her related activity, terms representing actors were not combined with their corresponding domain (for instance, "scientist" and "science" were not combined into one grouping, nor were "student" and "study" or "teacher" and "teaching"). The decision to separate those words did not make a significant difference because related words all fell into the same categories. Word frequencies then were compared to develop a list of 20 most common terms in each category (Table A-2). Some words, primarily in the science category, were used exclusively in one semester's forums but not in the others; when that was the case, that word was excluded from the list of top 20 words in that semester and the next most frequent word on the list was used in its place.

Table A-2: ***Selected Words and Their Frequencies by Category***

Rank	Category 1 (Academic)		Category 2 (Science)		Category 3 (Career)		Category 4 (Social)	
1	196	school/ schools	152	gene/genes/ genetic/genetics	367	work/works/ worked/working	175	hope
2	137	research	92	lab/labs/ laboratory	114	job/ jobs	160	hi
3	108	class/ classes	98	science/ sciences/ scientific	52	company/ companies	133	interest/ interests/ interested/ interesting
4	80	graduate/ graduated/ graduating/ graduation	62	biology/ biological	40	career/ careers	108	help/ helps/ helpful
5	79	course/ courses	48	dna	29	opportunity/ opportunities	85	home
6	75	phd/ phd's	42	medicine/ medical	24	management	85	thank/ thanks
7	60	learn/learned/ learning	31	chemistry/ chemical	22	office	76	need/ needs
8	57	study/ studying/ studied	26	cancer [1]	19	industry	75	family
9	52	student/ students	26	clinical	19	business	74	chat/ chatting
10	48	college	25	disease/ diseases	17	interview	74	sorry
11	47	semester	25	drug/ drugs	16	hospital/ hospitals	70	feel/feels/ feeling
12	42	mentor/ mentoring	25	scientist/ scientists	13	department/ departments	58	care
13	39	book/ books	23	data	12	money	58	enjoy/ enjoyed
14	36	ementor/ e-mentor/ ementoring/ e-mentoring	22	sequence/ sequences/ sequencing [1]	11	profession/ professional	57	hello
15	36	university/ universities	20	experiment/ experiments/ experimental	9	physician	56	ok/ okay
16	31	exam/ exams	20	plant/ plants	8	organization/ organizations	54	happy
17	28	teach/ teaching [1]	18	pathology [1]	7	boss/ bosses	50	please
18	22	education/ educational	16	discover/ discovery	7	doc [2]	40	child/ children
19	20	grade/ grades	15	patients	7	skills	38	husband/ husband's
20	19	final/ finals	14	blood	6	customers	38	luck/ lucky
	19	professor/ professors [3]	14	evolution [3]	6	staff [4]		
			12	biochemical/ biochemistry [3]				
			12	forensic [3]				

[1] Not used in fall semester
[2] Not used in spring semester
[3] Used only in fall semester
[4] Used only in spring semester

Two coding exceptions were noted among the most frequently occurring words. The word "due" was excluded from the list entirely because it often was not used in the academic context in which it had been coded. The word "course" was coded as an academic term but was used occasionally as part of the phrase "of course"; however, because it was used in the academic context much more frequently, it was included on the list.

Using that subset of frequently occurring terms, all occurrences of those terms were highlighted in each of the discussion forums using a different color for each category. The resulting color mappings in all the forums then were reviewed for patterns. Notable patterns included:

- the co-occurrence of academic and social words at the beginning of many forums;
- the presence or absence of scientific or career-related words in the middle of certain forums;
- the overall presence of a certain topic throughout a forum;
- overall mix and density of all four topics throughout a forum.

Limitations of the Method

Relying on word-frequency counts assumes that the words that are mentioned most often are the words that reflect the greatest concerns. There are several weaknesses to this method:

- Synonyms may be used for stylistic reasons throughout a document and thus may lead the researchers to underestimate the importance of a concept.

- Each word may not represent a category equally well. This study attempted to compensate for this by looking only at high-frequency words, but this still gives equal weight to all frequently occurring words.
- Because some words have multiple meanings, a single word could be coded in multiple categories; only by reviewing every word in context can the consistent usage of words be tested.
- The method did not factor in misspellings, which were fairly frequent.

Appendix B

Mentors and students were asked to evaluate the quality of their relationships using the following items from the post-program questionnaire (Wildemuth et al., 2001):

For students:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5. My mentor was interested in me.	1	2	3	4	5
6. I was comfortable asking my mentor questions.	1	2	3	4	5
7. I am interested in continuing my relationship with my mentor.	1	2	3	4	5
8. I am interested in meeting my mentor face to face.	1	2	3	4	5

For mentors:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. My student(s) were interested in me.	1	2	3	4	5
2. I was comfortable answering my students' questions.	1	2	3	4	5
3. I am interested in continuing my relationship with my student(s).	1	2	3	4	5
4. I am interested in meeting my student(s) face to face.	1	2	3	4	5

For both:

The overall quality of the mentor-student match was _____.

- ❍ very poor
- ❍ poor
- ❍ neutral
- ❍ good
- ❍ excellent