Active and Interactive Learning Online: A Comparison of Web-Based and Conventional Writing Classes

—BRAD MEHLENBACHER, CAROLYN R. MILLER, DAVID COVINGTON, AND JAMIE S. LARSEN

***Abstract*—*This study examines how students enrolled in two Web-based sections of a technical writing class performed compared to students enrolled in a conventional version of the class. Although no significant difference in student performance was found between the two learning conditions, our data reveal intriguing relationships between students' prior knowledge, attitudes, and learning styles and our Web-based writing environment. One finding that we focus on here is that reflective, global learners performed significantly better online than active, sequential learners, whereas there was no difference between them in the conventional class. Our study highlights the complexity of effective teaching and the difficulty of making comparisons between the online and the classroom environments. In particular, we maintain that the transfer of active learning strategies to the Web is not straightforward and that interactivity as a goal of instructional website design requires significant elaboration.*

***Index Terms*—*Active learning, distance education, educational assessment, interactivity, learning styles, online courses, technical writing instruction, Web-based instruction and training.*

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The authors are with North Carolina State University, Raleigh, NC 27607 USA (email: brad_m@unity.ncsu.edu).
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The debate about the relationship between instructional technology and educational reform is a heated one, exciting many educators and filling others with apprehension, but most would argue that fundamental changes are well underway [1], [2]. Colleges and universities are rapidly moving courses and even entire degree programs onto the Internet at a staggering rate. According to the National Center for Education Statistics (NCES 98-062, October, 1997), 75% of some 26,000 distance education courses delivered to over 753,000 students in 1994–1995 will have moved online by 1999. And distance education courses are just a fraction of the total number to be offered via the Internet by the early 21st century. Thousands of traditional lecture- and laboratory-based university courses across the U.S. and Canada are being transformed by faculty for full or partial Web-based delivery [3], [4]. In its 1998 review of the "rapidly expanding phenomenon of online education," EDUCAUSE estimates that "the Internet and World Wide Web now deliver online courses to more than one million students." These changes have prompted an even livelier debate about the effectiveness of distance education, the role of computers in post-secondary education, and the very definition of "effective" teaching in the research literature.

Traditionally a mission of university extension units to

reach nontraditional students by a variety of means, distance education now often refers primarily to computer-based instruction. However, distance education and computer-based instruction have distinct and not necessarily compatible histories. Those who are suspicious of distance education are often reacting primarily to computer-based models of learning as being impersonal and as involving little or no contact between instructors and students; they are being met with the argument that contemporary online technologies can be very personal and very interactive. Network-based technologies build learning communities, it is claimed, create opportunities for historically marginalized voices to enter into the conversation, and can facilitate the development of student-centered classrooms [5], [6]. Unlike cassette-, video-, and television-based distance education, Web-based distance education provides students with "access to the world's best instructors and information sources without [them] having to set foot on campus" [7, p. 22]. Tapping into the interactive capabilities of computers, proponents of distance education argue, will make off-campus instruction more active than the lecture-based, passive learning model of the traditional classroom.

It is important to add that the World Wide Web is not the only factor creating the perception that educational traditions are being transformed (or require transformation). Koschmann, Kelson, Feltovich, and Burrows maintain that educational reform is critical because of the dozens of studies that reveal that "existing educational systems are producing individuals who fail to develop a valid, robust knowledge base; who have difficulty reasoning with and applying knowledge; and who lack the ability to reflect upon their performance and continue the process of learning" [8, p. 85]. Hanna suggests that educational reform is occurring at the institutional level due to the rapid growth of and approaches to education, in addition to the university's increased "focus on responsiveness to learner needs and desires such as convenience, timing, engagement, application of knowledge to the workplace, and learning by doing" [9, p. 91]. This urgent student orientation, however, has been linked directly by many to transformative technologies and their potentials [10]–[13]. For example, the potential for distributed access to instructional materials, interactive simulations, and "friendly" hypertextual information display has made the Web seem an ideal environment for student-centered active learning.

Writing instruction has welcomed the challenges and the promises of Web-based teaching as much as any field. Because computers are a technology of language and communication, writing instructors have used them in increasingly complex ways. Thus, writing researchers have documented efforts to produce effective hypertext systems for collaboration [14]–[17]; have explored the relationship between electronic tutoring, conferencing, and writing [18], [19]; have built tools that support writing and design [5], [20]; and have integrated Multi-User Domains, Object-Oriented (MOOs) [21], [22] and Online Writing Labs (OWLs) into the teaching of writing (see the University of Maine's Writing Center Online for a comprehensive listing of OWL resources: http://www.ume.maine.edu/~wcenter/).

In this paper, we report on a course development and assessment project that we undertook in 1997–1998. We developed a course website prototype to explore the issues and potentialities for teaching writing in a Web-based online environment, then piloted the course with two sections and a control section, and finally conducted a quantitative assessment of the performance and experiences of the students and instructor. In what follows, we review briefly some current thinking about both distance education and writing instruction, highlighting the commitment that has been made in both areas to the benefits of active learning and of interactivity between student and the instructional environment. We then describe the background and motivations for our project, the design goals and constraints for the online course, the conditions of the experimental course sections, and the assessment methods used to collect the data. After stating the results, we discuss the role and meaning of active learning and online interactivity in our interpretation of the results and their relationship to other instructional initiatives.

Current Assumptions About Effective Instruction

Much of what is considered good practice in higher education is based on the assumption that active learning is more effective than passive learning, and that interaction between the instructor and the student, among students, and between students and course material is a critical part of active learning [23], [24]. Chickering and colleagues [11], [25] have articulated "seven principles of good practice in undergraduate education," namely, that good instruction

1) encourages student–faculty contact,
2) encourages cooperation among students,
3) encourages active learning,
4) gives prompt feedback,
5) emphasizes time on task,
6) communicates high expectations, and

7) respects diverse talents and ways of learning.

Similarly, Felder [26] has emphasized the integration of active and collaborative learning into engineering education for more than a decade and has reported dramatic results in terms of student responsiveness, satisfaction, and problem-solving flexibility with curriculum content. His cooperative student groups successfully self-assign responsibilities to group members, self-assess their progress, develop test preparation plans together, and learn to generate research questions and to brainstorm problem-solution scenarios. Iterative group activity, practice, and feedback, Felder [27] argues, lead to improved student performance, and these practices have been established in various educational settings.

Assumptions About Effective Distance and Online Education The research on distance education, correspondence courses, and extension teaching is about seventy years old and almost always supports the widely cited "no significant difference" phenomenon [28]. Hundreds of comparative studies of classroom teaching versus alternative media for delivering educational content, whether via cassette, videotape, television, or the Internet have found that distance education courses are no less effective than traditional, face-to-face courses offered at most educational institutions. Technology advocates add that emerging technologies are capable of providing as much interaction between instructors and their students as instructors can manage [29].

Critics, however, interpret "no significant difference" to mean that because there is no evidence that distance education courses do anything to enhance, improve, or enrich students' learning experiences, performance, or subjective satisfaction, administrators ought to invest their energy in trying to reduce class sizes and improve instructor salaries and existing teaching facilities [30]–[32]. To this end, Noam [33] stresses that technology cannot facilitate effective teaching and learning, but that the cornerstones of good teaching must always involve "mentoring, internalization, identification, role modeling, guidance, socialization, interaction, and group activity." Moreover, Phipps and Merisotis raise a number of questions about the research that has produced the no significant difference claims, concluding that "there is a relative paucity of true, original research dedicated to explaining or predicting phenomena related to distance learning" [32, p. 2], and that "the overall quality of the original research is questionable" [32, p. 3].

Assumptions About Effective Writing Instruction Although there has been much recent discussion about appropriate research paradigms for composition, there is pretty strong agreement about what makes for effective instruction. Most composition specialists agree that instruction should focus on the writing process and provide collaborative writing situations for authentic social purposes and audiences [34]. As Anson notes in a recent essay,

> the teaching of writing ... is founded on the assumption that students learn well by reading and writing with each other, responding to each other's drafts, negotiating revisions, discussing ideas, sharing perspectives, and finding some level of trust as collaborators in their mutual development. Teaching in such contexts is interpersonal and interactive, necessitating small class size and a positive relationship between the teacher and the students [35, p. 269].

These assumptions are reflected in our field's statements about instructional standards. According to the CCCC Executive Committee's [36] standards for the effective postsecondary teaching of writing, for example, writing instruction "requires persistent and frequent contact between teacher and student both inside and outside the classroom." Similarly, the Association of Departments of English [37] defines effective teaching as being "student-centered," "interactive," and "time-consuming," stressing that "a good teacher endeavors to respond to students' ideas frequently and constructively" and "promptly" in a "classroom environment in which students know they are valued" and where student writing (that is, "notes, drafts, and journals, as well as polished essays") is "an integral part" of the course.

Writing instruction, in fact, has been in the vanguard of new active learning approaches to university teaching because it yields a student-centered classroom, where the instructor serves as a coach and the students actively engage each other and their own efforts at expression. Effective writing instruction increasingly highlights the interaction between written communication and spoken and visual discourse; emphasizes the community-building, social nature of communication; and carefully models and critiques both well-established genre conventions and emerging ones. The writing class, and its concomitant focus on interactivity, then, can become an integral part of the undergraduate academic experience. The challenge is to emulate and perhaps extend these instructional approaches in online settings.

Activity and Interactivity in Writing and Online Instruction

Research in the teaching of writing and in instructional

computing shares many of the same assumptions about how to teach effectively: the assumption that active learning is more effective than passive learning and that interaction between the instructor and the student and among students is a critical part of active learning. We are struck by how well accepted practice in writing instruction matches Chickering and Gamson's [25] seven principles, as well as their application to online environments by Chickering and Ehrmann [11] (see Table I).

In a writing class or in an online learning environment, most research and practical advice privileges interactivity, activity, feedback, collaboration, and immediate responsiveness to student needs and concerns. Good teachers already employ such teaching strategies when they facilitate a student-centered class where discussion and response produce a community of engaged learners. Good teachers are especially sensitive to students in face-to-face instructional settings and frequently adjust the in-class presentation of course material in response to student questions, body language, and classroom mood. If a graphical representation or concept description seems particularly informative or useful to students, effective teachers have learned how to revise their delivery of class materials to capitalize on student interest and motivation, tailoring their lesson to the situation and learning opportunity at hand. It is this responsiveness that teachers also aim to incorporate into Web-based instructional materials and forums when they attempt to create learner-centered online environments. Both writing instructors and instructors who teach online would therefore likely agree that, as student populations become less and less traditional, attuning instruction to the varying needs of students will be even more imperative.

In addition to student–instructor interaction and ideally to student–student interaction,

TABLE I
CHICKERING AND GAMSON'S [25] SEVEN PRINCIPALS OF "GOOD PRACTICE IN UNDERGRADUATE EDUCATION" COMPARED WITH WRITING INSTRUCTION AND ONLINE INSTRUCTION

Good Practice in Education	Good Practice in Writing Instruction	How Online Instruction Could Facilitate Good Practice
encourages contact between students and faculty	small class sizes (national standards recommend less than 20) and emphasis on the complete writing process	ease of student access to faculty through E-mail and electronic conferencing
encourages cooperation among students	collaborative peer review, group exercises, and collaborative writing	ease of collaboration and perceived sense of online "community"
encourages active learning	constant student application of precepts and guidelines	students more willing to challenge authority and to take less conventional communication roles
gives prompt feedback to students	frequent feedback on drafts and revisions from both teachers and other students	use of help desks, hotlines, and other course management and user assistance resources
emphasizes time on task	courses designed around writing tasks, emphasis on process from drafting through revision	network tracking systems can monitor student use of particular materials and provide students with the opportunity to read and review materials as often as they require
communicates high expectations	emphasis on practice and on revision and peer review for continued improvement	models of excellence available online, web dissemination of student work emphasizes importance of quality, call for continued involvement in online class "experiments"
respects diverse talents and ways of learning	emphasis on meeting the needs of different audiences, use of diverse strategies	provides different paths to objectives and alternative representations of instructional materials, self-paced, flexible access

effective learning situations involve content that is meaningful, organized by explicit instructional goals and strategies for achieving those goals, and that is aesthetically and functionally suited to the students' current levels of understanding. In face-to-face classes, instructors have traditionally relied on lecture presentations of the course content, as well as whiteboards, chalkboards, overhead projectors, slide projectors, and, recently, computer-output displaying projection screens. Faculty preference for verbal, one-to-many presentations of course content has been noted by researchers who advocate visual, collaborative styles of information presentation [26], [38]. Outside the face-to-face classroom, students may interact with course content through reading coursepacks or textbooks, performing laboratory work, solving problem sets, and working on writing assignments. Recently, proponents of active learning have also established settings where students, working with other students, engage in course content through guided experimental activities, Internet listservs, forums, or computer conferencing software, making student–student interaction as well as student–content interaction key components of effective science and technology instruction [8]. The Writing-Across-the-Curriculum movement has been a major means by which student–content interaction has been enhanced through the use of formal and informal writing exercises in courses in all disciplines.

Hoey et al. [23], influenced by Moore [39], suggest that as more instructors move their classrooms online, a fourth type of interaction will become increasingly important: student environment interaction (see Khan [3] and Moore and Kearsley [40] for numerous chapters that focus specifically on this dimension). The environment in general refers to the physical or Web-based location for learning, which may include specific online tools that students interact with such as email and listserv programs, MOO's, chatrooms, network file exchange platforms, forums, and computer-conferencing software [5], [41]–[43]. Environments may be well designed and easy to navigate, convenient, reliable, accurate, and comprehensive, or they may be the opposite.

In their survey of Web-based educational materials, Wallace and Weiner [4] and Collins and Berge [44] divide them into the following categories:

- Web-based course administration (e.g., syllabi, course readings, registration, attendance, participation records).
- Reference textbooks (e.g., hyperlinked and/or multimedia "deep archival reference" books or bibliographic databases).
- Lectures (e.g., guest lecturing or lecture notes or slides integrated with graphics and video/audio clips).
- Laboratory simulation and experimentation (e.g., animations, case studies, and interactive tutorials).
- Interactive chat (e.g., brainstorming, networking, project-based collaboration, mentoring in real-time environments).
- Recitation, assignments, and grading (e.g., online quizzes, tests, drills, and automated feedback).
- Virtual educational institutions (e.g., nonprofit course delivery servers like Virtual Online Universities).
- Collaborative learning (e.g., Lotus Learning Space, LeanLinc-Inet, and MOO's) [44, pp. 238–240].

Importantly, these Web-based educational materials are not necessarily interactive beyond presenting a Web document that contains a few links to cross-references, "see also" notes, footnotes, or secondary resources. In our examination of dozens of Web-based writing courses in 1997, we found numerous examples of online syllabi and course materials, several examples of Web-based lessons (e.g., Beam's technical writing course at the University of Waterloo, http://itrc.uwaterloo.ca/~engl210e), and a notable example of an online reference book, i.e., McMurrey's comprehensive online technical writing textbook at Austin Community College, http://www.io.com/~hcexres/tcm1603/tcmmain.html; however, because of limited connection speeds, very few sites contain examples of the kinds of drop-and-drag, direct-manipulation features users have come to expect from stand-alone software products.

Our initial goal of producing a useful Web-based writing course was grounded in our interest in how such a course "environment" might affect the interaction between students and their instructor, students and other students, students and the course content, and students and the learning environment. Surprisingly, few researchers have documented the differences between Web-based instructional environments and conventional classes in these terms. And, when they have done so, it has been difficult to control for the various confounding variables that challenge all educational research, for example, instructor effects, student attitudes and demographics, and methodological consistency across the conditions. Similarly, the Phipps and Merisotis [32] review of distance education research identified numerous shortcomings, including that it rarely takes into account differences among students, including demographic factors, experience, attitudes, and learning styles; in addition, they claim, the

research rarely involved randomly selected subjects or employed valid and reliable instruments. When writing researchers have documented the differences and similarities between teaching writing on- and off-line, they have tended to compare

- Computer classrooms to conventional classes, where the chalkboard, chalk, and perhaps overhead projectors are the primary conventional technologies, rarely documenting the specialized systems and technologies that define their "online" or Web-based experimental condition [45], [46];
- Individual modes of communication that facilitate conventional instruction, for example, phone versus face-to-face versus networked interaction [5], [10], [19], [20], [47]–[49];
- The process (the opportunities and particularly the problems) associated with teaching online to the process of teaching in a conventional setting, where student satisfaction with the online learning experience is established primarily through retrospective student reports or instructor observation [12], [41], [50].

In addition, previous studies have frequently produced research results that are inconclusive, unsystematic, or, worse, conflicting in their findings [49], [51], for example, that online environments encourage greater equitability [52] versus not encouraging equal participation [53].

Our goal was to design an online environment for a writing course that could emulate the conditions believed necessary for effective writing instruction and, at the same time, to take advantage of the online environment to improve instructional strategies if possible. We were interested in the extent to which the interactivity of a face-to-face classroom could be emulated online and the extent to which active learning strategies could be emphasized in online pedagogy. Our assessment of the difference between the two conditions would focus on their effect on students and their performance in the course and, importantly, our Web-based and our conventional classes would represent "best practice" as much as possible. The project was originally born out of campus-wide concern for effective instructional design on the Web and for assessing how Web-based courses influenced student work, performance, and attitudes.

Project and Assessment Design

During the summer of 1997, the Vice Provost for Information Technology at NC State initiated a campus-wide effort named "Project 25," aimed at aggressively moving twenty-five existing courses completely onto the World Wide Web by the Fall Semester of that year. This was an ambitious effort involving dozens of administrators, faculty, and support staff, meeting on a weekly basis, throughout the summer. At the same time, the Vice Provost invited us to explore the possibilities of offering writing instruction online. In conjunction with compiling a needs assessment for any effective writing course online, we began prototyping for online instruction, ENG 331, Communication for Engineering and Technology. Working with our institutional research office, University Planning and Analysis, we then planned, prepared, and implemented a large-scale assessment effort for three pilot sections taught by the same instructor, two that were Web-based and one that was taught in a conventional classroom setting. Notably, the instructor was a seasoned technical communication teacher (with over a decade of experience working for a large high-technology company) and consistently ranked very high in student evaluations.

Research Questions and Objectives Our research had two major objectives that set it apart from the studies mentioned previously:

- To gain a better understanding of how students learn in a Web-enhanced writing course compared to a conventional classroom.
- To assess differences in what students learn in these two instructional environments.

Because our initial research goals were ambitious and evaluative, we were as influenced by the hypothetico-deductive method of data collection as we were by the desire to generate data that would lead to productive hypothesis- and theory-building. After Kaufer, Neuwirth, Chandhok, and Morris [20], we believed that our study of tools would make explicit our understandings of writing tasks and instructional processes. Therefore, the breadth of our research goals listed above called for the rigorous application of multiple assessment measures. In addition to collecting information about the students prior to taking the course (e.g., gender, race, year, major, GPA), we also gave them four pre- and post-surveys that elicited information about their background and attitudes related to the course, about computer anxiety and writing apprehension, and about learning styles (see section on Student Assessment Materials).

We also felt that collecting qualitative data during the semester would provide useful supplementary details to our quantitative efforts. Therefore, we collected teacher process logs of problems encountered and solutions discovered; we held focus groups early and late in the semester with students from each condition (focusing on the quality of the course, organization,

materials, assignments, and problems encountered); we collected email archives of all student-instructor interactions over the course of the semester (including frequency of email per student); and we videotaped several conventional classroom sessions, particularly of student groupwork structures. The qualitative data we collected are voluminous and we are continuing to analyze them, though we report briefly here on the quantitative analyses of our email archives (frequency per student over the course of the semester).

Description of Assessment Process and Methods The data for this study were collected from three sections of ENG 331, Communication for Engineering and Technology, offered at NC State University during the Spring Semester 1998. The course fulfills a general education requirement for technical students; approximately twenty sections are taught each semester. Many engineering and other curricula require ENG 331 for junior and senior students. The course focuses on various professional genres such as proposals, formal reports, and instructions.

Two of the sections we studied were Web-based; that is, they used Web-based instructional materials, incorporated Internet tools, and required students to submit papers and exercises, to collaborate, and to receive feedback and assignments electronically. The third section was a conventional class which held regular meetings and de-emphasized the role of online materials in the instructional context (although students were aware of them and were not prohibited from accessing them if they wanted).

We very deliberately chose to refer to our face-to-face class as "conventional" rather than "traditional." Many comparative studies use the word traditional to describe classroom-based instructional settings but we believe that, accurately applied, traditional classes probably still (too often) rely on the time-worn, lecture-based, one-to-many approach to teaching that many of us experienced as undergraduates; our experienced instructor, conversely, employed research-grounded "best practice" strategies for teaching writing, such as group work, peer review, one-on-one mentoring, hands-on workshop exercises, and guided discussion. Thus, optimistically, we refer to this type of writing class as "conventional."

The conventional class met three times a week and the Web-based class met occasionally throughout the semester, when electronic coordination was particularly difficult as in the case of class oral presentations. Computer access was divided almost equally between labs and the home in the two conditions. All three sections were taught by the same experienced writing instructor. The primary difference between the Web-based sections and the conventional section was that instructional materials were either accessed via the class website or delivered in face-to-face classroom sessions. Thus, in the conventional and Web-based sections, the identical assignments were employed and only the method of submitting and sharing the written responses differed.

Participants Participants included students enrolled in one of the three sections through the university Registration and Records office; students did not know when they registered that their section would involve Web-based instruction. Both the Web-based and the conventional sections contained a cross section of engineering and other technical majors, in addition to a representative demographic breakdown (see Table II). Therefore,

TABLE II
STUDENT DEMOGRAPHICS OF WEB-BASED VERSUS CONVENTIONAL CONDITIONS BY GENDER, RACE, AND YEAR

Student Demographics		Web-Based Condition		Conventional Condition	
		N	%	N	%
Gender	Female	11	27	6	29
	Male	30	73	15	71
Race	Caucasian	30	73	19	90
	Minority	11	27	2	10
Year	Junior	20	48	11	52
	Senior	22	52	10	48

though we did not intervene in the registration process by randomizing the division of students into one condition or another, the registration process served a similar purpose. F-Tests revealed no demographic differences between the students in the two conditions for *gender* ($F(1, 60) = 0.02, p > 0.05$), *race* ($F(4, 57) = 0.90, p > 0.05$), *major* ($F(27, 34) = 1.24, p > 0.05$), *year* ($F(1, 60) = 0.07, p > 0.05$), and *prior GPA* ($F(1, 60) = 0.05, p > 0.05$). The cumulative GPA for the 41 students in the Web-based condition was 2.99 and for the 21 students in the conventional condition 3.03; we omitted the data for the majors of the students because they represented 29 different technical majors, and a breakdown was therefore unnecessary.

Course Structure and Writing Assignments Our technical writing course introduces students to the kinds of communication tasks they can expect to perform after graduation and in the workplace. Students receive intensive practice in writing using "best practice" strategies such as group work, peer review, one-on-one mentoring, hands-on workshop exercises, and guided discussion. Through assignments that are designed to engage the students in increasingly complex audience situations, students also learn to relate writing to oral and visual communication.

The seven major assignments for these three sections included an individual oral presentation, a collaborative writing assignment, and a group oral presentation. For each assignment, students were asked to analyze the communication situation and the potential primary and secondary audiences. The assignments required the students to move from addressing the needs of one reader to presenting information to a heterogeneous group of stakeholders. The first three assignments focused on the students' upcoming job search. Students were required to research a potential employer and to write an investigative report on their findings. They then applied this information in the second assignment as they created a targeted resumé and application letter. Finally, they presented a rhetorical analysis of two company websites in their professional fields. The fourth assignment was a collaborative writing assignment that required the students to improve a set of product instructions. They conducted usability testing on their improvements, and mailed their suggestions to the product's manufacturer. The remaining three assignments continued to focus the students' attention on more complex communication situations that included creating arguments, persuading groups of people, and handling negative news scenarios.

Course Site Description One of the challenges that our group undertook was the design of a website (http://courses.ncsu.edu/ENG331/larsen) that would emulate and perhaps extend our goal of effectively teaching writing, compensating for the loss of classroom interaction, and taking advantage of electronic capabilities for working with texts. We therefore paid careful attention to providing a site that was easy to navigate and that had a simple, visually obvious structure. We anticipated that students might access the site using different browsers and modem speeds, so we avoided the use of elaborate graphics and images to facilitate quick loading. The site incorporated well-documented principles for effective online information and was designed so that any writing instructor would be able to use it with minimal Web competence and minimal start-up learning.

The course instructor worked hard to create exercises that asked for frequent student responses via webforms, email, and document submission. Our goal was to emulate the amount of interactivity that exists in the conventional classroom. Our inventory of activities required students to perform numerous reading and writing activities. Both the Web-based and the conventional classes, in fact, relied on the same activity/assignment structure, although the Web students submitted all their writing via the computer and conventional students were free to submit hardcopy versions of their work; in addition, the website included ten activities where students filled out forms (submitted only to the computer) as part of their interaction with the course materials. There were a total of 49 reading activities and 17 writing activities, for example, reading to learn, to do, to analyze or evaluate, and writing to reply, to respond to peers, and to apply criteria or knowledge.

The resulting design of the course site was simple but very flexible and maintainable. The files for the site are located on a university Unix server; files are FTP'd to the appropriate directory by the instructor. Templates were provided for the instructor to fill in with text (using forms constructed with CGI scripts). The website has continued to evolve since our data were gathered.

Performance Measures In many of the studies cited in Russell's "no significant difference" report [28], student performance is synonymous with final course grade **only**. Noting that, especially in the case of writing instruction where grade can often factor in a host of variables that may or may not be captured by the final products of the students, we created a pre- and post-survey focusing on course content and also had three experienced writing instructors assess student portfolios and group projects at the completion of the course.

The Content Survey: The content survey consisted of 12 statements and asked students

to rank their competency from 1 = no competency to 5 = excellent competency. Thus students were asked to agree or disagree with statements such as "I know how to use various pre-writing strategies to produce preliminary drafts" or "I know how to write progress and status reports to be read by multiple readers with varying levels of technical expertise." The aim was to capture in declarative statements the essential procedural knowledge that our course covers.

Expert Assessment of Student Portfolios: Three professional writing instructors who had no prior contact with the students assessed 21 portfolios that were randomly selected from the three sections. The portfolios contained all the student projects that were graded during the semester. In addition to the individual student portfolios, all the group projects in the three sections were evaluated by the three assessors. Each assessor rated each student's portfolio using five specific criteria: professionalism, persuasiveness, understanding of audience, responsiveness to audience, and overall improvement. For the group project assessment, each assessor rated each group on two different criteria: responsiveness to assignment and cohesiveness and integration of collaborative effort. Each criterion was rated on a Likert-type scale with 1 = totally inadequate and 5 = excellent.

Assessment of Student Variables The student assessment materials consisted of four surveys/instruments:

Learner Demographics and Preferences: The learner demographics survey was developed by NC State's University Planning and Analysis office for use across campus; it gave us information about the students' previous computer and Internet experience, about their preferences in terms of student–instructor and student–student interaction, and about their background and study habits. The version used with students in the Web-based course included additional questions about Web use and problems encountered. This instrument was conceived as a formative assessment tool and had not been empirically validated [23], [42].

Computer Anxiety Survey: Heinssen, Glass, and Knight's [54] computer anxiety survey has been employed and validated in several writing studies [55], [56], and elicits students' perceptions and feelings about computer capabilities and ease of use [57].

Writing Apprehension Survey: Daly and Miller's [58] writing apprehension survey has also been used and validated in several previous studies [59], [60], and elicits students' perceptions about writing abilities, talent, teachability, and processes.

Inventory of Learning Styles: The Inventory of Learning Styles was developed by Richard M. Felder and has been tested and refined for almost a decade using data collected from hundreds of students across numerous disciplines [61], [62]. Students answer 44 questions and are ranked on four learning style "dimensions," from active to reflective, visual to verbal, sensing to intuitive, and sequential to global. Thus, active students prefer to process information through engagement in physical activity, through discussion, or in groups, whereas reflective students tend to work alone over stretches of time and prefer personal introspection; visual students prefer pictures, whereas verbal students prefer written and spoken words; sensing students prefer sights and sounds, whereas intuitive students prefer memories and ideas; and sequential students prefer logical, incremental steps, whereas global students prefer total picture reasoning and holistic connection-making.

Procedures The two Web-based sections and the conventional section were taught by the same instructor, using the same pedagogical approach and following the same syllabus and lesson plan, though one was primarily online and the other was taught in a face-to-face class situation. The five surveys (course content, demographics, computer anxiety, writing apprehension, and inventory of learning styles) were administered during the first two weeks of the course. Participation in the study was voluntary and, because the surveys were incorporated into class activities, participation was almost 100% (21 students in the conventional class and 42 students in the two Web-based classes), though not all 63 students filled out all five of the pre- and the post-surveys. Of the 63 students across the two conditions, 57 out of 63 students filled out both the pre- and the post-surveys regarding demographics, while only 60 filled out both the surveys on course content. Thus, total numbers of students filling out each of the surveys differed from survey to survey but never involved less than 56 of the total 63 students filling out a given survey. Confidentiality was maintained throughout the study through the use of student identification numbers. The demographics and attitudes, computer anxiety, and writing apprehension surveys were again administered at the conclusion of the course.

RESULTS

Very much in line with existing research findings, there was no significant difference between the Web and the conventional conditions by final course grade ($t = -0.18$, $df = 61$, $p > 0.05$). The mean grades for the Web-based condition and conventional condition were 86.4 and 86.1, respectively.

We looked at the relationship between the overall average ratings

of the three portfolio assessors and the individual student's final grades and the group project grades. A Pearson Correlation test revealed significant positive correlations between the combined assessors' overall evaluation and course grades, for both the individual student portfolios ($r = 0.66$, $df = 16$, $p < 0.05$) and the group portfolios ($r = 0.86$, $df = 12$, $p < 0.05$). Therefore, the measures of student performance (course and project grades) correlated strongly with the holistic assessments of the three experienced instructors. This gives us some confidence that the course instructor's grades were not biased in some way but represent a good measure of actual student achievement.

We also found significant correlations between our pre-survey for course content knowledge and course grade ($r = 0.32$, $df = 58$, $p < 0.05$) and prior GPA ($r = 0.28$, $df = 58$, $p < 0.05$). A negative correlation was found between prior GPA and the change between the pre-survey score and the post-survey score ($r = -0.32$, $df = 44$, $p < 0.05$). This suggests that students with higher GPA's ranked themselves higher on the pre-survey and lower on the post-survey or, inversely, that students with lower GPA's scored themselves higher on the post-survey of writing content knowledge.

Importantly, even though no significant demographic or grade differences were found between the two conditions, this does not mean that the two groups were identical or that they experienced the two learning conditions identically. When we looked more closely at the demographics, the attributes, and the attitudes of the students enrolled in the different conditions, an interesting and somewhat more complex picture of what types of students perform better or worse in a given section emerged. The females in the Web condition performed significantly better than the males in the Web section ($t = 3.70$, $df = 33$, $p < 0.05$), though no performance differences by gender were found in the conventional condition. The average grade for the females in the Web condition was 90.3 and for the males was 84.9.

Scores on the learning style survey were related to grade in the Web condition only. A significant negative correlation was found between grade and score on the active-reflective survey ($r = -0.35$, $df = 40$, $p < 0.05$), indicating that students who were reflective learners performed better than students who were active learners. Also, grade was negatively associated with the sequential-global score ($r = -0.33$, $df = 36$, $p < 0.05$), indicating that students who were global learners received higher grades than students who were sequential learners. No relationships between learning style scores and performance were found in the conventional condition.

On the demographic survey for students in the Web-based condition, positive correlations were found between the importance of high expectations of the instructor and grade ($r = 0.39$, $df = 37$, $p < 0.05$), importance of discussion of course content with fellow students and grade ($r = 0.35$, $df = 37$, $p < 0.05$), and importance of time spent on the course relative to other courses and grade ($r = 0.41$, $df = 27$, $p < 0.05$).

This survey also revealed a positive correlation between the conventional students = final grades and their perceived experience level with computers in general ($r = 0.63$, $df = 16$, $p < 0.05$), and with Internet tools in particular ($r = 0.56, df = 16$, $p < 0.05$), though no correlation was found for the Web-based students and these attributes. Since all the written assignments required word processing, experience with computers may have heightened student performance in the class overall. Thus, notably, grades for the conventional students were negatively correlated with scores on the computer anxiety pre-survey ($r = -0.58$, $df = 17$, $p < 0.05$), meaning that students who showed higher computer anxiety ratings tended to get lower grades. A negative correlation existed between students' rankings of the importance of study groups and final grade ($r = -0.50$, $df = 16$, $p < 0.05$); interestingly, students in the conventional class who valued study groups tended to receive lower grades.

Students in the Web-based condition sent significantly more email messages to the instructor than the students in the conventional condition, averaging 6.6 versus 3.1 per student ($t = 4.66$, $df = 59$, $p < 0.05$). There were 276 messages sent by 42 Web-based students and 66 messages sent by 21 conventional students for a total of 342 email messages handled by the instructor during the semester. This difference is to be expected, of course, since the conventional students had the opportunity of interacting with the instructor face-to-face in the classroom, and the Web-based students did not. We present these data primarily to provide a quantitative basis for the frequently reported impression that email management and load constitute an important logistical consideration for instructors of Web-based courses [12], [63]. Indeed, informal analysis of the instructor log kept during the semester revealed numerous technical sessions related to updating and revising the class materials for the Web-based courses. Though our goal was not specifically to assess the workload produced by the Web-based courses, our instructor noted on several occasions that technical details and difficulties required additional preparation time.

Finally, a predictive model for grade was generated for students in the Web-based condition. The variables in the predictive model were prior GPA, gender, and score on active-reflective and the sequential-global dimension of the Inventory of Learning Styles instrument ($F(4, 36) = 28.39$, $p < 0.001$).

Discussion: The Role of Activity and Interactivity in Online Writing Instruction

Though Wallace and Mutooni [64] present findings where the average grade performance of Web-based students is higher than those receiving "traditional" classroom instruction ($p = 0.063$), our findings support the "no significant difference" phenomenon in terms of performance as outlined by Russell [28]. It may be that, in having students volunteer for either the Web-based or the conventional condition, Wallace and Mutooni [64] studied students who were more motivated than usual. The performances of our Web-based and our conventional students (as defined by course grade, pre- and post-surveys on writing content, and independent assessment of their written portfolios) were similar. We did not find this particularly alarming, nor did we predict that performance should differ given the multiple constraints facing students new to Web-based learning environments and, in general, the challenges facing engineering and technical students learning to communicate more effectively.

What was most interesting to us was how prior student experience, attributes, knowledge, attitudes, perceptions, and learning style types influenced how well students performed depending on whether they were enrolled in the Web-based sections or the conventional section. Although several of our results deserve discussion and exploration, we will focus here on those regarding student attributes, learning styles, and, in particular, the nature of interactivity and active learning online.

Though outside the focus of this article, one of the more interesting findings of our study was that females in the Web condition performed significantly better than the males, while no such significant difference due to gender existed in the conventional class. Eldred and Hawisher [5] have described at length the potentially equalizing nature of computer-mediated communication environments, though Selfe and Meyers's [49] study of gender communication suggests that the equalization phenomenon may not be as empowering for females as earlier researchers have hypothesized. Our findings suggest, however, that Web-based learning environments may facilitate performance among female students, in this case female students in technical majors. It may be that, outside the traditional classroom, female students feel less socially inhibited or excluded and, therefore, contribute more to the text-based "discussion" of the instructional content. Or it may be that, without real-time social cues from their male classmates, female students are able to adopt more natural study and work strategies with the course materials.

Other student attributes, similarly, may influence performance online. For example, Hartman et al. [55], in their comparison of traditional modes of classroom communication and electronic modes, found that different types of students reported using modes of communication differently. Thus, students tended to communicate more with other students in traditional ways (face-to-face, paper drafts) than in electronic ones (a process we did not track). In their [55] study, both writing anxiety and computer anxiety influenced the amount that students communicated, especially in electronic modes, and students with lower verbal SAT scores tended to use electronic modes less than students with higher scores.

Our application of Felder and Solomon's Inventory of Learning Styles instrument [62] provided provocative information about how different student learning styles may influence student engagement and performance in Web-based environments. Our results indicate that reflective (versus active) learners and global (versus sequential) learners performed better, a result that finds support in the preliminary research findings of Davidson, Savenye, and Orr [65], who found that "abstract-random" learners performed better than "concrete-sequential" learners in a computer applications in education course. Abstract-random learners, in their study, prefer intuitive leaps and "grab the essence of ideas and build themes as they work through information in a random fashion," whereas concrete-sequential learners prefer physical world, hands-on investigation that proceeds step-by-step through the instructional material [65, p. 350]. Thus, in our study, reflective learners who prefer solitary, quiet problem-solving as opposed to group discussion of problems may have been more comfortable in the Web course.

Our results surprised us somewhat since we had assumed that we had designed an "interactive" website that would favor active learners. Perhaps these results tell us something about the sheer amount of interactivity there is in the conventional classroom and the level of difficulty we face in attempting to emulate it on the Web. They do, as well, remind us that the meaning of *interactivity* online is not at all stable. As Rose has asserted, "if the words 'interactive' and 'interactivity' proliferate in texts on educational computing, it is despite their apparent lack of denotative value" [66, p. 43]. Two of the common meanings that Rose cites are a

high degree of learner control and an information-rich environment. Another recent discussion defines interactivity very differently, deriving its definition from conversation analysis: the extent to which messages in a sequence are related to each other, as shown by a high level of agreement, use of first-person pronouns, and other features [67]. Instructional and multimedia designers often describe the use of video/audio clips, simulations, forms to fill out, and collaborative learning technologies as interactive. Thus, at the very least, we believe that we need to think more carefully about online interactivity and why we value it.

Although educational technologists promote more interactive systems, it may be that when designing learning environments, we need to carefully consider our instructional objectives and our students' learning styles before following that instinct. Our more reflective learners, for example, may not benefit from environments that provide instantaneous feedback and response; they may prefer reading to learn, following links until they develop a fuller representation of the entire learning space, and then acting, inputting, or writing.

In our desire to promote active learning, we may be guilty of promoting more interactive learning environments, environments that give immediate responses to students but that do not necessarily facilitate reflection or a careful examination of all the materials and tasks. Thus, Najjar's assertion that "an interactive user interface appears to have a significant positive effect on learning" is tempered by his acknowledgment that multimedia features can distract rather than focus, that low aptitude learners appear to benefit more from multimedia than high aptitude learners, and that interactivity influences users in different ways depending on their motivational level, age, and the methods used to test them on their learning [68, pp. 314–315]. Rose identifies the essential tension between learner reflectivity and the interactive experience when she notes that, though researchers "valorize learner control, nonlinearity, and flexibility as interactivity's defining characteristics," skeptics of the power of interactivity might also imagine "... the shadowy figure of the disavowed other lurking behind these wide-eyed adventurers: the shadow of a child sitting mesmerized and immobile before the computer, only her index finger on the mouse moving occasionally as a stream of images passes in a more or less predetermined sequence before her glazed eyes" [66, p. 45]. An "interactive" learning environment does not necessarily invite learner activity and engagement.

Of course, as Internet speed becomes less of an issue, educational websites are certain to become even more interactive, but the price may be that more reflective learners fare poorly for the design "upgrade." Our reflective learners benefited from a site that required reading to learn and reading to act or to do. And, as Ryan reminds us, reading is **already** a highly interactive event:

> Increasing the reader's participation in the creative process, and thereby questioning such distinctions as author/reader, actor/spectator, producer/consumer, has been a major concern of postmodern art. This does not mean that without these efforts reading would be a purely passive experience: theorists such as Iser or Ingarden have convincingly demonstrated that a world cannot emerge from a text without an active process of construction, a process through which the reader provides as much material as she derives from the text. But the inherently interactive nature of the reading experience has been obscured by the reader's proficiency in performing the necessary world-building operations [69, pp. 16–17].

As sites provide more opportunities to input information, to receive immediate feedback, and to "build worlds," the interaction between learners and the features of their learning environment may change and teachers need to be aware of such shifts in audience orientation and site usability. With hardcopy texts, such issues do not exist beyond the parameters of page turning, searching, and the accessing of special sections (e.g., answers, examples, review, exercises). Similarly, in face-to-face classrooms, attending to details of the classroom setting or environment often reduces the amount of attention that students are able to place on the instructional content (except in cases where instructors invite students to attend actively to each other, a shared text, or supplementary overhead materials). It seems critical then to avoid collapsing interactive learning with active learning behaviors.

Collins further distinguishes between *interactive*, *active*, and *passive* learning, noting that

> The costs and benefits of active learning vs. passive learning are probably well known, but the costs and benefits of interactive learning vs. active learning are less well known. The costs of high interactivity are a lack of thoughtfulness by the student because things move fast, and a lack of problem finding and construction by students because everything they do is responsive to some situation. The benefits of high interactivity are that students receive immediate feedback on the success of their actions, they find such environments extremely motivating, and they are very active trying out

> different skills and strategies [70, p. 352].

Though we all agree that, in conventional classrooms, active learning has many advantages over passive learning, it may be that moving online encourages what Dumont describes as "the paradox of the active user," a user who is highly motivated to accomplish goals quickly but whose "skills tend to converge at relative mediocrity" [12, p. 195]. Thus, active users can be particularly good at moving quickly though a series of low-level tasks to reach a well-defined goal, but they may not fully understand the underlying complexity of the environment they are using. Active users, for example, may know how to search the Internet for specific information in order to complete a research assignment, but they may not reflect on the instructor's goals to have students learn how to efficiently and effectively sift through online information as a way to strengthen student information gathering and to promote advanced learning opportunities. Reflective, global learners may understand the importance of learning how to use the tools and also of understanding the overall instructional goals and content of the online course. They may develop a richer picture of the learning environment as a space where interface design and functionality can sometimes overshadow or even compete with the site's educational merit and instructional purpose.

CONCLUSION: FUTURE INSTRUCTIONAL INTERACTIVITIES

How and to what degree interactive learning environments interact with our students' learning styles and strategies requires more investigation [68]. Our data suggest that the type of active engagement that we require of our online students may be different than the type of engagement we expect in a conventional classroom. Students must feel comfortable reading Web materials and moving from hyperlink to hyperlink to make sense of the "big picture" of the course materials and the course in general. And students must also feel comfortable interacting within our online learning environments by contributing to the class community via email and listserv exchanges with the instructor and with other students. But students are still required to read a great deal of instructional material (or to view it graphically). Students must adapt to working in some degree of isolation, though they can be very much virtually connected to other students and to their instructors. And given the newness of Web-based learning environments, students must also develop both their technical skills with the setting and their working understanding of the subject matter, balancing procedural with conceptual or declarative knowledge.

Web-based courses are in their technical and process infancies, as Dumont [12] illustrates in great detail. Our experiences during 1997–1998 of trying to create a useful, usable, and exciting Web-based writing instruction environment for students only further supports the position that much yet remains to be done. The technology does not yet allow instructors or students to seamlessly interact between distributed features of the Web and local features of their own workspace and, thus, the interaction between websites and word processors, instructional materials such as CD-ROM and video/audio devices, and between instructors and students are awkward at best.

We were frustrated to find that the types of tasks that writing instructors routinely carry out in their classrooms are not easy to emulate online, despite technological claims that such teaching and learning environments readily exist; online annotation and commenting, synchronous conferencing, file sharing and manipulation, easy to use email programs, document comparison, graphics and text integration, bibliographic software, course administration tools, Web generation editors, voice-video extensions, and testing, quizzing, and exercise checking programs exist, but they are very much "in development" and therefore not usually integrated, pre-packaged, or particularly accessible to content experts interested in moving their teaching onto the Web. Kellogg and Richards [71] address at length many of the ergonomic shortcomings of Internet-based tools and research has begun to focus on learners as **users**, supporting our argument for the importance of usable Web-based instructional environments [72].

With the marriage between tools and learning tasks so ill-formed, it is not surprising that the features of an ideal Web-based writing instructional environment are very much in development. We imagine, in a perfect technological world, that our students would be able to easily switch from one function to another in a single environment, work with either formatted or unformatted texts, alone or in groups, search texts that emulate hardcopy documents, access a library of document templates and tutorials on software, benefit from research on heuristics, and be guided through their drafting efforts. Teachers would have systems that routinely update them on student difficulties, track student use and questions, provide security measures that protect student privacy, and provide alternative access methods that facilitate different student learning styles. These learning environments would avoid numbing users with increased levels of sensory input that invite neither learner activity nor comprehension, thereby striking a balance between the "hot" media of the Internet and

the "cool" engagement of students involved in lively interaction with other students, instructors, and course content [29].

Our experiences designing and assessing Web-based writing instruction have led us to develop a preliminary taxonomy of ways that learners, instructors, and learning materials interact with each other in both conventional and online classes (see Table III).

Table III outlines five dimensions of an instructional situation that are possible in any conventional or Web-based course, though our focus is primarily on Web-based writing instruction. It is important to note that, in our descriptions of conventional and online classes, we are presenting **ideal** learning situations; in fact, as more instructors provide supplementary class materials on the Web, the distinction between face-to-face and online learning situations will continue to blur.

In any instructional situation, we need to keep in mind how the backgrounds and previous knowledge of our students interact with the tasks we ask them to accomplish, the social dynamics that we expect them to participate in, our instructional objectives for our course, and the learning environment and tools they are required to interact with. Thus, in Web-based classes, students who are visual learners might benefit most from instructional course materials that are primarily graphical in nature; they may not respond well to text-intensive listserv discussions but may

TABLE III
DIMENSIONS OF INSTRUCTIONAL SITUATION CHARACTERIZING WEB-BASED AND CONVENTIONAL CLASSES (INFLUENCED BY [29], [68], [73]–[75])

Dimensions of Instructional Situation	*Relevant Activities or Attributes*	*Ideal Conventional and Online Learning Experiences for Students*
Student Background and Knowledge	Ability to apply skills, learning and technology experiences, standardized test taking and general educational success, life experience, age, gender, intellectual abilities, attitude, and motivation	***Conventional Class:*** Facilitates group activities, extrinsically motivating, active, verbal ***Online Class:*** Highly goals-directed, carefully monitored, self-directing, encourages intrinsic motivation and a positive attitude toward working alone
Student Tasks	Actions with learning materials, exercises, goals, processes, e.g., reading to learn, reading to learn to do, reading to analyze, reading to compare, confirm, correct, submitting to computer	***Conventional Class:*** Focused on whiteboard content, encouraging note-taking and active reading ***Online Class:*** Focused on content and schedule, balances visual and textual information, facilitates cognitive and metacognitive strategies for future learning
Social Dynamics	Interaction with instructor and peers, responsiveness, social abilities, personal style, strategies for scheduling, group management, and self-assessment	***Conventional Class:*** Supporting non-verbal communcation, encouraging mutually-defined goals and task-oriented ***Online Class:*** Provides real time, interruptible, bi- or multi-dimensional, social situations; balances affective and task-oriented goals strategically
Instructional Objectives	Communication of content, set objectives, information exchange requirements, topic pacing, sequencing, adaptation to audience, methods of evaluation, strategies for topic elaboration	***Conventional Class:*** Discussion-oriented, mixture of activities, practice and application enhance theory ***Online Class:*** Goal/criterion directed, controlled sequencing, availability of inquiry options, responses evaluated quickly, exploratory, visual
Learning Environment and Tools	Numerous instructional materials, e.g., reading and writing tools, individual and shared documents, viewing and dissemination methods, atmosphere that promotes mentoring and open exchange of ideas and discussion; ergonomically designed	***Conventional Class:*** Small, discussion-facilitating space, free of distractions, groupwork, ample tablespace ***Online Class:*** Focused visually, instructional goals/materials separated from navigation; encourages multiple paths of discovery via questions and answers; stresses interpersonal communication (E-mail, listservs, chats, bulletin boards)

thrive during graphical Web-board brainstorming sessions; they may feel more comfortable with loosely structured instructional goals and activities; and they may appreciate tools that are graphical and self-descriptive. Our taxonomy, then, might serve as a general heuristic aid for instructors thinking about moving their conventional courses online.

Research on the complex relationship between learners and alternative Web-based learning environments surely requires extensive elaboration. How such environments augment, enhance, or impede learners, and how their previous experiences and learning styles interact with tools designed to support student–instructor, student–student, and student–content interaction is a considerable challenge. And how the design of our Web-based environments anticipate different learner backgrounds and knowledge, support learner tasks and engagement, facilitate learner communication and collaboration, and present subject matter meaningfully are all dimensions of teaching online. Ultimately, efforts that integrate online design and instructional content with research and careful assessment promise to further enrich our understanding of what it means to teach effectively.

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Brad Mehlenbacher teaches communication for engineering and technology, computer documentation design, and online information design and evaluation at North Carolina State University. He is co-author of the (1993) Ablex book, *Online Help: Design and Evaluation*, and has published in various ergonomics and professional communication journals. He has chapters in *Society of Text* (MIT Press), *The Computer Science and Engineering Handbook* (CRC Press), and the 1997 NCTE award-winning *Computers and Technical Commiunication* (Ablex Press).

Carolyn R. Miller is Professor of English at North Carolina State University, where she directs the professional writing program, which includes the technical writing course discussed in this article as well as a business writing and scientific writing course. She also directs the Center for Communication in Science, Technology, and Management, which sponsored the course development and assessment described here. She has published on rhetorical theory, rhetoric of science and technology, and technical communication in a number of journals and essay collections.

David Covington is an Associate Professor of Engish at North Carolina State University and Director of the Humanities Computing Laboratory. He directed the team who designed the Communication for Engineering and Technology website described in this study.

Jamie S. Larsen has published more than twenty technical manuals and online documents while working at IBM and as a Freelance Writer, and has presented on Web course development and student roles in collaborative settings at the Association for Business Communication Conference. She has the B.A. degree from Rice University and the M.S. degree in technical communication from NC State University, where she currently teaches communication for science and research and communication for engineering and technology.