Collaborative Graduate Education across Multiple Campuses

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ABSTRACT Multi-institutional approaches to graduate education continue to emerge as a way to better prepare students for collaborative work. In this article, we describe a graduate course designed to investigate application of conservation biology principles by local land use planners. "Where is Conservation Science in Local Planning?" was offered jointly by three institutions and integrated inquiry-guided, collaborative, and computer-mediated learning. Participants collaborated across universities to investigate this question and create products based on their work, including a presentation and two peer-reviewed manuscripts. We used a wiki for brainstorming and collaborative writing, a virtual classroom for work meetings, and video conferencing for building community and making complex decisions. Pre- and post-course questionnaires were used to evaluate the effectiveness of the course for improving skills in collaboration, use of collaborative technologies, and subject-area knowledge. Student development mirrored those areas where learning was required to consistently support class-wide activities. Students reported that they gained knowledge about collaboration, increased their mastery of communication skills and use of collaborative technologies, and gained knowledge about course subject matter. Students did not indicate significant changes in knowledge or activities related to leadership. Participants gained a fuller understanding of the benefits—collective creativity and enhanced accountability—and drawbacks—time required to build relationships and engage in deliberation—of collaborative research. Faculty participants suggest that future offerings continue to follow an inquiry-guided, collaborative learning approach using similar collaborative technologies, but include more explicit guidance about leadership and attempt to generate a smaller number of products.

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The course "Where is Conservation in Local Planning?" was a multi-university course that grew out of successful single-institution work at North Carolina State University that used a collaborative research approach to inquiry-guided learning. Using this approach, graduate students learn subject-area content by carrying out original research as a collaborative team, with a strong emphasis on development of professional skills through immersion in the process (Hess and Drew, 2004). Students in previous course offerings have liked this approach because they are involved in "real" research and experience first-hand the collaborative research and writing processes. Faculty members have liked the approach because it provides another avenue for conducting research, allows them to blend research and teaching in an innovative and stimulating fashion, and can lead to scholarly products (e.g., Favreau et al., 2006; Hess et al., 2006a, 2006b; Andelman et al., 2004).

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In this course, we integrated inquiry-guided learning (Lee et al., 2004), collaborative learning and leadership (Johnson and Johnson, 2003), and computer-mediated learning (Hiltz, 1994) approaches, and expanded the level of collaboration to include multiple campuses. This provided graduate students with an authentic experience through which to learn more about collaborative research by engaging them with students and faculty at distant campuses. This article describes the course and reports how this approach influenced students' abilities to use interdisciplinary collaborative skills, computer-mediated learning tools, and subject-area knowledge.

Teaching and Learning Approach

Inquiry-guided learning refers to a range of practices that promote learning through an active, question-driven investigation of complex issues (Lee et al., 2004). Typically, the subjects of inquiry do not have single or "right" answers, if they have clear answers at all; at times participants must struggle to define the questions themselves. Learning occurs as students are immersed in opportunities to identify issues, collect and analyze evidence, interpret the results, and present their findings. This approach formed the foundation for conducting the course, and our model included faculty and students as co-inquirers.

Collaborative learning is a pedagogical process in which learning occurs as participants build their knowledge through deliberate, structured interaction with others (Johnson and Johnson, 1989; Svinicki, 1992; Stage et al., 1998; Thompson et al., 2003a). This model of learning is gaining recognition as an important approach to fostering

the capacity of individuals to participate in collaborations later in their professional careers (Jeffrey, 2003; Anthony et al., 2007). Particularly for students in natural resources, collaborative skills will be critical as they take part in addressing complicated interdisciplinary questions and issues (e.g., Thompson et al., 2003b). The approach to collaborative learning in this course included encouraging the development of leadership skills (identifying tasks, developing action plans to complete tasks, and following through in completing work) in the collaborative context (e.g., Johnson and Johnson, 2003).

Given new means of electronic communication, collaboration among colleagues across great distances is becoming increasingly common in many professional pursuits (Brown et al., 2006; Friedman, 2006; Johnson et al., 2002). This course incorporated electronic forms of communication in a "blended learning" environment, both by necessity and as a professional development opportunity. This approach is supported by the work of educational researchers who have recognized and explored the possibilities for authentic, real-time interaction among participants in computer-mediated settings (e.g., Harasim, 1990; Mason and Kaye, 1990). Computer-mediated learning is now a recognized vehicle for collaborative construction of knowledge, offering different "spaces" where collective synchronous and asynchronous thinking can occur (Harasim et al., 1995; Stacey, 1999; Schellens and Valcke, 2005). The effectiveness of such "blended learning" approaches has also been documented by natural resource educators (e.g., Teplitski and McMahon, 2006; McAndrews et al., 2005; Riffell and Merrill, 2005).

These pedagogies were integrated to provide faculty and graduate students from three universities the chance to work on a challenging, interdisciplinary natural resource question. Faculty and students at each institution investigated knowledge and application of conservation biology principles in their respective regions, and then shared findings among institutions to develop an understanding of the different dynamics at work across the country.

Specific Objectives: Teaching and Learning Research

The effectiveness of this approach in guiding the professional development of participants, as well as their growth in subject-area knowledge was evaluated. Specifically, we assessed whether this approach:

- Was an effective way for students to increase their *knowledge* about collaboration, leadership, and communication within and among several institutions
- Provided an opportunity for participants to increase their *activities* in these areas
- Enhanced participants' *knowledge and skill* with collaborative technologies
- Contributed simultaneously to construction of *knowledge* about conservation science in local planning and about conducting research

The Course

Course Focus and Structure

"Where is Conservation Science in Local Planning?" was offered at three universities simultaneously—Iowa State University, North Carolina State University, and the University of Washington. Although we expected our efforts to be heavily reliant on technology for communication among institutions, prior experience conducting collaborative work highlighted the importance of face-to-face interaction for students (Thompson et al., 2003a; Hess and Serow, 1998). Thus, each institution scheduled weekly, face-to-face class meetings. Given scheduling constraints and the 3-hour span of time zones, the University of Washington (on quarters) could not offer the course at the same time of day as Iowa State and North Carolina (both on semesters). Classes at Iowa State and North Carolina State met at the same time each week for nearly 3 hours, allowing students and faculty from those universities to interact regularly through video-conferencing. The University of Washington class met for 3 hours every other week during their first quarter, and up to 5 hours weekly during their second quarter.

Email and printed notices were distributed at the three institutions to recruit students to the course. The notices identified the central question of the course and stressed the multi-university setting, the research experience, and the collaborative nature of the course (i.e., that learning about collaboration would occur through immersion in the process). Deciding on more exact goals for the course and the nature of the research questions was part of the learning experience.

Twenty-six students enrolled (Table 1), representing diverse disciplines: sustainable agriculture, animal ecology, forestry, community and regional planning, landscape architecture, public administration, and policy studies. Two faculty members facilitated the course at each institution. Faculty expertise centered on natural resources but encompassed several sub-disciplines, including natural resource policy, conservation biology, and urban resource management. The breadth of experience among faculty and students, and the topic we studied, contributed to the interdisciplinary nature of the course. To foster a sense of community, all participants shared 1-page biographies prior to the first course meeting. This provided an initial "social presence" (e.g., Gunawardena and Zittle, 1997) that was reinforced by an "all-hands" video-conference during the second week.

Because this course was conducted using a collaborative research model (Hess and Drew, 2004), there was no syllabus in the traditional sense of a week-by-week description of topics and activities. Instead, the syllabus included learning outcomes, subject-matter, and professional development objectives; information to be read, presented, and discussed to build a common foundation among participants during the first few classes; and a final due date for products at the end of the semester. The subject-matter objective of the course was to carry out original research into the role of conservation science in local planning and disseminate the results. Goals included at least one presentation of our work and a policy-relevant, written document. The

Table 1. Numbers of students enrolled in the courses by institution. Course credits, start, and end dates are also shown. Iowa State and North Carolina State were on a semester schedule. The University of Washington was on a quarter schedule and held the course through two quarters with differing credit-hours each quarter; most students enrolled for only one quarter.

Institution	No. of students	Credits	Start date	End date
Iowa State University	6	3	19 January	4 May
North Carolina State University	2	3	12 January	27 April
University of Washington				
Enrolled winter quarter only	7	1	11 January	8 March
Enrolled spring quarter only	7	5	28 March	6 June
Enrolled both quarters	4	6	11 January	6 June
Total	26			

professional development objectives were to participate in collaborative research, experience the peer-review process, improve communication skills, and develop leadership skills.

Students arrived at the first class session having shared short biographies, completed an initial reading and thought assignment, and ready to work. The first session was devoted to discussion of course objectives, goals, and expectations; grading; collaboration; available technologies; and developing action items for our next meeting and forming cross-institutional teams to complete them. After the first week students, with faculty guidance, scheduled learning activities, discussions, and deadlines. Class time was used primarily to discuss issues that arose during the week as teams completed assignments, make decisions about direction, and assign further tasks for moving forward. A typical session proceeded as follows, with an agenda, co-created by faculty and students, posted on the course wiki before the session:

- Subject-matter issues: What have we learned during the week? Address questions raised, resolve issues, develop action items and assignments.
- Professional development issues: Discuss and resolve issues that arose with collaboration, technology, and scheduling.
- Planning issues: Review action items and calendar, establish and schedule milestones, create appropriate cross-institutional teams to complete new assignments.

For example, during the first meeting we split the students into three-person, cross-institutional teams to develop independently a list of questions to ask local planners during a panel session arranged early in the course. Outside of class, teams worked collaboratively on the assignment, posted their ideas to the course wiki, and prepared to discuss and prioritize them. During our second meeting, we collaborated to refine the initial questions and clarify the thematic and geographic scope of our inquiry—two issues that had arisen as the teams completed the assignment. We also discussed and resolved difficulties encountered with collaboration and the technologies used during the week. At the end of our second session, we constituted three new larger cross-institutional teams to carry out agreed-upon tasks: literature review, survey development, and sampling frame specification. This process of teams forming around new issues occurred continually through the semester, with participants developing further tasks and reconstituting teams on an ongoing basis.

After initial content-related readings and discussion, course participants developed more specific research questions:

- What is the status of planning for conservation of biological diversity in planning jurisdictions within our study areas?
- What policies and practices enhance or impede the protection of biological diversity in these jurisdictions?

We addressed these questions by developing, administering, and analyzing a survey of directors of planning departments in the jurisdictions near the host universities: the greater Des Moines metropolitan area in Iowa, the Triangle region of North Carolina, and the Seattle–Tacoma area in Washington (Miller et al., 2008). Through this process, students were engaged in:

- Developing specific goals and objectives from a complex question (e.g., Huba and Freed, 2000)
- Navigating the complexities of survey development and implementation, including Institutional Review Board procedures
- Developing professional skills, including working in small and large teams, developing timelines to guide activities, and communicating with other professionals in multiple formats
- Choosing venues for and communicating their findings to varied audiences including planners and other researchers.

Technology Used

Three technologies—a wiki, synchronous electronic learning software, and video-conferencing—supported most interactions among participants. Electronic mail was also used extensively.

The Wiki: For Asynchronous Brainstorming and Collaborative Creation

Much of our interaction occurred through the course wiki. A wiki is a website designed for the collaborative creation of content (http://en.wikipedia.org/wiki/Wiki; verified 21 Nov. 2008). Wikipedia (http://en.wikipedia.org/; verified 21 Nov. 2008) is the best-known example, but there are now thousands of wikis and many wiki software packages available. The essence of a wiki is that all authorized users are able to create new web pages, link them into an evolving structure, and edit content created by others. The software preserves all versions so that participants need not fear inadvertently "damaging" or losing earlier work. Participants in this course used a web-based wiki called JotSpot (http://www.jotspot.com/; verified 21 Nov. 2008).

Faculty used the wiki extensively during course development, including the creation of a very general syllabus (course description), meeting agendas and minutes, and other course-related documents. Once the course began, students were added to the list of authorized users and they joined the electronic collaboration process. During the course, the wiki was the communication center for planning, coordination, brainstorming, and writing. One faculty member served as the wiki administrator, responsible for establishing access rights, keeping content organized, and consulting with students and faculty who encountered difficulty using the software.

The Virtual Classroom: For Work Meetings

Synchronous interaction among participants occurred in a virtual classroom. We used a software package called Elluminate (http://elluminate.com; verified 21 Nov. 2008) that allows users at many different computers to speak to one another (using inexpensive headsets) , send text messages, and share content in real time on a virtual whiteboard or by uploading files.

Primary uses of this technology were for faculty and small team meetings. Course participants formed three- to eight-person teams to carry out specific tasks (literature review, survey administration techniques, questionnaire construction, data analysis, draft manuscript preparation) during the semester. Each team included individuals from all three institutions, and met outside of scheduled class times using the virtual classroom, ensuring cross-institutional collaboration at all stages of the course. Typically, participants used Elluminate as a "conference call" technology and relied on other methods to share content (e.g., wiki pages, web-based documents, and documents sent to participants via email in advance).

Video-Conferencing: For Building Community, Attaining Critical Mass, and Making Complex Decisions

This course made use of video-conferencing through an internet protocol-based system called Polycom (http://www.polycom.com/usa/en/products/products.html; verified 21 Nov. 2008). Video-conferences among all three universities occurred at the beginning, middle, and end of the courses. The primary purpose of these meetings was to allow participants to see and get to know one another, building a sense of community among learners (Gunawardena and Zittle, 1997). A secondary purpose was to ensure that participants at the three institutions were "on the same page." A "checkpoint" meeting occurred midway through the course, and a third meeting late in the process was scheduled to make decisions about how work would be completed when the courses ended.

Weekly videoconferences were conducted between Iowa State and North Carolina State. This interaction provided critical mass for North Carolina State, where only two students were enrolled, by allowing the students at the two universities to function as a unit. Participants at these institutions were able to meet for about 2 hours each week to discuss issues that had arisen during the week, brainstorm, work out complex decisions, and plan for the coming weeks.

Methods of Evaluation

Questionnaires

A questionnaire was developed that contained 53 items to query students about their knowledge and skills with respect to collaboration, leadership, communication, web-based technology, and subject-area knowledge (municipal planning and conservation biology). The institutional review board at each of the three universities approved the questionnaire and survey procedures. Identical questionnaires were delivered in person or by email to all students at Iowa State and North Carolina State (n = 8), and students enrolled in spring quarter at the University of Washington (n = 11), before and after participation in the course. Students used an anonymous identification number on each survey, allowing us to match pre- and post-course responses.

Questions allowed responses on a six-point scale. Students were asked about their knowledge using a response scale ranging from 1 = *nothing* to 6 = *enough to use comfortably* (Table 2). For skills, students were asked how often they had engaged in specific activities with a response scale ranging from 1 = *never* to 6 = *always* (Table 3). Students were also asked to provide narrative evidence supporting items that they ranked highly.

Mean pre- and post-course scores for each question were determined, and tested for changes in pre- and post-course responses. For each question, we used data only from students who responded to the question on both the pre- and post-course surveys; thus, the number of responses varied among questions as shown in the tables. Pre- and post-course mean responses were tested to determine if they were significantly different from 3.5 (a neutral response on the scale) using a two-tailed t-test with $\alpha = 0.05$. The mean change in ratings for each question was tested to determine whether it was significantly different from zero (no change) using a two-tailed t-test. To detect potential biases in this approach, pre- and post-course means of all respondents were compared with those of respondents who completed both pre- and post-course surveys for each question. Means, standard errors, and statistical tests were calculated using the "Proc T-Test" function in SAS version 9.2 (SAS Institute, Cary, NC).

Structured Reflections

Near the end of the course, four questions were given to students and faculty and written, narrative responses requested. These questions were posed to elicit narrative responses about (1) the expectations of participants when they began the course; (2) whether those expectations had been met; (3) the different forms of technology that we used to collaborate, and which technologies were particularly effective; and (4) which aspects of the course were beneficial and detrimental to learning (for students) and teaching (for faculty). After the course concluded, one faculty member used content analysis to identify common themes among responses. This information was used to support and clarify the quantitative results gathered using the questionnaire.

Table 2. Student respondents reported knowledge about collaboration, leadership, and communication before and after the courses on a 6-point scale (1 = nothing, 2 = very little, 3 = enough to be confused, 4 = enough to try using, 5 = enough to use comfortably, 6 = enough to use confidently). Pre- and post-course mean responses were tested to see if they differed statistically from 3.5, the mid-point of the scale that we considered a neutral response; significant differences at the α = 0.05 level are indicated with an asterisk (*). Statistically significant shifts between paired pre- and post-course ratings were used to identify changes that might be attributed to the course; p values are shown for these tests (probability that the difference is zero, last column).

Questions	*n*	Pre-course mean	Post-course mean	Post-course less pre-course mean†	*Pr* > *t* *x* = 0
A. KNOWLEDGE ABOUT COLLABORATION					
How much do you know about…					
1. Being part of an effective collaborating team?	15	4.7*	5.3*	0.6	0.033
2. Your own attitudes about working collaboratively?	15	4.6*	5.1*	0.5	0.041
3. Your competency in collaborating?	15	4.5*	4.9*	0.5	0.068
4. Helping others work effectively in collaboration?	15	4.3*	4.9*	0.5	0.104
5. Essential components of effective collaboration?	15	4.4*	4.9*	0.5	0.089
6. Collaboration in multidisciplinary efforts?	15	4.2*	4.7*	0.5	0.111
B. KNOWLEDGE ABOUT LEADERSHIP					
How much do you know about…					
1. Your attitudes about leadership?	15	4.7*	4.7*	0.0	1.000
2. The characteristics of leadership in a collaborative context?	15	4.1	4.7*	0.7	0.086
3. The distinction between positional leadership and collaborative leadership?	15	3.3	4.1*	0.9	0.043
4. The relationship between leadership and learning?	15	4.0	4.5*	0.5	0.110
5. Recognizing opportunities to provide leadership?	15	4.6*	4.9*	0.3	0.364
6. Providing leadership in a multidisciplinary context?	13	3.8	4.1*	0.4	0.268
C. KNOWLEDGE ABOUT COMMUNICATION					
How much do you know about…					
1. Being an effective communicator?	15	5.0*	4.9*	−0.1	0.774
2. Balance between giving and receiving information?	15	4.6*	5.0*	0.4	0.082
3. How communication fits into collaborative problem-solving?	15	4.4*	5.0*	0.6	0.045
4. How to anticipate what collaborators need to know to be most effective?	15	3.6	4.6*	1.0	0.008
5. Professionalism using different forms of communication?	15	4.9*	4.9*	0.0	1.000
6. Communicating across disciplines?	13	4.2	4.5*	0.4	0.268

* Mean differs from 3.5 at α = 0.05.
† ±0.1 difference in means shown may occur as a result of rounding off.

Results and Discussion

Surveys were returned by 16 of 19 students, an 84% response rate. Of these, between 11 and 15 matched sets (58–79%) were available for specific questions, which allowed us to calculate change in responses through time (due largely to inadvertent omissions by the respondents). Six faculty (100% response) and eight students (31%) submitted post-course reflections. The low rate of return for student reflections was most likely due to the volume of course activities at the close of the semester; comments from them have been used only to clarify survey results detailed in this article.

For the pre-course survey, mean scores of all respondents differed little from those for whom matched sets were available. On average, the scores for respondents with matched sets were 0.09 lower than for all respondents. The difference for the post-course survey was somewhat larger, with scores for respondents with matched sets averaging 0.54 higher than those for all respondents. Thus, students who completed questions on both surveys tended to report slightly lower scores on the pre-course survey and somewhat higher scores on the post-course survey than students who did not complete both surveys. This potential bias would cause us to overestimate the treatment effect of the course.

How effective was this course as a vehicle for students to increase their knowledge *about collaboration, leadership, and communication within and among several institutions?*

Students reported that their knowledge about collaboration increased somewhat during the course. Coming into the course, students reported that, on average, they had

Table 3. Student respondents reported activities in collaboration, leadership, and communication before and after the courses on a 6-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = usually, 6 = always). We tested pre- and post-course mean responses to see if they differed statistically from 3.5, the mid-point of the scale that we considered a neutral response; significant differences at the α = 0.05 level are indicated with an asterisk (*). Statistically significant shifts between paired pre- and post-course ratings were used to identify changes that might be attributed to the course; p values are shown for these tests (probability that the difference is zero, last column).

Questions	*n*	Pre-course mean	Post-course mean	Post-course less pre-course mean†	*Pr > t* *x* = 0
A. USING COLLABORATIVE SKILLS					
During collaboration, how often have you…					
1. Deliberately used your own skills to enhance collaboration?	11	4.3	4.5*	0.2	0.714
2. Thoughtfully engaged in activities to improve collaboration?	11	4.0	4.0	0.0	1.000
3. Considered your own attitudes about collaboration during work?	11	4.1	4.5*	0.5	0.378
4. Practiced skills that encouraged others to use their strengths to improve work?	11	3.2	3.9	0.7	0.181
5. Planned to help others engage in collaboration?	11	3.5	3.7	0.2	0.742
6. Deliberately engaged in multidisciplinary collaboration?	11	3.4	4.5*	1.1	0.082
B. USING LEADERSHIP SKILLS					
How often have you…					
1. Made a conscious choice to lead in a learning situation?	14	3.8	4.1*	0.3	0.525
2. Provided leadership associated with a position?	14	4.4*	4.1	–0.3	0.500
3. Provided leadership not associated with a position?	14	3.4	3.6	0.1	0.671
4. Deliberately modeled behaviors that you would like to see others demonstrate?	14	4.1*	4.2	0.1	0.844
5. Empowered others to provide leadership?	14	3.7	4.0	0.3	0.391
6. Provided leadership in a multidisciplinary context?	13	2.9	3.8	0.9	0.020
C. USING COMMUNICATION SKILLS					
During collaboration, how often have you…					
1. Engaged in professional communication in a collaborative effort?	12	3.3	4.7*	1.4	0.006
2. Consciously thought about the balance between giving and receiving information?	12	3.5	4.3*	0.8	0.002
3. Used professional communication skills to solve problems?	12	3.8	4.6*	0.8	0.011
4. Provided information to enhance partners' contributions?	12	3.4	4.5*	1.1	0.016
5. Purposefully sought effective communication from others?	12	3.5	4.2*	0.7	0.054
6. Consciously thought about how to communicate across disciplines?	10	3.6	4.4*	0.8	0.053

* Mean differs from 3.5 at α = 0.05.
† ±0.1 difference in means shown may occur as a result of rounding off.

enough knowledge about collaboration to *try using it* or *use it comfortably* (Table 2A). Students cited experiences in other classes, the workplace, and previous collaborative research as justification for their ratings. The post-course responses indicated only modest gains for knowledge about collaboration, but these gains were statistically significant for knowledge about being part of an effective team and their own attitudes about collaborative work (Table 2A, Questions 1 and 2). On post-course surveys, students commented that this course was "the most collaborative experience I have had," and "this course provided *a lot* more experience in collaboration" (emphasis by student). Others indicated how much they had learned about collaboration, for example, "I got a very good sense of what makes for good collaboration, and what makes for bad collaboration." Another student noted, "I am more comfortable now working with other students outside of class and from other institutions, and am more prepared to adjust for the schedules and constraints of others."

At the outset of the course students rated their knowledge about leadership somewhere between *enough to try using* and *enough to use comfortably*, and their leadership knowledge did not change by most measures (Table 2B). A statistically significant gain was detected, however, for

knowledge related to the distinction between positional and collaborative leadership (Table 2B, Question 3). In fact, students commented that prior leadership knowledge was closely tied to positional leadership: serving as a team captain, being an officer in a student organization, and through military experiences. Students recognized that leadership in the context of this course was tied more to issue identification and taking responsibility for following up on tasks and activities themselves than to directing the activities of others.

Although survey responses did not indicate a change in students' abilities to recognize opportunities to lead, most respondents indicated in their narratives that the course provided many such opportunities. One student commented specifically that opportunities for leadership heightened the beneficial experiences of the course, and facilitated learning for other students. This is consistent with emerging ideas about learning and leadership: self-reflection and organization of new information contributes to one's own and others' understanding of complex information (Johnson and Johnson, 2003; Dickman and Stanford-Blair, 2002). Being willing and able to provide such leadership is important in developing the habits associated with being responsible and accountable in a collaborative context (Wiersema and Licklider, in press) and likely to enhance students' future collaborative efforts.

Initial student ratings for knowledge about communication indicated that most were prepared to put their knowledge into practice, particularly knowledge about being effective communicators and using different forms of communication. Student knowledge about communication did not increase by most measures, but we detected statistically significant increases in knowledge of how communication fits into collaborative problem-solving, and how to anticipate what collaborators need to know to be effective (Table 2C, Questions 3 and 4). Knowledge and skill in these areas are very likely to be important for productive future collaboration. Respondents' comments on post-course surveys were focused on the central role of communication in problem solving and providing information. One respondent went so far as to say that "collaboration is *all* about communication" (respondent's emphasis). Another respondent wrote that "learning to communicate within and between institutions was one of the biggest take-away lessons for me as we worked through decision-making and problem solving."

On the pre-course survey, several students commented on professionalism in communication, noting that one must pay close attention to avoid unintended "tone" in computer-mediated communication. In post-course reflections, a few students indicated that they perceived negative tone at times during course interactions and that this impeded their learning. While research on collaborative learning in computer-mediated environments indicates that efforts to provide "social presence" will counteract some of the negative aspects of "faceless" communication (Gunawardena and Zittle, 1997), consistent mindfulness is required of all participants.

Was this course an opportunity for participants to increase their activities in collaboration, leadership, and communication?

Students rated their activities in collaboration, leadership, and communication prior to this course lower than their knowledge (Table 3). There were no detectable gains in activity levels for collaborative skills (Table 3A). This, and relatively modest gains overall for knowledge and activity may also be linked to students' overestimating their knowledge early in the semester, and being more critical in their self-evaluation following the course experience, thereby diminishing measurable change (see also Wiersema and Licklider, in press).

There was a detectable increase for providing leadership in an interdisciplinary context (Table 3B, Question 6). Students indicated that they were able to identify many opportunities for leadership during the course, that they provided leadership in these situations, and that they modeled leadership behaviors for others. Faculty, however, indicated in their post-course reflections that their expectations for students to be involved equally with faculty in research-related activities and provide leadership to accomplish those tasks frequently were not met. Although faculty modeled the kinds of leadership activities they expected students to emulate, and presented opportunities for students to take those roles (consistent with the "immersion" approach to other professional skills), explicit discussion of these opportunities or instructions for students to assume these responsibilities did not occur. In some cases this approach worked, but student leadership might have been greater if faculty more clearly articulated this as a specific goal and provided guidance beyond modeling the behavior.

Student surveys revealed statistically significant increases in four out of six items related to communication: engaging in professional communication, conscious thought about the balance between giving and receiving information, using professional communication skills to solve problems, and providing information to others to enhance collaboration (Table 3C, Questions 1–4). Interestingly, this was a cluster of questions for which many differences between the means on pre- and post-course items were not significant for all respondents, whereas the differences for those from whom we received matched surveys were significant. In other words, respondents with "matched" questionnaires reported engaging in more communication-intensive activities on the post-survey. Student comments on the post-course survey emphasized the importance of this course in affording the opportunity to practice, for example, "balancing the need to listen to others with the desire to contribute my own ideas." Students also noted the importance of professionalism in all forms of communication, and that activities in this course heightened their awareness of how professionalism could contribute to collaborative efforts and how lack of professionalism could detract from those efforts.

Did this approach enhance participants' knowledge and skill with collaborative technologies?

Students reported gains in both knowledge and skills with respect to collaborative technologies (Table 4). Aver-

age initial student ratings for knowledge hovered around *enough to be confused* and skills were used *rarely*. By the end of the courses, students felt they knew enough about the technology to use it comfortably, and their skills had increased to the point where they used the technology often; some indicated that they had started using the technology in applications beyond this course.

To reach agreed-upon goals associated with research products, several small teams consisting of participants from all three institutions were formed during the semester that focused on particular aspects of the work. These groups interacted frequently, at times even daily, using the wiki and virtual classrooms. Students had to increase their knowledge about these technologies to participate effectively.

Several students noted how useful the course wiki was for building products, such as a survey or manuscript, in an asynchronous fashion. Some students really liked using the course wiki, one exclaiming, "Wikis are great!" Several students indicated that it was possible to detect social presence: "the wiki really helped create community—bits of participant personality really do come through on the wiki." Yet, other students disliked it strongly, indicating that in their view "nobody likes the wiki!" or that it was "overwhelming." Other researchers have noted that heavy reliance on computer-based content can lead to "cognitive overload" (e.g., Delialioglu and Yildirim, 2007). Several participants indicated that, in spite of some quirks and problems, the wiki became easier to use with time. Faculty commented in their reflections that although the wiki allowed us to work across time zones more gracefully, it became unwieldy at times as course content grew. Faculty also noted, however, that the wiki was "essential" and that they were not aware of other similar tools that would eliminate some of the "downsides."

Although fewer students commented on the virtual classroom, those who did indicated that it was "a great tool for collaboration." In post-course reflections, several students suggested that Elluminate sessions were the most fruitful means of collaboration used during the course. Faculty also indicated that these sessions were very effective for small groups (six to eight participants) and that this interaction was most useful when guided by an agenda and when all participants contributed actively to the discussion.

Use of videoconferencing in the course received mixed reviews. Three-way videoconferencing was primarily useful "to put a face with a name," as one student put it. Two-way videoconferences between Iowa State and North Carolina State, which occurred almost every week, were viewed by students and faculty alike as more successful for "getting work done," if guided by an agenda, a designated leader to move the group through the agenda, and a note-taker to summarize decisions and action items agreed upon during the session.

Did this approach simultaneously contribute to construction of knowledge about conservation science in local planning and about conducting research?

Students made significant gains in knowledge about municipal planning and conservation biology, moving from somewhere between *very little* and *enough to be confused* to *enough to try using* (Table 5).

Students also commented on learning about the processes and products of research. Although some reported disappointment that there was not more "classroom learning" and "time spent with class texts," others indicated that collaboration between students and faculty, as well as among students in the small, inter-institutional groups were particularly beneficial for their learning. Students commented specifically on collaboration in small groups, indicating that increased accountability within those groups provided motivation to perform, "I respond well to peer pressure…honestly, no one wants to admit to a group in a joint meeting that you did not get the work done" (see also Hafernik et al., 1997).

Students who were at an early point in their graduate careers expressed some surprise at how challenging it was to conduct original research. For most of the students, processes associated with conducting a survey were novel and engaging learning experiences. Data from the survey of planners have been used to prepare multiple research products agreed upon by participants: presentations for a professional meeting and a research colloquium, a technical manuscript for a peer-reviewed journal (Miller et al., 2008), a manuscript for a teaching and learning journal (this article), and a draft publication for municipal planners.

Lessons Learned

Student development during this course most closely mirrored those areas where learning was required to support class-wide activities. Students gained knowledge about some aspects of collaboration and increased communication skills necessary to function in the course, reported increased abilities in using collaborative technologies that were used all the time, and reported that they gained knowledge about course subject matter. Students did not report significant changes in knowledge or activities related to leadership. Faculty expected students to learn about leadership in collaborative settings by observing faculty behavior; this did not occur, perhaps because students expected implicitly that faculty *would* lead the course. We learned that faculty must give explicit instruction related to all professional development outcomes; faculty modeling the desired behavior is likely insufficient, especially for leadership.

Administration of the course included several challenges. These included working across time zones and different institutional calendars (quarters vs. semesters); course offerings for different levels of credit; some turnover in students involved at the University of Washington during each quarter; timing related to breaks; and use of different mechanisms for summative evaluation of student participation. In future collaborative course offerings, faculty will standardize as many of these factors as possible. For example, students on quarter-based calendars would be asked to commit to a two-quarter course to maximize overlap and continuity with semester-based schedules, and credit levels would be balanced between semester and quarter courses.

The technologies we used, especially the wiki and virtual classroom, provided viable platforms the communication and collaborative work. Participants from the three distant campuses used the technologies to

Table 4. Student respondents reported knowledge and activities related to use of technologies in collaboration before and after the courses on a 6-point Likert scale. We tested pre- and post-course mean responses to see if they differed statistically from 3.5, the mid-point of the scale that we considered a neutral response; significant differences at the α = 0.05 level are indicated with an asterisk (*). Statistically significant shifts between paired pre- and post-course ratings were used to identify changes that might be attributed to the course; p values are shown for these tests (probability that the difference is zero, last column).

Questions	*n*	Pre-course mean	Post-course mean	Post-course less pre-course mean†	*Pr > t* *x* = 0
A. KNOWLEDGE ABOUT TECHNOLOGY					
(1 = nothing, 2 = very little, 3 = enough to be confused, 4 = enough to try using, 5 = enough to use comfortably, 6 = enough to use confidently)					
How much do you know about…					
1. Technology-assisted collaboration?	15	3.7	5.2*	1.5	0.004
2. Using a wiki to create content collaboratively?	15	2.2*	5.5*	3.4	<0.001
3. Internet-based collaborative learning software?	15	2.9	5.4*	2.5	<0.001
4. Telephone-based conferencing?	15	4.1*	4.6*	0.5	0.178
5. Internet-based conferencing?	15	3.5	5.5*	1.9	0.002
B. USING TECHNOLOGICAL SKILLS					
(1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = usually, 6 = always)					
How often have you…					
1. Created a wiki entry?	13	1.5*	4.6*	3.1	<0.001
2. Been in a course that used internet-based collaborative software?	12	1.8*	4.4*	2.7	<0.001
3. Led a discussion suing internet-based software?	13	2.2*	3.8	1.7	<0.001
4. Participated in a conference call (internet or phone-based)?	13	2.6*	4.7*	2.1	<0.001
5. Led a conference call (internet or phone-based)?	13	1.7*	3.4	1.7	0.002

* Mean differs from 3.5 at α = 0.05.
† ±0.1 difference in means shown may occur as a result of rounding off.

Table 5. Student respondents reported knowledge about municipal planning and conservation biology before and after the courses on a 6-point Likert scale (1 = nothing, 2 = very little, 3 = enough to be confused, 4 = enough to try using, 5 = enough to use comfortably, 6 = enough to use confidently). We tested pre- and post-course mean responses to see if they differed statistically from 3.5, the mid-point of the scale that we considered a neutral response; significant differences at the α = 0.05 level are indicated with an asterisk (*). Statistically significant shifts between paired pre- and post-course ratings were used to identify changes that might be attributed to the course; p values are shown for these tests (probability that the difference is zero, last column).

Knowledge about municipal planning and conservation biology	*n*	Pre-course mean	Post-course mean	Post-course less pre-course mean†	*Pr > t* *x* = 0
How much do you know about…					
1. Municipal planning processes?	13	2.8	3.9*	1.1	0.009
2. Municipal planning documents?	13	2.9	3.6	0.7	0.013
3. The relationship between municipal plans and ordinances?	13	2.8	4.0	1.2	0.004
4. Conservation biology principles?	13	3.3	4.4*	1.1	0.005
5. Application of conservation biology principles?	13	3.0	4.3*	1.3	0.003
6. Integrating conservation biology principles in planning processes?	13	2.7*	4.2*	1.5	<0.001
7. Integrating conservation biology in planning documents?	13	2.6*	3.9	1.3	0.003

* Mean differs from 3.5 at α = 0.05.
† ±0.1 difference in means shown may occur as a result of rounding off.

complete the courses and co-create a presentation for a national conference and initial drafts of two manuscripts.

However, heavy reliance on computer-mediated activities sometimes led to lower productivity than would have been ideal. This is probably due to the less immediate nature of asynchronous, computer-mediated communication (e.g., Brown et al., 2006) and variation in intrinsic motivation among students to engage effectively in the process (Delialioglu and Yildirim, 2007). In particular, there was a tendency toward posting information on the wiki at the last minute before meetings, incomplete group participation in preparing meeting agendas, and losing sight of the big picture. Faculty would recommend more accountability for timely participation in the completion of asynchronous tasks, likely in the form of additional interim deadlines as action items are identified.

There is a cost associated with allowing students to define course objectives and research methods. Faculty gave careful consideration to whether the research approach should be defined by faculty before the course began or created by all participants as part of the course process. The latter was chosen, because faculty wanted students engaged in deciding how best to answer the question, recognizing that the time required to do so could limit progress toward developing products. Faculty felt that the opportunity to engage all participants in deliberative decision-making about all aspects of the work was extremely valuable and more authentic. This frustrated a number of students, however, who were more interested in carrying out the research and developing products than in deliberating the approach. Given the realities of the relatively short period of time available (i.e., about 16 weeks), faculty participants would recommend a fairly well-defined question, research approach, and products, leaving students the tasks of working through the details.

Overall, this was a worthwhile experience. The diversity of ideas brought to the "classroom" by participants located in different parts of the country was exciting and stimulating. Faculty and student participants alike found the approach organizationally challenging, intense, and somewhat chaotic—but very rewarding. All participants gained a fuller understanding of the benefits (i.e., collective creativity, enhanced accountability as per Fox and Faver, 1984, and Hafernik et al., 1997), and the drawbacks (the time required to build relationships and engage in deliberation, also Fox and Faver, 1984) of collaborative research. Faculty have agreed that future offerings will continue to focus on a complex question, involve multiple institutions, and use similar technologies for distance collaboration. They will begin, however, with more specific research questions and approaches, include more explicit guidance about leadership, and work toward completing a smaller set of course products.

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