

AC 2007-389: INTERDISCIPLINARY PEDAGOGY: USING TEAMS TO TEACH THE BOK

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Abstract

With a full third of ASCE's prescribed Body of Knowledge learning outcomes based on professional practice and communication skills, engineering administrators must consider who is best suited to teach its various components. Teaching the interdisciplinary curriculum poses problems for traditional engineering faculty because most are not trained in communication and teamwork pedagogy. This paper considers how University of Utah approaches "who should teach the body of knowledge" by examining interdisciplinary team teaching in Civil and Environmental Engineering. It specifically focuses on the communication related learning outcomes 6, 7, 8, 9, and 15, and how University of Utah employs teaching teams, including instructors from Communication, Writing and Engineering in order to accomplish them by following the collaboration in one department-required technical communication course over four semesters.

The BOK and Traditional Engineering Faculty

The idea that multi-disciplinary collaborations might infuse engineering classrooms with multiple perspectives and expertise is not new. However, the implementation of such multi-disciplinarity in required Civil Engineering courses has largely been confined to multiple engineering disciplines, e.g. geotechnical, structural, and water resource engineers coming together to complete a project. These multi-disciplinary experiences help students demonstrate "an ability to function on multi-disciplinary teams," satisfying one of ASCE's prescribed Body of Knowledge (BOK)¹ learning outcomes. However, with a full third of the BOK's prescribed learning outcomes based on professional practice and communication skills, Civil Engineering administrators have begun to consider the interdisciplinary² characteristics of the BOK.

Among ten more technically-focused learning outcomes, the BOK entails that graduates demonstrate "(6) an understanding of professional and ethical responsibility, (7) an ability to communicate effectively, (8) the broad education necessary to understand the impact of engineering solutions in a global and societal context, (9) a recognition of the need for, and an ability to engage in, life-long learning, ... [and] (15) an understanding of the role of the leader and leadership principles and attitudes."³ All of these outcomes concern an intersection between the professional practice of Civil Engineering and other disciplines, such as writing, communication, ethics and education. Because it encompasses such a wide range of skills, teaching the entire BOK curriculum poses problems for traditional engineering faculty, not only because they lack pedagogy training in communication and teamwork,⁴ but because program-required courses must also include a full term of technical material. Pressed for time and specializing in technical skills, many engineering faculty find assessing students' written communication and teamwork difficult and time consuming. And yet these written, oral and teamwork deliverables are most likely the assignments that "demonstrate" the students' familiarity with many prescribed BOK learning outcomes.

Alternative Instructional Approaches in Undergraduate Engineering Programs

Many universities have implemented programs to address communication concerns in their undergraduate programs, tackling industry's call for junior engineers with better writing and speaking skills.⁵ These collaborations have developed under the umbrellas of such national endeavors as Writing Across the Curriculum, Communication in the Content Areas, Writing in the Disciplines and Communication Across the Curriculum. Some of these programs, like the one in University of Houston's Mechanical Engineering department, include a partnership with the university's Writing Center in which consultants teach workshops and hold consultations with teams and individual students in conjunction with specific undergraduate courses.⁶ This program reflects the partnership that the Massachusetts Institute of Technology (MIT) began in 1996 between its Aerospace Engineering faculty and communication instructors who taught communication practicum in conjunction with specific courses.⁷ More recently, the partnerships begun in MIT's ME department in 1990⁸ and in Mississippi State University's ECE department in 2004⁹ have resulted in "multidimensional scoring rubrics" designed to provide comprehensive feedback and help TA's grade student lab reports. Going even further to integrate writing and communication instructors into undergraduate engineering courses, Virginia Polytechnic University's ME¹⁰ and Georgia Institute of Technology's ECE¹¹ departments employ lecturers who teach communication components in required undergraduate engineering courses.

All of these programs are motivated by the concept that integrating the teaching of communication into engineering curriculum will result in graduates with greater communication skills and a better understanding of engineering concepts. As the organizers of the integrated communication practicum at MIT explain, over the past decade they have "found that integrating technical content and communication improves student learning by (1) linking the scientific research process with the exposition of scientific findings, (2) identifying high-level misunderstandings of technical content that are only obvious when students provide a written explanation of their research results, and (3) providing students a forum for giving and receiving substantial feedback on their research writing."¹² However, the level of integration in these programs varies, from communication components taught by communication instructors in the classroom to consultants leading workshops and working with faculty on grading rubrics. Most of these programs maintain a disciplinary separation in the classroom, with specific components taught by different instructors respective of their disciplinary specialty. Only one of the programs found in this research project includes a team-taught course developed by engineering and communication instructors together and taught equally by the instructional team.

In 1999 the University of Toronto implemented a five-week elective seminar in its College of Engineering (COE) that pairs an engineering faculty member and a writing instructor equally in the classroom. The developers of this program explain that "by bringing the engineer into a writing course, we hoped to take away some of the initial hurdles often faced by writing instructors working in an engineering environment... Moreover, the interaction between the two instructors, and their differing perspectives on written text, helped us show students the importance of the different communication issues engineers face in both the academic and professional worlds."¹³ This course exhibits the interdisciplinarity of engineering communication by putting instructors from different disciplines into conversation, crossing the traditional divides in discourse that many professional engineering documents (like proposals, environmental impact statements and feasibility studies) must breach in order to reach their complex audiences.

This equal, discussion based team teaching stimulates an awareness and appreciation of “lifelong learning” as it creates a space in which the instructors learn from each other in and out of the classroom.

Having added elements of leadership, teamwork, ethics and global awareness to its traditional BOK, ASCE has increased the need for interdisciplinary courses in undergraduate Civil Engineering programs. The team-taught seminar above attempts to achieve many of the learning outcomes suggested in the BOK, but it does so on a COE level, and in an elective, partial-term course. In order to address the BOK-required, interdisciplinary concerns of communication, teamwork, leadership, ethics, and global awareness, the University of Utah has implemented a team-taught, required, semester-long Technical Communication for Civil Engineers course in its Civil and Environmental Engineering (CVEEN) undergraduate curriculum.

This course, CVEEN 3100, is taught by three equal instructors, one Civil Engineering Research Professor, one Writing Consultant from the Department of English and one Communication and Teamwork Consultant from the Department of Communication. Course materials are developed in an effort that includes individual work revised in consultation with the rest of the teaching team, and honed over subsequent semesters as the team deems appropriate. In this way, materials belong to the course rather than any one instructor on the instructional team, and they evolve with the course. The CVEEN department at University of Utah has found the diverse student writing samples and presentations in this course to exhibit so many of the BOK learning outcomes that it is currently creating a database of CVEEN 3100 student coursework to use as documentation for its upcoming ABET accreditation review.

Besides recording the interdisciplinary experience of its students, the deliverables in this course increased in competency at an extreme rate over its first four semesters. As the second of a newly implemented (2004) trio of communication-intensive classes, beginning with the freshman introductory course, CVEEN 3100 prepares its students for the department’s Professional Practice and Design senior project by developing their competency in researching, writing and presenting the complex reports required in the capstone experience. The department has seen an increased competency in its senior students measured by their ability to produce higher quality documents with less instruction in that course. While evaluation of the increase in student competency is currently qualitative in nature, attempts to quantify student response and increased ability is currently being conducted. Because equal, interdisciplinary teaching teams are relatively rare in required Civil Engineering courses, the author of this paper hopes that a narrative of the team’s development and success will shed light on at least one solution to teaching the complex BOK ASCE has devised for undergraduate programs in Civil Engineering.

The CLEAR Program and CVEEN 3100

The Writing, Communication and Teamwork consultants who teach CVEEN 3100 do so through sponsorship from the Communication Leadership Ethics and Research program (CLEAR) funded largely by the William and Flora Hewlett Foundation. The program sponsors ethics, writing, communication, and teamwork instructors from the College of Humanities to work with faculty and students in traditional, required engineering courses in all seven departments of the University of Utah College of Engineering. It allows advanced graduate students with

experience in varying pedagogies to work side-by-side in classrooms with traditional engineering faculty to enhance the education in the College of Engineering's undergraduate curricula.

While the program has engendered much collaboration and experienced much success, no class has so fully incorporated the interdisciplinary team teaching model as the CVEEN 3100 Technical Communication for Civil Engineers course.

Evolution of Interdisciplinary Team Teaching in CVEEN 3100

When the CLEAR consultants first began to collaborate with CVEEN faculty in spring 2004, the technical communication course was taught, as many such courses, mainly with an emphasis on clear sentence structure. The course included lectures and exercises focused on correcting and clarifying existing sentences and paragraphs: basic sentence structure was defined; poorly written sentences were revised; confusing memos were rewritten. In the course, students performed high-intensity grammar work, in no particular thematic context. The hope was that patterns of clear sentence style and proper punctuation use would transfer to students' work in other Civil Engineering courses.

The main problem associated with this communication education philosophy was that it claimed a type of separation between mechanics and content that the consultants found unsatisfactory. Technical communication, they believed, needed to include grammatical work within an engineering context, thus fusing the content-mechanics divide produced by a segregated communication course. An interdisciplinary instructional team was formed of one Communication graduate student to focus on oral and team communication, one English graduate student to focus on written communication, and one CVEEN Research Professor to focus on providing an engineering context for the course. Together over the next two semesters, the team collaborated, negotiated and designed the CVEEN 3100 Technical Communication for Civil Engineers course as it is currently taught.

The course objectives have been narrowed from the original broad goal of improving students' capability to write clearly. The new objectives are familiarizing students with specific industry-standard report and presentation types, increasing their ability to produce professional reports, and increasing their ability to obtain a job after graduation by honing their resume writing and interviewing skills. Besides these more specific objectives, the course has taken on a role within the progressive communication heavy course thread within the four year curriculum, which means that it must build on the communication skills introduced in the freshman level CVEEN 1000 course, and prepare students for the Professional Practice and Design capstone course they will take just before graduating.

In order to achieve these objectives, the team agreed that coursework should center on an engineering project that would engage the students in engineering topics while providing a context for written reports and presentations. The project needed to include questions of ethics and global impact in order to develop deliverables that would document ASCE's prescribed BOK learning outcomes. It also needed to involve both individual and team based documents. It had to be engineering based and yet not demand too much calculating or collecting of data in order to maintain its focus on report writing and presenting. The instructors agreed on a project that would be divided among student teams and would examine environmental issues in Utah

caused by population growth. Among other topics, the resulting assignments regarded phosphorus loading in Utah Lake, pollution in the Bear River, decreasing water resources, and the impact of green building practices. Over three semesters the student and instructional teamwork concepts for the class were honed.

In the first semester, 60 students were divided into four 15-student teams. Each student was required to create a proposal and engineering report based on the team project, and intra-team reports were not to duplicate information. During that semester, the instructors met once every two weeks to set the lecture schedule and discuss appropriate content. The course was taught mainly through lectures, with the engineering professor teaching approximately 60%. Guest lecturers spoke on library resources, Franklin-Covey planning and time management, and web-based communication. The CLEAR consultants gave focused lectures on resume writing, sentence clarity, outlining reports, and presentation skills. Functioning on a coordinated, multi-disciplinary model, the instructors formed a team with one administrator keeping track of the lecture and assignment schedule. Although the instructors collaborated on the schedule, assignments and grading, they each held distinct positions within the course and assumed responsibilities accordingly.

During the next semester, the members of the instructional team remained stable, yet team dynamics changed drastically. Meetings increased from once every two weeks to twice a week. With a semester's experience of one another's lectures, the instructors were able to comment, and offer advice on their contents. They participated in each other's presentations during class, offering alternate perspectives on subjects and discussing the ways audiences of differing backgrounds might approach subjects and materials differently.

The atmosphere in the classroom changed from one of multi-disciplinarity, with individual instructors speaking on discreet topics, to one of interdisciplinarity in which topics were explored by all three instructors. Instructors freely acknowledged differences in disciplinary approaches in their classroom discussions. For example, in a presentation on cover letter writing, the Engineering Professor might discuss the audience and impetus for the letter, the Communication Consultant might address rhetorical strategies in conjunction with that audience, and the Writing Consultant might address issues of voice and sentence style. Instructors frequently learned from one another's contributions to discussion and noted so in class, inspiring further discussion of how and why professionals in different fields approach certain types and aspects of documents. The atmosphere of education among not only the students but the instructors inspired discussion of continued, life-long learning, and the manners in which it takes place.

The class allowed students to receive writing instruction based on the expertise of a writing instructor, commented on theoretically by a communication specialist and brought into a disciplinary perspective by a professional engineer. Oral and teamwork curriculum was likewise delivered by a communication specialist, with the addition of comments and testimonies of the writing instructor and professional engineer. Engineering project concepts were described by the engineering professor, and applied in writing and communication applications taught by the CLEAR consultants. This interdisciplinary formula has become the backbone of the CVEEN 3100 course, and allows its instructors to meet all the course objectives, and hit all five of the BOK's professional communication objectives in a lively classroom atmosphere.

This second semester of team teaching used constant collaboration, compromise and cooperation of all the team members to create a truly interdisciplinary environment in a core disciplinary course. At every point during the semester the students could appeal to any of the instructors' expertise for answers to their questions. The student project teams again numbered four, but consisted of 8-10 members this time, as enrolment was limited to 36 instead of 60. While the limitation of enrolment made a difference in the size of the required classroom, the instructors believe that the reduction in student team size was more significant in terms of student learning. Two entirely team-based reports were introduced. All of the course assignments are noted in the table below. Individual assignments included a resume, memo, four quizzes, technical description and operating instructions for a machine, and a final exam. Team assignments included a building inspection report and presentation, a project proposal, and an engineering report and presentation.

Individual Deliverables	Team Deliverables
Resume	Team Working Agreement
Memo	Building Inspection Report & Presentation
Quizzes	Written Proposal
Technical Description and Instructions	Research References Assignment
Final Exam	Engineering Report Document & Presentation

Student evaluations and instructor reflection brought about a few changes the next semester. The Engineering faculty and Writing Consultant remained stable while a new Communication and Teamwork Consultant joined the team. Student team size in the third semester was decreased to 4-5 students in order to maximize the team experience, and place more equal work loads on each member of each team (as recommended by the Teamwork Consultant). More points were given for individual deliverables in order to increase the students' feeling that they each were fully responsible for their own grades. The biggest problem that occurred in the second semester had come in the form of student complaints that the teaching team provided not only different instructions for assignments, but that their grading seemed to be based on different criteria. In order to combat this inequity, enhanced by the multi-disciplinary nature of the teaching team, more detailed expectations including outlines and rubrics were created for each major assignment. The teaching team chose one instructor to present each assignment and its grading criteria, and that instructor also graded that assignment him or herself, thus making the evaluation of all students equal for each assignment.

Although the teaching team made several small changes to the curriculum and delivery process, they did not continue to meet nearly as often in this third semester. Over-all, the course seemed to be set, the instructors were comfortable with the delivery and grading process, and the work of

teaching the course diminished considerably. The students were able to gain the full measure of interdisciplinary experience, the instructors were able to fully reap the benefits of co-instructors, and the team did not need to commit more than an hour or two a week to preparation as course materials had already been created for each lecture and assignment.

Conclusion

While the improvement in student deliverables marks a certain success in CVEEN 3100 and may be attributed to many influences, the course's greatest achievements have come as a result of the interdisciplinary collaboration. The many hours of meeting, sharing ideas, honing assignments and lectures, and evaluating student work have wrought a course in which three equal pedagogical perspectives come together in the classroom to forge new ground. The work of the instructors has created several written, oral and teamwork assignments that record the students' apprehension of specific ASCE BOK learning outcomes. The working agreement displays their understanding of teamwork dynamics and leadership roles, the proposal conveys their understanding of professional communications and varied audiences, research projects record their knowledge of the local and global impact of specific engineering practices, which in turn reveals an awareness of engineering ethics. While another course may require the same assignments, the instructional team of CVEEN 3100 and the administrators of the CLEAR program believe that the interaction of the teaching team in the classroom opens an interdisciplinary space that reflects the interdisciplinarity of the ASCE BOK. In terms of faculty development and lifelong learning for the faculty, the instructional team provides a ground for critique and collaboration that would be hard to parallel.

Summarizing the salient points of the CVEEN 3100 collaboration in its first four semesters, Appendix A provides an overview of its original goals, dynamics, and results juxtaposed with the revised goals, dynamics and results of its more recent semesters. Each semester has witnessed a greater degree of student achievement, documented in sample final reports and presentations. These reports and presentations reflect clearer written articulation in report sections, more logical content organization, more sophisticated graphic presentation of report formats, and more confident and comprehensive presenting skills. While this success is at least partially due to the increased ability of incoming students, having received specialized instruction in the freshman course co-taught by CLEAR consultants, the ability of the students to produce representative, industry-standard documents remains a great achievement. This success is felt in the capstone Professional Practice and Design course, as students enter already familiar with the document and presentation models they are expected to create in a higher-level, real-world project.

Teaching the complex ASCE BOK curriculum presents every Department of Civil Engineering with a complicated instructional challenge. The CLEAR program has helped the CVEEN department at the University of Utah to incorporate experienced Writing, Oral and Teamwork Communication instructors into the traditional engineering classroom in order to achieve the professional communication objectives presented by ASCE in its report on the BOK. Enhancing the communication instruction throughout the four year undergraduate program has allowed this department to develop graduates more able to function in industry, with greater confidence and ability recognized by their employers. We hope that sharing our experience will provide the Engineering Education community at large with an alternative to traditional teaching configurations and enhance programs across the entire academy.

Notes

1. Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice, "Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future." American Society of Civil Engineers, Jan. 2004.
2. While the terms "multi-disciplinary" and "interdisciplinary" are similar and often used interchangeably, this paper takes Joe Moran's model in his book *Interdisciplinarity*, which discusses multi-disciplinarity as referring to "the simple juxtaposition of two or more disciplines as one finds...individual courses that are team-taught by members of staff from different disciplines" and interdisciplinarity as "always transformative in some way producing new forms of knowledge in its engagement with discrete disciplines." Moran, Joe. *Interdisciplinarity: the New Critical Idiom*, New York: Routledge, 2002.
3. Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice, 2004.
4. Pappas, E.C. and Hendricks, R.W. "Holistic grading in science and engineering," *Journal of Engineering Education*, vol. 89, pp. 403-408, Oct. 2000.
5. Miller, R., Olds, B. "A Model Curriculum for a Capstone Course in Multidisciplinary Engineering Design." *Journal of Engineering Education*, October, 1994, pp. 1-6.
6. Hodges, Colley, Wilmot, Cari-Sue, Askew, Robert, and Bannerot, Richard. "Teaching Technical Communications in an Introductory Design Course through Interventions from the University's Writing Center." *ASEE Frontiers in Education Conference Proceedings*, 2004.
7. Barrett, Edward and Waitz, Ian. "Integrated Teaching of Experimental and Communication Skills to Undergraduate Aerospace Engineering Students." *ASEE Frontiers in Education Conference Proceedings*, 1996.
8. Poe, Mya, and Freeman, Dennis. "Integrating Technical Writing into a Large Lecture Course." *ASEE Frontiers in Education Conference Proceedings*, 2004.
9. Powe, Alexis and Moorhead, Jane. "Grading Lab Reports Effectively: Using Rubrics Developed Collaboratively by Ece and Technical Writing Instructors." *ASEE Frontiers in Education Conference Proceedings*, 2006.
10. Virginia Polytechnic Institute and State University Department of Mechanical Engineering, "Michael Alley," Virginia Polytechnic Institute and State University, <http://www.me.vt.edu/people/faculty/alley.html> (accessed March 2, 2007).
11. Georgia Institute of Technology School of Electrical and Computer Engineering, "Faculty Profile: Christina Bourgeois," Georgia Institute of Technology, http://www.ece.gatech.edu/faculty/fac_profiles/bio.php?empno=504860 (accessed March 2, 2007).
12. Poe, Mya, and Freeman, Dennis, 2004.
13. Pinkus, Rebecca , and Simmons, Craig. "Professional Writing Seminar for Engineering Students: A Pilot Project and Evaluation." *ASEE Frontiers in Education Conference Proceedings*, 2000.

Appendix A

CVEEN 3100 Progressive Course Dynamics

Who:	One English PhD Grad Student, One Communication PhD Grad Student, One Civil Engineering Research Professor	
When:	Mid-Program, Sophomores and Juniors	
Where:	A Required Core CVEEN Course	
Why:	Fulfills the advanced writing requirement and bridges the elementary skills taught in the Freshman Class and the advanced skills needed in the Capstone Course	
What:	See Below	
Initial Goals	Revised Goals	
To teach a relevant advanced writing course that would bridge form and content rather than attempt to impart "writing skills" separately from engineering skills	To teach a technical communication course that prepares and improves student's abilities to produce discipline specific work	
To design assignments that would resonate through the students' future curriculum and professional practice	To develop student proficiency in specific writing, presenting and teamwork deliverables that they will use in other disciplinary courses, specifically the Professional Practice and Design Capstone Course	
	To teach communication skills that progress from those skills taught in the Freshman level course	
To bring together teachers of writing, oral and teamwork communication, and professional engineering in order to enhance student learning	To enhance student learning by employing the varying pedagogy and perspectives of instructional experts in multiple disciplines on the same topics	
Initial Course Dynamics	New Course Dynamics	
Instructors met once every two weeks to coordinate schedule	Instructors meet twice a week to discuss lecture content	
Instructors planned syllabus and assignments together in planning sessions	Instructors offer feedback to each other on assignments, delivery of material and effectiveness of course elements	
Instructors lectured separately on predetermined topics	Instructors deliver lecture content together with one leading and others offering differing perspectives and additional ideas	
Writing assignments were graded by all three instructors	Each assignment is graded by one instructor only	
Presentations were graded by the oral communication instructor		
60 students produced one, course wide/long engineering report and presentation on a large team of 10-15 students that mainly included individual parts brought together in one presentation	30-40 students produce 2.5 team reports and 2 team presentations that are fully integrated, single documents	
60 students produced mainly individual work	Additional team process and sensitivity training is introduced to 5 student teams	
Original Results	Latest Results	
Instructors were encouraged by the synergy of the teaching team if disappointed by the level of student learning outcomes	Instructors were surprised at the amount of time that thorough collaboration takes and very happy with the level of student learning outcomes	
Students performed with average success	By the 4th semester, student performance surpassed the instructor's idea of what was possible	
Instructors were dissatisfied with the level of instructor collaboration in the classroom	Instructors have been surprised and elated at the amount they have learned from one another	

Numerous students complained of incongruity in the grading by various instructors	Instructors each spend nearly equal time evaluating and responding to assignments (the writing consultant spends more time than the others)
Students produced individual proposals that reflected an elementary understanding of a civil engineering proposal	Students enter the capstone course proficient at producing proposals, engineering reports and presentations
	Instructors have become hybrid as a result of being exposed to foreign pedagogies and material