INTEGRATING COMMUNICATIONS INTO TEAM-TAUGHT SENIOR DESIGN COURSES

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Abstract

Effective communication is universally recognized as one of the most important traits of an outstanding graduate. The Aerospace Engineering Department at Embry-Riddle Aeronautical University is team-teaching several courses with the Humanities and Communications Department faculty to better prepare the engineering graduate for effective technical communication. This collaboration began in the spring of 2003 with the laboratory for the Materials Science course and now exists in the senior capstone design courses.

For the Materials Science with Laboratory course, a supplemental COM course was offered in parallel to the lab in order to help students write and edit their lab reports. This served as an effective means to help the students turn in better reports and also helped the faculty learn how to collaborate between departments. An Engineering Style Manual was one of the early products of collaboration between the Aerospace Engineering and Humanities and Communications departments.

Due to the writing and presentation intensive nature of the senior capstone design sequences, the extension of this collaboration to the design courses was natural. While the students at first were hesitant to utilize the Communications faculty, they quickly realized that those faculty were a resource to help them write and present more effectively, and that their grade was improved as a result. As the team-teaching relationship has evolved, the quality of the students’ reports has also improved.

This paper discusses the evolution of the collaboration between the Aerospace Engineering and Humanities and Communications departments. The benefits and challenges associated with this cross-college team-teaching are discussed along with effective means of addressing the challenges. While this requires a significant investment in time, the improved communication skills of the student and the enhanced inter-departmental coordination are worthwhile and notable.
Introduction

The following sections describe the integration of humanities and communications (HU/COM) training into senior engineering design courses at Embry-Riddle Aeronautical University in Prescott, Arizona (ERAU/Prescott). This integration was accomplished through the introduction of linked and team-taught courses, with an HU/COM instructor added to the College of Engineering (COE) faculty who would typically teach the course. The HU/COM instructor provides students with additional guidance in technical writing, group presentations, and teamwork. The senior design courses were chosen for this project in order to provide students with supplemental HU/COM instruction just prior to their entering the workforce, thereby affording them timely training.

This paper begins by explaining the context that led to the introduction of linked and team-taught courses. The evolution of three such courses is described in detail, followed by a discussion of the successes and challenges encountered in developing revised course content. The paper concludes with a discussion of plans for future collaborative efforts between HU/COM and engineering faculty at ERAU/Prescott.

Context

ERAU/Prescott is a 4-year university in Northern Arizona with an enrollment of approximately 1,700 undergraduate students. The most popular engineering degree program is Aerospace Engineering (AE). Students majoring in AE take typical AE courses such as Engineering Materials Science with Laboratory, Solid Mechanics, Experimental Aerodynamics, Space Mechanics, Aerodynamics and Structures. There is a strong emphasis on laboratory and design work to prepare the students for the senior capstone design courses.

Students majoring in AE must choose one of two design tracks: aircraft or spacecraft. The aircraft track culminates in a sequence of two senior design courses: Aircraft Preliminary Design and Aircraft Detail Design. Likewise, the spacecraft track also has two senior design courses: Spacecraft Preliminary Design and Spacecraft Detail Design.

In each of the Preliminary Design courses, students work in teams to design a conceptual craft from the ground up. These craft may be designed in response to a set mission statement (e.g., in response to the yearly AIAA design competition) or according to the interests and objectives of the student teams and instructors. In the Detail Design courses, each team selects one component or set of subsystems from their craft—a wing, a tail, a satellite solar tracking system—and creates scaled models that they then subject to various tests, such as wind tunnel, vibration, and static structural tests. These design and test results are then presented by each team at a formal briefing at the end of the semester.

From this brief description, ERAU/Prescott’s pedagogical approach clearly embraces application of theory rather than theory alone. What is less obvious is that this approach also stresses documentation, from numerous lab reports in Engineering Materials Science with Laboratory to a series of design and test reports in the senior design courses, and effective presentation, negotiation, and teamwork, which students must master by the end of their senior design courses.
All AE students must take (and pass) a Technical Writing course and a Speech course as prerequisites for entry into engineering courses with significant report writing content. However, the AE faculty were concerned that students still required supplementary HU/COM instruction to hone these professional communication skills, in part due to the results from annual internal reviews in preparation for a program review by the Accreditation Board for Engineering and Technology (ABET). Alumni survey results also indicated that graduating engineering seniors were not satisfied with the HU/COM instruction they had received at ERAU. At this point, the AE faculty reached out to the HU/COM faculty. After a series of fruitful discussions and negotiations, the faculty from both departments agreed that they would pursue an instructional strategy that was, at the time, quite new for ERAU: collaborative teaching.

Collaborative teaching refers to both linked teaching and team-teaching. In linked teaching, an instructor from a math, writing, ethics, or other general education discipline links the content of their course to that of another course so as to provide a synergistic outcome. Thus, a math instructor might link their course to a space physics course, introducing or reinforcing the mathematical notions that are used in space physics, and using space physics examples to contextualize the math problems.

In team-teaching (at least as now practiced at ERAU/Prescott), a general education instructor and a science or engineering instructor cooperate in the planning and delivery of a single course, sharing the class responsibilities more or less equally. Thus, a math instructor might attend every class meeting of a space physics course, “guest teach” the first twenty minutes of the class, introduce the math concepts that the space physics instructor will use later in her own lecture, and then help to answer questions and grade homework.

In ERAU’s case, three AE faculty (Prof. Jim Helbling, Dr. David Lanning, and Dr. Ron Madler) chose to collaborate with two HU/COM instructors (Dr. Angela Beck and Dr. Patric McElwain). Such inclusion of communication instructors can demonstrably benefit students’ communication skills in at least four ways. First, the communication instructor can provide supplementary instruction in skills and strategies that are immediately contextualized; thus, “rules of grammar” or “rules of negotiation” are no longer theoretical and vague but rather readily applicable and more easily grasped. Second, the communication instructor can provide the rhetorical tools that allow students to master the genres specific to their discipline (e.g., lab reports, design proposals), genres that engineering instructors have mastered but may have difficulty articulating.

Third, both instructors may draw upon the expertise of their counterparts to import materials and pedagogical methods that enrich the course; thus the instructors may co-construct models that have both proper mechanics and formatting and proper disciplinary content and organization. Fourth, by attending every class meeting, the HU/COM instructor serves as a “built-in” tutor, thus students can comfortably approach the communication instructor for feedback and revision guidance.

Additionally, the faculty from both AE and HU/COM Departments profit from close daily collaboration. Examples of benefits to faculty include developing an awareness of course...
material outside of one’s expertise, gaining insight from diverse viewpoints, providing outside support for department internal review, and engaging in interdisciplinary scholarly activities such as interdisciplinary research. These benefits also include more intangible notions such as fostering community across department boundaries and appreciating each other’s contributions to student education.

With these benefits in mind, the AE and HU/COM faculty chose to pursue collaborative teaching in three phases. First, as a test case a new writing course was developed and linked to an existing Engineering Materials Science with Laboratory course. Second, an HU/COM faculty member was invited to team teach one of the senior design courses, Aircraft Detail Design, and to thus provide both written and oral communication instruction on a supplementary basis. Third, a similar team-taught course was developed for the spacecraft track as an HU/COM faculty member joined the Spacecraft Preliminary Design faculty. The development of each of these three courses will be described in further detail in the following sections.

**Historical Process**

**Engineering Materials Laboratory**

Engineering Materials Science with Laboratory was the first course chosen for introducing collaborative teaching practices as ERAU/Prescott. Engineering Materials Science with Laboratory is a required 3-credit hour course typically taken by AE students during their junior or senior year. In this course, students undertake studies on physical and mechanical properties, mechanical testing, and processing of typical engineering materials. Chemistry, Solid Mechanics, and Technical Report Writing classes are all prerequisites.

Accompanying the 3 hour-long lectures each week is a 3-hour weekly laboratory, conducted in the Aerospace Engineering laboratory facilities, that allows hands-on laboratory experiences for each student. Integral to the work is a minimum of 3 formal lab reports based on in-class experimental work. These reports are required submittals during the semester, along with several informal lab write-ups. Course guidelines specify that reports must follow a traditional format that includes an Abstract, Table of Contents, Introduction, Theory, Apparatus and Procedures, Results and Discussion, and Conclusion and Recommendations sections.

While students either work individually or in small groups while performing the in-class experiments, all written lab reports are required to be individual work. In fact, Engineering Materials Science with Laboratory is notable in that it is the only junior or senior course that requires each student to complete several individually written reports, and may therefore be one of the last chances in the curriculum to improve each student’s writing ability before graduation. Thus, collaborative teaching of the laboratory portion of this course, in the form of an optional 1-credit hour linked course taught by an HU/COM faculty, was introduced.

The semester that the linked course was introduced, Dr. David Lanning was the COE instructor for Engineering Materials Science with Laboratory; Dr. Angela Beck was the HU/COM instructor invited to teach the linked course. The linked course was designed so that one aspect of lab report writing was reviewed in detail each week. For example, one week Dr. Beck might lecture on framing a hypothesis using disciplinary-specific language in the Introduction section,
and the next week she might lecture on providing sufficient contextual support in the Theory section. Students would study models of the section under question, listing pertinent organizational, format, language, and grammar elements, and then would use these lists to guide their own writing.

The course was also designed so that Dr. Beck would read multiple drafts of each student’s lab report, providing revision suggestions and proofreading comments (5 reports, each approximately 20 pages in length). Thus, students gained multiple opportunities to successfully revise their lab reports before submitting them to Dr. Lanning for a grade.

The first semester that the linked writing course was offered, roughly half of the students enrolled in Engineering Materials Science with Laboratory also enrolled in the linked course (approximately 8 students). The response to the course was positive, and the linked writing course was offered again the next semester, with increased enrollment. The success of this collaborative course was due in great part to the regular communication between Dr. Lanning and Dr. Beck; they met weekly to discuss student needs, to share model reports, and to ensure that the content of the linked course served the content of the engineering course. As a test of collaborative teaching practices at ERAU/Prescott, the linked course was a success. ERAU was now ready to attempt collaborative teaching in the form of team-teaching in the senior design courses.

**Aircraft Detail Design**

As previously mentioned, the senior design courses are required 3-credit courses, taken in the senior year, that allow students, in teams of approximately 6 members, to design an aircraft or spacecraft and then test one component or set of subsystems. Extensive written reports and formal oral presentations are required in each course.

Team-teaching was first introduced into a senior design course in the Spring 2003 semester, when Dr. Beck joined Dr. Lanning in teaching the Aircraft Detail Design course. Dr. Beck’s participation was set at 1-credit hour for this 3-credit hour course. During this initial attempt at team-teaching, Dr. Beck’s role was more of a communications consultant who proofread written submittals and critiqued oral presentation skills, much as she had done in the linked course. While this was a useful beginning to the process, the engineering students did not fully appreciate the opportunity to improve their HU/COM skills.

In the Fall 2004 semester, Professor Jim Helbling rotated in as the engineering instructor for the course, and opted to continue team-teaching with Dr. Beck. Dr. Beck’s role was expanded slightly during this second semester as she provided lectures to students on proper technical writing style and the expected content of written submittals. She also scored the students on their oral presentation abilities, thereby accounting for 50 percent of their individual presentation scores. However, because these scores comprised only a small percentage of the students’ overall grade, both she and Prof. Helbling felt she needed to have additional grading responsibility in order to gain additional influence over the students’ learning.
Therefore, in the Spring 2004 semester, Dr. Beck took responsibility for 30 percent of the students’ technical writing scores for the course. All writing submittals were first graded by her on a 3-point scale for proper writing style and format, and subsequently scored by Prof. Helbling on a 7-point scale for technical content. Dr. Beck continued to proofread writing assignments prior to their submittal, and also continued to assist in scoring individual presentation skills. (At this point there were 4 teams, with approximately 30 formal submittals per team, with the final report ranging from 60 to 100 pages in length.)

However, in response to suggestions from students who had previously taken the course, she took on a more active role in promoting team interaction skills and providing guidance for increased proficiency in the presentation of technical information. She also required students to submit in-class writing assignments to her via email, which accounted for 5 percent of the students’ overall grade for the course.

Due to the positive feedback received from students during the spring semester, few changes were implemented in Fall 2004. One minor change was to reverse the order of lectures given such that Prof. Helbling would lecture last on days when both HU/COM and technical content were presented during the same class period. This change was introduced in response to student comments indicating that it was difficult to “switch gears” back to a technical discussion within the teams following the HU/COM lecture. Dr. Beck also expanded her lectures on improving team-interaction skills, which has always been a problematic issue within the design teams.

Based upon the improved quality of student written work, positive feedback on student course evaluations, and positive comments from ABET, team-teaching continues to be practiced in the aircraft design track; furthermore, it has been expanded into the spacecraft design track, as discussed in the following section.

**Spacecraft Preliminary Design**

Dr. Beck also worked with another engineering instructor, Dr. Ron Madler, in Spacecraft Preliminary Design, and experienced a similar transition in that course as she did in Aircraft Detail Design. A second HU/COM instructor, Dr. Patric McElwain, replaced her in Spacecraft Preliminary Design in fall of 2005, while Dr. Beck maintained her already established presence in Aircraft Detail Design.

Following negotiations with Dr. Madler, Dr. McElwain’s participation was set at 1-credit hour of a 3-credit hour course. Further, much like Dr. Beck, Dr. McElwain’s duties included reviewing drafts of individual and team documents outside of class as requested by the students before submission, and grading the individual and team documents for format, style, and grammar. (The final team documents each exceeded 100 pages.) He was also responsible for evaluating student oral briefings following a scoring instrument previously created by Dr. Beck (three team briefings in all, including a final formal briefing.

The 18 students in the course (6 students divided into 3 teams), about half of whom Dr. McElwain had previously in other classes, such as Technical Writing or Values and Ethics, responded positively to his presence and indicated, at the end of the semester as well as during it,
that having an HU/COM instructor available to help them with their written and oral work enabled them to produce work that was stylistically clearer, grammatically correct, and more professionally formatted.

**Successes**

Although a quantitative assessment of the success of the team-teaching arrangement is difficult at this time due to a lack of data, a qualitative appraisal is possible based upon student course evaluations and feedback received from a recent audit performed by ABET.

The percentage of positive student comments has increased steadily every semester since team-teaching was introduced in Spring 2003. Overall, students greatly appreciate having a faculty member dedicated to improving their HU/COM skills and understand the impact of those skills on their performance as an engineer. There have been many positive comments on the HU/COM instructors’ willingness to provide almost immediate feedback on written assignments, and on how incorporating that feedback into report sections throughout the semester makes the final compilation of design reports much less difficult and stressful.

The ABET auditors were impressed with the COE’s strategy in addressing a perceived weakness in HU/COM skills as documented in recent alumni surveys. The ABET criteria require engineering programs to show that graduating students have HU/COM experience and have demonstrated the use of that experience to enhance the technical content of their curriculum. Bringing communications faculty into the senior design experience certainly helps to fill that requirement, and the auditors whole-heartedly endorsed the process.

Ideally, alumni surveys would be re-evaluated to determine whether the team-teaching policy had, indeed, addressed the perceived weakness in HU/COM skills that led to the initial development of the program. However, because the team-teaching arrangement is still in its relative infancy, there are an insufficient number of graduates who have been exposed to the new curriculum. A follow-up survey is currently being planned which will provide a more direct indication as to the success of the program.

**Challenges**

Although ultimately rewarding, team-teaching is a challenging endeavor as it requires substantial changes in the classroom culture. Some of the challenges experienced at ERAU/Prescott have included the following:

1. Instructor roles in each team-taught class needed to be clearly articulated through negotiation (and re-negotiation) each semester;

2. Students were uncertain how to respond to the presence of an HU/COM instructor in an engineering classroom during the first semester;

3. The HU/COM instructor lacked authority in the engineering classroom during the first semester;
4. The work loads (teaching credits) for the team-taught courses were unevenly distributed between the instructors.

These challenges have been successfully met due in great part to extended, frank discussions between the team-teaching instructors.

The first challenge in particular, the articulation of the HU/COM instructor’s role, required extensive negotiations. Before the beginning of each semester the participating instructors met several times to discuss the role that the HU/COM instructor would assume in the engineering class. A lack of clearly defined roles could have led to both student confusion and misuse or under-use of the HU/COM instructor’s services. During these discussions, questions such as the following were posed:

1. What learning outcomes would the HU/COM instructor target?
2. Would the HU/COM instructor be considered a full instructor in the class? Or would she be seen as an in-class tutor?
3. Would the HU/COM instructor provide formal lectures? If so, what would the content of the lectures be? Would she lecture each class meeting? Every other class meeting? And how long would these lectures last?
4. Would the HU/COM instructor read and provide feedback on first drafts of student work? On final, graded drafts?
5. How frequently would the HU/COM instructor attend the senior design course? Every class meeting? Once a week? Would she stay for the entire class meeting, i.e., approximately 2 hours? Or would she only stay for the first hour?
6. During open work time, would the HU/COM instructor invite students to approach her with questions on their writing, revision, and oral presentations?
7. Would the HU/COM instructor be required to attend the mid-semester and final project briefings? If so, what type of feedback on the briefings would she provide?
8. Would the HU/COM instructor provide any course documentation, i.e., posted lecture notes, grading rubrics, course contracts?

By investing time to discuss these questions as thoroughly as possible, instructor roles were clearly articulated before the semester began.

Nevertheless, because team-teaching between the COE and HU/COM had not been attempted at ERAU/Prescott, during the first semester of this venture the students were uncertain how to respond to the HU/COM instructor. Some ignored her invitations to submit rough drafts for review; others submitted multiple drafts throughout the semester. Some ignored her feedback on
their presentation skills; others scheduled private practice sessions with her before their briefings. The goal was for all students to take advantage of the HU/COM instructor’s services, and thus for all students to improve their HU/COM skills before graduation. Unfortunately, this was not occurring.

After discussion the instructors determined part of the problem to be that the HU/COM instructor had no authority to assign grades for student work. Because she would not grade their documents or oral presentations, some students did not feel it necessary to seek her guidance. The solution to this challenge was to alter the HU/COM instructor’s role, granting her the authority to assign 30 percent of the grade for every draft and for every final document. Her grade would assess the students’ organization, formatting, word choices, grammar, and mechanics; the engineering instructor’s grade would assess the students’ technical content and accuracy. This change to the grading process was clearly stated in the course syllabi in all successive semesters, and students were provided with rubrics that clearly articulated all grading criteria. Since these changes were made, students have made much more effective use of the HU/COM instructor’s services in the senior design courses, affording them more opportunities to improve their technical writing skills before they enter the workforce.

A final challenge that team-teaching has presented at ERAU/Prescott is the division of teaching credits between instructors. Unfortunately, because the HU/COM instructors are supplementing the engineering instructors, the HU/COM instructors have typically only been granted 1 or 2 teaching units (i.e., half credit or less), while the engineering instructor is granted 3 or 4 teaching units (i.e., full credit). Because HU/COM instructors usually attend every class period and stay for most if not all of every class, and because they spend countless hours each week reviewing student papers in these writing-intensive senior design courses, it has been argued that they should be awarded full credit along with their engineering counterparts.

This challenge is ongoing, and is a common hurdle in team-teaching. Overcoming this challenge will again require negotiation with academic administration: the affected Deans and Department Chairs. Happily, the academic administration—especially the involved Department Chairs, who are responsible for scheduling—at ERAU/Prescott supports this team-teaching venture.

**Future Collaboration**

Future collaborations between the COE and the HU/COM Department are planned. In addition to continuing team-teaching in Aircraft Detail Design and Spacecraft Preliminary Design, as well as offering the course linked to the Engineering Materials Science with Laboratory, the HU/COM Department plans on expanding its presence in other engineering courses based on the needs of the COE.

In addition, with the success of the team-teaching experience with the COE, the HU/COM Department has initiated team-teaching in other colleges and departments, creating team-taught courses such as Senior Thesis and Values and Ethics. Both the COE and the HU/COM Department are pleased with the outcomes their collaborations have accomplished to date and are confident that future collaborations will yield further successes.
References


Biography

ANGELA BECK, Ph.D.
Currently an Assistant Professor in the Dept. of Humanities/Communications and the General Education coordinator for the College of Arts and Sciences at ERAU/Prescott. Her research interests include the development of teaching strategies (such as collaborative teaching) that help students move from novice to expert writers in their chosen disciplines.

JAMES F. HELBLING, M.S.A.E.
Currently an Assistant Professor of Aerospace Engineering at ERAU/Prescott where he teaches structural analysis, computer aided design, and aircraft detail design courses. He has 21 years of industry experience with McDonnell Douglas (now Boeing) and Northrop Grumman Corporation where he specialized in structural fatigue loading and served as manager of F-5/T-38 Engineering.

DAVID B. LANNING, Ph.D.
Currently an Assistant Professor of Aerospace Engineering at ERAU/Prescott where he teaches courses in structural analysis and engineering materials. He spent several years in fatigue and fracture research at the Air Force Institute of Technology and has until recently worked on the Air Force High Cycle Fatigue Program.

RONALD A. MADLER, Ph.D.
Currently the Department Chair for the Aerospace Engineering Department. Additionally, he teaches courses in the spacecraft design sequence including the Spacecraft Preliminary Design course. His background is in engineering education, astrodynamics and space debris.
PATRIC McELWAIN, Ph.D.
Currently teaches technical communication, film, science fiction, and ethics at ERAU/Prescott. He is Chair of the Humanities and Communications Department, and his research interests include film studies, Anglo-American science fiction, and cultural studies. He believes that everything one needs to know about life can be gleaned from the television series *Buffy the Vampire Slayer.*