

# English Teachers and Engineers: A New Learning Community\*

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*Humanities faculty are finding that they have much to contribute to the revitalization of the undergraduate engineering curriculum. Many courses in the English department have long employed methodologies such as small group discussion, peer writing workshops, and audience analysis that become lifelong skills. Now that the call to innovation in an ever more demanding engineering curriculum has sounded the need for lifelong learning skills and for training in group dynamics and communications, Humanities/English and Engineering faculty have shared goals and methodologies in innovative ways. In particular, integrated programs at Arizona State University, Texas A&M, and Drexel University have explored the problems in adapting to a change from traditional curricula, have found solutions that benefit faculty and students, and are continuing to search for solutions that may encourage others to join a unique learning community. Because existing paradigms do not prepare students for a workplace which is multicultural and demands interdisciplinary teamwork and collaboration, a workplace which is itself a community of diverse workers and learners, new ways of structuring and delivering these courses must be developed.*

## INTRODUCTION

IN THE 1994 report *Engineering Education for a Changing World*, a prestigious group from industry and academia affirms the recommendations originally made in *A National Action Agenda for Engineering Education* and adds that 'colleges must educate their students to work as part of teams, communicate well, and understand the economic, social, environmental and international context of their professional activities. These changes are vital to the nation's industrial strength and to the ability of engineers to serve as technology and policy decision makers [1]'. This change in educating the new engineer in some ways inverts the traditional curriculum. The new curriculum provides a broad base for engineering in the first two years with specialized courses in the upper division. The fundamentals of engineering are presented 'up-front' and integrated with science, humanities and mathematics; when higher-level sciences and mathematics are presented later, they are tied to professional engineering interests. The founding principles respond directly to the recommendations made in *A National Action Agenda for Engineering Education* [1].

In response to the need for these changes in engineering education, six national coalitions funded by the National Science Foundation

(NSF) have been formed. Although all of the institutions in each coalition are working to improve engineering education, three institutions are integrating English and Humanities into their freshman year curricula along with math, science and engineering: Drexel University, in the Gateway Coalition ('Enhanced Educational Experience for Engineers' or E4); Texas A and Arizona State University, in the Foundation Coalition ('Freshman Integrated Program in Engineering' or FIPE). This integration reflects a new paradigm in academia, a paradigm in which participants co-operate in a community whose goal is continuous improvement and mutual support rather than competition for limited resources and disciplinary separatism. The role of English and Humanities faculty within this community is critical to the success of its interdisciplinary focus and a challenge to existing paradigms which reinforce the separatism. This interdisciplinary co-operation among faculty and institutions has reaffirmed that learning communities create supportive and productive environments in which students and faculty respect each other and value each other's contribution as crucial to the goal of an integrated and holistic education for engineering students.

Under the old paradigm, many first-year composition students find that English proves to be their most difficult course. Sometimes these students find English difficult because they have had poor high school preparation. Sometimes,

\* Accepted 1 September 1996.

however, their difficulty stems from the negative attitudes they have toward Freshman Composition because they see the course as remote and separate from their fields of study. English is something they have to endure rather than something they enjoy.

In the traditional first course in English at many universities, students typically analyze, compare and contrast, define, classify, or trace causes and effects in papers that respond to texts from Literature and various other disciplines. In the second English course, students learn to do library research, summarize and paraphrase source material, document sources, critique arguments and other source material, combine source material into synthesis essays, and develop a position paper based on research. Classwork can include a variety of group activities from brainstorming to revision and peer editing, as well as class discussions of material and lectures. While many teachers may use some group work, most typically do not use collaborative learning strategies. Usually classes are limited to 25, with one teacher responsible for planning and delivering material, facilitating group work and discussions, grading, and conferencing. Neither the class nor the teacher has any formal interaction with other English classes or classes in other disciplines. Although the class may become a community of writers, as writers the students are not connected to any larger community.

Because these students are disconnected from the world outside of the English classroom, they often feel that English 101 and 102 are enormous burdens to be borne with gritted teeth and varying degrees of impatience. Consequently, the teacher can waste a good deal of time winning over reluctant students in the beginning of the semester only to repeat this process after returning the first graded paper. At the end of the semester the teacher may still be addressing students' complaints that he or she has been overly picky about such unimportant issues as grammar, spelling or unclear sentences, issues which, they contend, do not affect their grades in other classes.

While English is crucial for a student's survival within the university and later as a professional, freshman students in a traditional classroom simply cannot see its relevance. They believe that their writing is less important than their ideas because, outside of English, writing is often not emphasized as a fundamental tool for expressing ideas clearly. Students do not think writing will be important after they graduate because they are not exposed to the value placed on writing in their majors or in the workplace. As one student put it, 'I'm going to be an engineer. I don't need to know how to spell. Besides, I'll always have a secretary'. While English and Humanities teachers can justifiably argue that the subjects their students read, think, and write about are valuable in themselves, they are hard put to convince their students of this fact.

Not only are freshman students unconvinced about the value of writing for academic and professional survival, they are also unprepared for discipline-specific academic writing. While the goals of Freshman English are to train students to think and write analytically in general (which is problematic in the traditional one-semester, isolated classroom paradigm) thus preparing them to handle diverse assignments in other courses, students do not learn to write the kinds of papers that are required in other classes, for example lab reports, reviews of literature, or team reports. Although these kinds of writing also require skills such as research, summary, synthesis, serialization and analysis, they are not considered traditional assignments for Freshman English. In fact, because composition classes are isolated from other departments on campus, teachers often do not know to what extent students are being exposed to relevant current issues or arts and humanities and feel that the mission of the English teacher is to provide this exposure.

Teachers also suffer from this isolation. In addition to not knowing what students are learning in other classes, teachers also lose out on the intellectual stimulation and mutual support of colleagues in other disciplines. The satisfaction and sense of purpose that come from working together with other faculty to provide an integrated educational experience for students cannot be found in the isolated one-teacher classroom. This kind of interaction encourages teachers to try new things and to modify them and try them again, to grow intellectually and to gain perspective about their attempts from other teachers. Even when they seek out other faculty in their own department, teachers in the traditional composition classroom have a more difficult time assessing their own effectiveness and achieving the kind of dialogue that characterizes good teamwork.

The time-frame of the traditional one-semester course also poses some disadvantages. For example, even though composition classes are small, creating a mutually supportive atmosphere in which students bond with each other and with their teacher is difficult in one semester. In one semester students can learn to work fairly well with each other, but in a two-semester program students have time to build the trust that allows diverse personalities to become a community of writers who depend on each other for intellectual, emotional and academic support. In addition, the teacher does not really know students' strengths and weaknesses well until the semester is almost over. Any follow up and reinforcement of skills is impossible. Consequently, students must repeat the process of getting to know each other and a new teacher the next semester, again using time and energy that could be better spent reviewing writing skills which need more work.

The traditional program does, however, allow students more flexibility because they are not limited to registering for the classes offered by

the integrated curriculum, and they can drop and add one class without jeopardizing their other classes. In addition, some students prefer not to take all of their classes with the same classmates for an entire year. Some want to meet diverse groups of students and have diverse classroom experiences. However, we believe that integrating Freshman English with other classes offers more benefits than drawbacks.

Drexel University, Texas A&M, and Arizona State University have responded to both the need for a revised undergraduate curriculum in engineering and these problems in Freshman Composition. Texas A&M and Arizona State University are currently running their pilot programs. Drexel's program, begun in 1989, is being expanded in the Gateway Coalition to instigate systemic change in the upper division as well. The Coalition's goals include encouraging lifelong learning, diversity in the student body, and continuous improvement in the faculty as well as the students.

### SPECIFIC CURRICULUM PROGRAMS

#### *Drexel's program: Humanities in the Integrated Engineering curriculum*

At Drexel University, design techniques are incorporated throughout the entire curriculum to emphasize that engineering is the intellectual centerpiece and freshmen do a major design project that involves credit in Engineering and Humanities classes [2, 3]. As of 1994-95, the entire class of approximately 500 freshmen were enrolled in the program with unanimous approval of the College of Engineering. All freshmen are grouped in cohorts of one hundred each for lectures and recitations of twenty-five each that remain as units for the entire year. Study groups and design groups are easily formed from the recitations, and these groups bond with surprising strength. The Humanities course synthesizes the design experience with classes on creativity, group dynamics, and communications skills, as well as literature.

Humanities faculty teach as a team, combining backgrounds in literature, rhetoric and technical communications. This team structure responds to the need for a multiplicity of tasks, not all within the range of the teacher usually responsible for the one-term freshman Humanities course. Sharing our talents allows us to take advantage of each other's expertise and to learn from one another. Moreover, because we tell the students that we are experts in some fields and learners like them in others, we model the value of lifelong learning, the willingness to take risks to encourage creativity and the need for continuous improvement.

The syllabus for the entire year is developed over the summer by the Humanities team who choose texts and assignments as a group. Readings include a novel, poetry, short stories, essays, and a play which the students must see in production.

Assignments include papers co-ordinated with Chemistry, Biology, and Engineering Design. In addition, journal entries are required three times a week for the entire year; they cover responses to readings and reflections on being an engineer, and form the basis for a paper in early Spring on how the students perceive their development. Recognizing the visual learning style of many engineering students, the syllabus also includes a unit on seeing through graphics and film, and a trip to the Philadelphia Museum of Art. When the syllabus is designed, each teacher uses his or her expertise to suggest texts and write assignments. These are discussed by the group and changes are made so that everyone feels comfortable with their ability to learn and teach new material. When the group reaches consensus, they add the topic to the syllabus; they consider both faculty and student evaluations when determining whether to reuse previous topics. Faculty teaching the syllabus must have time to develop it together; each must feel a sense of ownership to achieve the consensus necessary. Professors for the other courses must also be consulted about changes that may affect their calendar or choice of assignments.

To accomplish this degree of interaction and integration, Humanities faculty meet for an hour each week during the academic year; the team leader also meets with leaders of all the other courses taken by the freshmen engineering students at weekly staff meetings that include student representatives actively involved in critiquing the program. At the Humanities meeting, the faculty meet to brainstorm ideas for classroom activities, to review our progress on the syllabus, to grade group projects when they involve students from more than one teacher's class, and to discuss problems.

Each teacher on the team has an idiosyncratic approach that is valued and accommodated within the constraints of the assigned texts and agreed upon work. As an example, everyone read Jonathan Swift's *A Modest Proposal*, but each teacher used the essay in a different way. A one-hour common lecture to each cohort of 100 (five cohorts for the five hundred freshmen) introduced the technical writing that would be necessary for the engineering design project. The Engineering faculty co-ordinated the timetable for the project with Humanities faculty in order to have the students learn how to write the abstract, proposal, and final report and to have time to draft and revise this work in Humanities classes. For the two-hour recitation, students were asked to read and be prepared to discuss *A Modest Proposal*. Just as the small-group discussion is meant to foster the individuality of the student, it elicits the individuality of faculty, evidenced by the various ways in which the discussions began. In one class, the teacher introduced the essay as a model for a technical proposal and compared the parts a proposal should have to Swift's essay. In a second class, the teacher began with a detailed look

at the rhetorical structure of the essay as a model of clear, precise, and persuasive prose, a necessity for a winning technical proposal. In a third class, the teacher put the essay in a social context and discussed the use of language as a political tool with comparisons to Nazi propaganda. In a fourth class, the teacher put the essay in an historical context and tied it to a required library research assignment. Obviously students had a variety of experiences and could extrapolate the others. They started thinking about the importance of communication in relation to design and they all used class time to generate and refine ideas for design projects that included an ethical dimension.

This cultural shift from the teachers' autonomy to their interdependence is not easy to achieve, but teachers who have participated as members of the team find the sense of community rewarding and the whole experience enlarging as they enjoy sharing what they know and learning what the others know. Team members volunteer to attend each other's lectures to provide a diversity of viewpoints in class and come to each other's aid as a matter of course; jobs are often done before the team leader can ask for volunteers to do them.

When the interdependence within the Humanities course and within the engineering program is recognized as a challenge rather than a burden, the relationship yields surprising results. One of the most surprising is the poetry assignment tied to an engineering project. For the engineering lab, each student must produce a one-page fact sheet explaining with text and graphics how some technical device works. When a poet on the Humanities team and an engineer who loved poetry were talking informally, the idea emerged that students should write a poem about their device as part of the How it Works Project. Humanities faculty developed easy guidelines for writing poems and related the idea to developing creativity by expanding ways of looking at something. Because the engineer considered writing poetry important, and because he also wanted students to develop their ability in public speaking, all students had to read their poem in a lecture; for each cohort, one lecture period from Humanities and one from Engineering Lab was devoted to the poetry reading. Students wrote different types of poems, anatomies, analogies, and personifications, even creating visual image poems of their devices, all of which they read with great pride in their accomplishments. The poem is now a required part of the How it Works Project.

The Humanities course is also linked to the Chemistry and Biology components of the first year. In Chemistry, a required research paper became part of the curriculum because the Humanities course could provide instruction on the research process, while the Chemistry professors reinforce the value of research in their lecture and in a Humanities lecture. Students are asked to write a research paper on a chemical topic of their choosing. The first step is for students to

submit a one-paragraph summary of the topic to the Chemistry professor. For 90% of the students, this summary is approved without change, but students with topics too broad or too diffuse to treat in a five-page paper are asked to redefine their topic. The first draft of the paper is peer-reviewed in Humanities classes, after students have been taught how to prepare a research paper and synthesize sources. The Chemistry professors grade the final draft for content and style. Interestingly, for their research students often choose ethical questions that reflect some of the reading they have done in Humanities. The results have been so positive that the biology component has adopted a similar type of combined assignment.

For Biology, the assignment has been related to a Humanities requirement for reading nonfiction. Students have read essays by Lewis Thomas or Stephen J. Gould, for example, and have had discussions in lectures that included three biologists arguing with one another. The paper assignment is drafted and reviewed in Humanities and graded in Biology. Students have been amazed to discover that science is based on argumentation and evidence, with communication skills influencing 'hard fact'.

#### *Texas A&M's p333rogram*

The Foundation Coalition's experiment in integrated curriculum at Texas A&M University in its first year involved 100 students with faculty from engineering, math, physics, chemistry, and English. From the 1995-96 academic year, the 100-student pilot moved into the sophomore year, and the freshman program expanded to include 240 students. One of the clearest goals of the program has been to meet the demand of leaders in education, government, and industry for more effective instruction in communication. By increasing opportunities for practice in a curricular setting where writing and speaking were understood to be integral to successful performance in science and engineering, we hoped student motivation and ultimately student performance would improve.

The first challenge was to convert the regular English courses into an integrated format that spread writing instruction over two years. In the traditional curriculum at A&M, engineering majors take three hours in Freshman Composition (English 104, which stresses the reading-writing connection and focuses on nonfiction prose and research writing) and three hours in sophomore speech or writing (usually English 210, an introduction to scientific and technical communication). They may also take a course in writing about literature (English 203) to fulfill part of the humanities requirement in the university's core curriculum. In the integrated program, we decided to give four hours of English credit in the first year (two each semester) and two hours in the second year (one each semester). By the end of the two years, we planned to convert everything in the traditional composition class and the traditional

technical writing class, but instruction in technical writing would begin in the freshman year. In addition, students who came to the program having already received credit for freshman English (through Advanced Placement testing or transfer credit) could take an alternative track that gave them credit in English 203 instead of English 104.

Consequently, we ended up with a two-track freshman program, one with more of a literature component than the other, though both including intensive instruction in writing complemented with a wide range of readings, and both tapering into technical communication by the end of the first year. The readings in the straight composition track came from a textbook of essays on science and technology. In the literature-composition track, we added readings in science fiction (from the *Norton Book of Science Fiction*).

The writing assignments in the first semester of both tracks included essays based on readings, lab reports, and essays from the integrated portions of their regular tests. On one test, for example, the students were asked to calculate the angle needed to maximize the jump distance from an amusement park's skate board ramp. Part of the problem was to compose a memo outlining safety considerations in the design. On another test, the students were given a short reading on the difficulties involved in interpreting models of global climate change. The writing prompt was as follows:

You are an environmental engineer with a utilities company in Dallas. Your boss (not an engineer) recently heard a well-known scientist in climate modeling say that within a few years, the number of days per year in Dallas with temperatures over 100 degrees F will increase from 19 to 87 (on the average). The boss is worried about increased demand for electricity in such a scenario. Write a memo to him explaining why it might be risky to aggressively pursue increasing production capacity on the basis of such predictions alone.

The second semester began with a research paper on a topic chosen by the individual students but with a clear relation to readings in the course. The freshman course culminated in an exploration of alternative means of communication—graphics, oral presentation, and multimedia. The second assignment was to give an oral proposal for the term engineering project that effectively integrated speech and visual support. The project report had to be developed as a multimedia presentation.

Three points of focus distinguish this curriculum from the traditional curriculum. First, of course, is the element of integration. In the experimental first-year program, English is perhaps the most fully integrated component in the program; compared to engineering, math, physics, and chemistry, a larger percentage of the total grade is derived from integrated projects—the lab reports, essay tests, and project reports. This represents a radical departure from the usual arrangement in which engineering students take a course that, despite our

protests to the contrary, seems to be only loosely connected to the work they do in the sciences.

Second, the technological emphasis in the course delivery is much stronger than in the traditional freshman and sophomore English course (though a number of teachers currently experiment with delivering their courses in computer classrooms). Every class in the Foundation Coalition program takes place in a room with integrated personal computers (PCs with Pentium processors and Ethernet connections). In addition to individual writing assignments done with computer support, we use the Daedalus Integrated Writing Environment (version 4.0) to support collaborative work, ranging from writing in small groups to computer-mediated, synchronous conferences as a replacement for the usual discussion of reading assignments. The teachers in the course have learned quickly that ordinary lectures and discussions won't work in this environment; the computer is too much of a distraction for these technically-oriented students. The only solution is to put the computers to work for us.

The third distinguishing area of focus is the emphasis on collaborative learning that characterizes the entire approach of the Foundation Coalition. Again, English teachers in regular courses experiment widely with this pedagogy, but few have the opportunities we have for teaming with colleagues and thereby modeling collaborative activity for the students. Nor do they have the advantage of working with student teams that co-operate in courses beyond the English class and thus regularly reinforce the value (or necessity) of collaboration. Moreover, a significant portion of the total grade for each student is based on team projects, such as the oral report and multimedia presentation in the second semester.

These advances in subject-matter integration, technology, and collaborative pedagogy have proved powerful enough to encourage our continued commitment to the experiment in integrated engineering education.

#### *Arizona State University's integrated program*

Since this course is a pilot program at Arizona State University, the English faculty had to meet certain constraints: 1) Students who took the course must emerge as prepared as those taking the regular Freshman English courses and must be able to function successfully in a second-semester Freshman Composition course if they decided not to continue with the program after the first semester; 2) The course we developed must meet the approval of the Composition Director and therefore could not differ radically from regular Freshman English courses. Therefore, we decided to revise the Freshman English courses in two areas: course content and teaching methodology.

We decided to focus our integration on three areas: types of papers, content of papers, and an integrated journal project. During our planning session in the preceding summer with the rest of

the team, we began by identifying key papers for engineering students that were not often part of the regular Freshman Composition course. These key papers included cause and effect analysis, revised lab reports for a general audience, and a team research paper. A cause/effect analysis, we determined, is a key paper for all engineering students; however, this paper is sometimes avoided by teachers who consider it too sophisticated for freshmen. The revised lab report for a general audience is definitely specific to this course, and yet we have an example in our current core text, *Writing and Reading Across the Curriculum*, an example that suggests that this kind of writing assignment is common in the 'real world'. Furthermore, after consulting with the FIPE team, we determined that engineering students are often asked to present their reports to audiences who do not share their technical expertise. We therefore considered that such a task would lead to analysis of audience and language rarely done in a Freshman English class. We also determined that sophomore and junior engineering students are required to write team papers and we decided that working on a team paper in their freshman year would prepare them for later work.

Our content integration emerged in two ways. First, we supplemented the core texts with James Adams's introduction to engineering titled *Flying Buttresses, Entropy, and O-Rings: The World of an Engineer*. This text provided us with the basis for two papers, a summary paper and a definition paper and several journal assignments set early in the semester to introduce students to engineering. Next, we sought out topics from the team that would integrate with concepts the students were studying in the other classes in the program. Thus our comparison-contrast paper focused on Huxley's scientific method versus Fermi's scientific method. In turn, the students were able to return to and employ these methodologies in their engineering final exam. In a later assignment, the students wrote a team paper on an engineering feat, failure, or new technology, comparing the popular view of their topic with the professional view. Such a paper allowed them to once more explore the notion of audience as well as develop research skills.

Finally, course integration solidified with the journal project. Each subject area, Physics, Calculus, Chemistry, Engineering, and English set journal assignments during the week. These journal assignments include reflections on reading, reflections on material or concepts raised in class, questions that ask students to apply concepts they have learned to another field, and definitions and explanations of concepts written so that English teachers can understand them. This last requirement reflects Fulwiler's assertion that 'writing is basic to thinking about, and learning, knowledge in all fields as well as to communicating that knowledge' [4]. Moreover, such writing assignments lead students to reflect and process rather than merely regurgitate material. The journal is

graded on completeness and depth rather than on correctness, and the FIPE team shares the reading of these journal entries that are collected on a two-weekly basis. First, the knowledge that all faculty read and grade the journals underscores the notion that our students must always write with a wide audience in mind rather than write to a specific teacher. Second, since the students know that the whole team will read the journals regularly, they also understand that writing is not limited to the English class.

However, the more radical revision of the course has occurred in terms of teaching methodologies. English is taught in small classes of 25. The English Department therefore insisted that two teachers must staff the integrated section since the number exceeded 25. However, this brought an unexpected bonus. Rather than teach the class as we normally would, we decided to team teach each class. We believed that this approach could better incorporate team work, active learning, and co-operative learning. Therefore, we both plan out and teach each class session together. To ensure that our classes go smoothly, we meet during the break to plan out the course and decide who will lead each block. Then, during the semester, we set aside time for weekly meetings to discuss what we plan to do the following week, and we prepare detailed lesson plans so that we are both able to be active in class, supporting and enhancing each other's presentation. In terms of teaching, this has been the most successful aspect of the course. The students still have the feel of a small class, but they have two experienced teachers demonstrating by their presence and actions the importance of teamwork. Moreover, two teachers in one class of up to 50 students would be able to carry out more effective team work and active and co-operative learning than would one teacher with 25 students, an important consideration in planning to expand the program. Team teachers can circulate in the room more freely and offer more advice.

The revision of the class in terms of content and methodology has been successful without compromising the core ideals of our Composition program. In fact, we believe that this model could indeed be adapted to other subjects.

## ADVANTAGES TO STUDENTS

### *Advantages to students in Drexel's program*

Drexel's evaluations of the project, both qualitative and quantitative, verify its success in several respects. The evaluations most attractive to many outsiders cite the considerable improvement in grade point averages and in retention rates in engineering, which nationally have been declining [5, 6]. In analyzing student journals, an outside evaluation concluded that 'the most successful student experience... was that of the group design project. Students were challenged to work in teams, to be creative engineering designers, to

solve problems, and to make professional presentations and written reports. They felt a real sense of accomplishment and pride when they had finished [7]. Early evaluation has already found that E4 students think a lot about 'what it means to be an engineer'. Students view engineers, in general, as creative problem solvers, unlike students in the regular curriculum who view engineers as number crunchers or gadget builders. Further, they recognize the value of teamwork and the importance of good communication skills [8]. In surveys of the students from the second and third years of the project, 'The Humanities component—especially communications skills—has emerged as a critical component and important skill for presentations, team work and Co-op' [9].

#### *Advantages to students in Texas A&M's program*

The A&M students tend to perform better than their peers in regular English. Many factors influence this improvement, no doubt, but we believe that the processes of integration and collaboration must have some positive effect. Writing comes to seem a more natural extension of other academic activities, and concepts like audience awareness take on greater meaning in the community of learners that arises in the collaborative atmosphere created by the Foundation Coalition.

Furthermore, the students who claim never to have liked writing and never to have done well in English are among the most vocal advocates of this new program—avowedly because of the clear connection the curriculum makes between communication and the technical fields. The integration makes it possible to deliver writing instruction in many genres of composition—not only in the traditional essay, but also in engineering reports, business genres like memos, and in the emerging genres of electronic communication—e-mail, conferencing, and multimedia. This variety not only adds interest, but also suggestively reflects the evolution of literacy in the world beyond the traditional English classroom.

#### *Advantages to students in Arizona State University's program*

Although this is a pilot program and has only been running for one semester at the time of writing this paper, several positive benefits are emerging. The most attractive advantage to students is the higher grades that result from this class, despite the fact that this group of students entered the program with slightly lower than average SAT/ACT scores. A comparison with a non-integrated English 101 for the fall semester 1994 shows that fewer students failed (1 in the integrated course and 7 in the regular), fewer students withdrew (1 and 3), and more students earned 'Bs', (9 and 3). These grades are not significantly higher to warrant the judgment of grade inflation; rather, fewer students dropped and fewer failed. Two teachers can provide more time per student in the class and outside during

office hours. This enables weaker students to solicit more help in the critical first few weeks.

Students also benefit from the atmosphere of shared writing and shared problem solving that emerges in the English classroom. Their teamwork in other classes is maintained in this class so that they develop true interdependence with their peers although the majority of papers are still individual. Indeed, this co-operation is so noticeable that when one student whose first language is not English felt that despite having tested into this class he should take a section for foreign students, his peers objected and offered extra help.

Furthermore, since we conduct a majority of office hours in the computer classroom that is open to students outside class hours, the students are comfortable discussing writing problems in front of their peers. This means that they do not regard themselves as the only ones with problems, they are not ashamed of their problems, and they are willing to share their ideas and writing. In fact, one student was willing to discuss a course grade and her disappointment in front of a team member. He was able to interject that not only would he have been happy with her grade, but that he thought her grades overall were impressive. This spirit of openness and co-operation is surely a fundamental for their professional careers.

The final benefits for students result directly from the integration of subject matter. For example, our students were delighted when they were able to apply what they discovered in their comparison-contrast analysis on Fermi and Huxley to their final integrated exam. This all-day problem-solving exam required students to employ math, physics, engineering, and English. In teams, the students were asked to discover the contents of a sphere by using measurements, estimations, and testing. Then the students were asked to write a report that would be graded for content by the engineering faculty and quality of writing by the English faculty. The journal project yielded a second benefit. Although students sometimes felt that the journal project was time consuming, they reported that having to reflect on concepts and subjects and write about them for a general audience was a real test of their understanding. The journal enabled them to identify immediately problems they were having and solve those problems before a test. Furthermore, in addition to the immediate benefits of short-term integration, we also believe that there are long-term benefits. This kind of integration leads to synthetic rather than fragmented thinking. Students are challenged constantly to make connections, a challenge that they will need to meet in their professional lives. One student summed up the effect of integration well. When asked at an NSF review if his professors had told students what engineering is, he answered no; rather he and his classmates had learned what engineers do through their classwork. He went on to explain that the reading and writing we had required in English defined and illustrated what

engineering includes and how engineers work in the design process, as well as the importance of clear communication in that process.

### ADVANTAGES TO FACULTY

#### *Advantages to faculty in Drexel's program*

The first advantage is that Humanities has played a pivotal role in the interdisciplinary program at Drexel [10, 11]. In the Three-day Summer Workshop on Team Teaching offered to Drexel and other Gateway faculty, the role of Humanities is highlighted as synthesizing the program goals. One participant said in the evaluation, 'I was pleasantly surprised and impressed by the enthusiasm and camaraderie of all the faculty in the program, as well as the position of respect in which humanities courses are held by the engineering and science faculty'.

A second advantage and the most valuable effect of the E4 project is that it has established a unique learning community, a fact that is documented by the outside evaluator who interviewed faculty and students and analyzed student journals in each of four years. The program has succeeded in establishing 'community' in a variety of ways. In focusing on outcomes for students, faculty have transcended disciplinary boundaries to form a new community as an interdisciplinary team. In addition, students have developed a sense of community as a result of team projects and study groups that give disadvantaged students effective support. Project Kaleidoscope found effective. Together, the faculty and the students are a community of learners who meet in class and in weekly planning sessions where all are engaged in a common pursuit, the development of professional engineers. The dilemma is that while we view the learning community as the reason for our success, visitors focus on secondary questions. 'How do you integrate calculus and physics?' 'When do you teach Statics?' 'How do you grade and credit hours for combined courses?' 'Are you teaching them any REAL literature?'

Before questions like these can be answered, faculty must have established a community that shares a common pedagogical basis. However, such interdisciplinary commitment runs counter to the competition among departments for resources and among faculty for research time.

#### *Advantages to faculty in the Texas A&M program*

In our positions as assistant professor and a full professor, we have been active as curriculum consultants, planners, and occasional teachers in the A&M program; the working teachers have been graduate TAs in English. We wanted to model the program much as it would be taught if the curriculum were expanded to include all engineering students. At the huge state universities, this usually means involving graduate students or part-timers in writing instruction. The two TAs in the project

have discovered the greatest advantages to be the increased motivation of the students and the opportunity for collaborative work and technological experimentation.

#### *Advantages to faculty in Arizona State University's program*

The most important advantage has been the shift away from the notion that English is the only class that cares about writing. Being part of a team, being seen by students as part of a team, sharing the course development and assignments and developing an integrated journal has enabled us to overcome the often insurmountable hostilities that students feel: English is unimportant to them, it is a course to be endured rather than enjoyed, and finally English is peripheral to their fields and careers.

Secondly, this kind of integration leads to a camaraderie rarely experienced in any field. English professors rarely work with professors outside their field, so they tend to regard themselves as the isolated bastion who care about writing. The weekly meetings and summer preparation involving multi-disciplinary faculty build a spirit of co-operation and sharing that really fulfills the notion of a university.

Finally, our model that uses two teachers in the classroom allows for true team teaching. Teaching is one of the few professions in which people work on their own and are rarely seen by their peers. Our model breaks with that tradition, allowing us to give each other constant feedback, suggestions, compliments, and support. In turn, we believe that we have become better, more innovative, and more interested teachers. Moreover, because we also develop assignments and grade those assignments together, we believe that we have developed better assignment and grading skills. We provide a constant check on each other.

We note that this model could really benefit the English department. Since engineering pays for one teacher and English the other, the English department currently benefits. We suggest that the English department could also benefit were it to explore team teaching further.

### POTENTIAL DIFFICULTIES

#### *Potential difficulties for Texas A&M*

The difficulties that lie ahead for the Foundation Coalition's integrated curriculum at Texas A&M are all associated with the size of the institution. The big question is, can we upscale and maintain the uniqueness and instructional quality that we've perceived in the pilot program.

Consider the question of facilities, for example. As we prepare to increase the size of the first-year program from 100 to 240—the rationale being to get each section of the math and physics classes up from 50 to the customary 120, so that we can argue for the cost effectiveness of the program—we are



faced with accepting a classroom setup for a large lecture. By installing the right technology—some kind of small computer at each seat, for example, or a network connection for laptops—we can maintain our commitment to active learning. But what about our interest in collaboration? Not only is teaming physically difficult in lecture halls, the setup, with seats bolted to the floor, and rows tiered upward from the point of focus at the lecture podium, also sends the wrong message. It suggests that the important action is down front, where the professor stands ready to dispense essential information. The cost of refitting a number of big classrooms to make them suitable for collaborative learning is staggering, but many of us in the integrated program are willing to fight for this change.

The question of faculty looms large as well. The English Department has been willing to participate in the pilot project largely because Engineering has provided partial funding from the grants that support the project. Expansion raises new questions because English would then have to fund its part of the program without additional assistance. We already have trouble training enough TAs and hiring enough lecturers to meet the demand for technical writing courses, which require special instructional skills and a command of information outside the usual course of study for English graduate students in a traditional program like ours that stresses literary scholarship. To meet the needs of the first-year integrated program as we have designed it, we would have to accept a new burden of training to help new TAs gain the technical skills to teach in a networked computer classroom and manage collaborative interchanges within and among teams.

In next year's pilot, we plan to experiment with a technological innovation that could help up to cope with the challenges of expansion. For 100 of the 240 students, we will use the same approach we used this year—dividing them into sections of 25 and assigning two well-trained TAs to cover two sections each. For the remaining 140, however, we will be experimenting with a different form of delivery, borrowing from the distance-learning mode. The idea is to make weekly lessons available on-line—including directions for team analysis of readings and regular writing assignments—and to abandon regular meetings of the class altogether. Instead, we would have weekly help sessions staffed by TAs. The help sessions would be optional unless a particular student or group was having particular difficulties, in which case they would be required to attend the help session. Regular communication would be maintained both by submission of assignments and by e-mail. Thus we would allow teaming and technology to replace the traditional classroom completely.

Since we have not yet tried this arrangement, we do not know whether it will produce good results, but our experience of teaching in the networked

classroom with a strong emphasis on collaboration suggests that it might. In the current arrangement, the teacher's role is that of facilitator and tutor. Removing the teacher from the classroom and replacing the classroom itself with a network of active writing groups linked by computer are merely the next steps in a program designed to encourage students to take responsibility for themselves and their peers in the learning process.

#### *Potential difficulties for Arizona State University*

Like Texas A&M, Arizona State University faces the same difficulties with facilities. In addition to physical difficulties, the next most obvious difficulty is convincing the English department that this kind of program enhances rather than dilutes Freshman English. Since Freshman English traditionally takes as its subjects humanities-related issues, some may worry that this course will dilute or destroy that. Indeed some may see Freshman English becoming subject-specific service courses that could be taught by subjects other than English. However, if English takes the lead in these kinds of integrated courses, it can still maintain control of the classes. They will not be lost to other subjects.

Next, if the ASU model continues, some departments may not wish to take part because initially, during the pilot phase, they will be paying for a class that they currently receive for free. However, careful discussion and dissemination of results combined with support from Writing Across the Curriculum and Composition could do much to persuade these departments that benefits will far outweigh costs.

In addition, despite substantial scholarly articles, research, and workshops on campus, some departments including English may feel that active and co-operative learning methods are inappropriate in the Composition classroom. This can be resolved by more workshops and opening classrooms to observers. We would also encourage those interested to attend one or more of the weekly meetings to experience for themselves the camaraderie generated by a program such as this.

#### *Potential difficulties for Drexel*

Because Drexel is now in its fifth year of integration, it faces less potential hostility from the English department. Nevertheless, like Arizona State University and Texas A&M, Drexel also notes that dissemination is one of the most important difficulties that must be overcome. At the NSF Coalitions Evaluator Workshop, October 20–22 1993, in Baltimore, Caylin Culler of MIT explained that dissemination is far more difficult and important than many realize. Her own experience in the Developing Scholars Program at Berkeley proved that papers and conference presentations are insufficient. Major innovations must be experienced by the individuals wishing to import them, and must be adapted to their particular context. For innovators to convey the

complexity of their projects, they must combine verbal presentations with experiential learning.

To maintain the current success and ensure the future success of its expansion within and beyond engineering and Drexel University, a culture of co-operation must be fostered. Coalitions mark the beginning of a cultural shift to co-operation among colleges and universities, despite their need to compete for enrollment. The expansion of learning communities that exceed geographical boundaries has been heralded by technology that makes information accessible to anyone with a computer and a phone line. Newcomers must understand that it is truly an interdisciplinary community, not just a curriculum they need to build.

To build this community, Drexel has some specific solutions. First, the Three-Day Summer Institute on Team Teaching could be offered to other coalition members. This workshop combines presentations, group activities, and journal writing for reflection and discovery. Students also present some of the most interesting design projects and are available for discussions. Therefore the workshop would benefit coalition members outside Drexel. Next, an electronic conference would allow members to share ideas and review new action plans. Third, all coalition members should join the national dialogue on educational reforms. Fourth, systematic gathering of evaluation data will allow for continuous improvement. Finally, coalition members must try to disseminate information and evaluations of their programs.

## CONCLUSION

In *Effective Teaching: A Workshop*, Richard M. Felder argues forcefully that students learn best, retain more, apply that knowledge more creatively, and function more successfully when their teachers employ active and collaborative learning techniques [12]. Moreover, a recent survey of industry by ASME/NSF indicates that teamwork and communication skills are the two most important skills desired of new bachelor's-level engineers. Certainly our integrated curricula that include English and the Humanities support this model because courses overlap, concepts are reinforced in numerous ways, and teachers communicate with each other and know what their students are learning. Writing synthesizes the whole program. And yet this model benefits the faculty as well. English teachers are no longer isolated from other students, feeling that they alone bear the responsibility for writing at the University. In addition, English faculty support other faculty's attempts to improve their students' communication skills. This course represents true Writing Across the Curriculum.

This emphasis on writing that results from integrating with English prepares students more thoroughly for their professional lives than do our traditional models. Moreover, students experience

teamwork early in their careers before their jobs or their companies' success depends on their ability to work in teams. They develop their teamwork skills gradually in a mutually supportive atmosphere so that when they enter the work force, they are prepared for the professional world. It behooves the English and Humanities departments to stay at the forefront of a movement that so benefits student and faculty alike.

Furthermore, this view is upheld by those outside English and Humanities. Murray Gell-Mann, Nobel prize-winning physicist, argued in a recent address at Drexel University that professors need to redefine their roles. He pointed out that 'lectures' originated when there was a need for someone who could read to educate others who could not, and later there was a need for students to copy the words being read since a text was a rare and prized commodity. He proposed that professors should feel liberated from the need to lecture to impart information readily available in books, videos, and other electronic media; rather they should guide students by posing questions, mediating between conflicting information, or presenting their own recent research for dissection. Interestingly, a professor in the audience interpreted Gell-Mann's remarks to mean that professors were redundant. What he meant, Gell-Mann explained, was that teaching skills most of us have learned are no longer the ones we need to best reach our students.

Students are turned off by the lecture mode which dominates engineering and science courses. An important study by University of Colorado verifies the impact of poor teaching: almost 41% of the students cited it as a major reason for leaving the major and 98% cited it as an issue they had considered [13]. Yet, if lecturing constitutes poor teaching, students and faculty alike are ill-prepared for collaborative learning. If we succeed in convincing faculty to abandon outmoded ways and adopt an approach that recognizes a community of learners, we still must deal with students' unwillingness to accept the responsibility of their role in the community. As Kenneth Bruffee astutely notes in *Collaborative Learning*, 'Students may also resist consensus group work or other kinds of collaborative learning because social engagement can be hard work. It calls upon a range of abilities that many college and university students may not yet have fully developed or refined: tact, responsive listening, willingness to compromise, and skill negotiation:—and I'm not sure the faculty have those skills either if judged by battles about whose discipline should be teaching those skills [14]'.

As the diversity of the student population grows, surely one of our most important functions will be to teach our students how to work in a group. For those of us redefining our roles, it is a challenge to mediate in a community where we are experts watching others struggle to enter our realm of professional knowledge and yet remember that

we are also still learning—about our students' needs and how varied they may be from those of our own college days. The faculty involved in these integrated courses at Arizona State University and Texas A&M have informally echoed the Drexel faculty who commented to evaluators about how much more productive and creative

students working in small groups and teams had been during the year. They identified positive student-faculty relationships as key to the success of this program [15]. Clearly the English and Humanities faculty play a key role in the community of learners developing the professional engineer.

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