MIXING WRITING WITH FIRST-YEAR ENGINEERING

An Unstable Solution?

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Most first-year students have little in-depth knowledge of their chosen profession—particularly in engineering, which has so few high school experiences connected to it. Moreover, chemical engineering departments rarely offer core courses until the sophomore year and hence have little contact with first-year students interested in chemical engineering. Recently, more departments have begun offering seminars or other career-oriented activities for first-year students,[1] recognizing that early engagement with the profession can increase motivation for learning and improve retention in the major.[2,3] Improving student understanding of engineering should certainly allow students to make informed, rational decisions about their academic and professional careers, but providing them with such an understanding can be challenging and too often devolves into passive activities such as seminars and introductory technical courses. By contrast, a process that engages students actively in learning about and identifying with engineering would benefit both them and the profession.

Students' ability to identify with their chosen profession improves both motivation for learning and retention in the major and also seems to influence their ability to write effectively. Science writing is often influenced by "a student's inadequate sense of self as scientist,"[4] and a similar rhetorical struggle would be expected for students in engineering disciplines. If engineering students do not view themselves as engineers, they cannot become fully aware of the audience to which they are writing and the specific needs of that audience. Consequently, they approach engineering writing without adequate knowledge of the language practices that define their discipline. Traditional writing assignments such as lab write-ups, while helpful in shaping students' thinking and identifying what is new knowledge to them, may not help them adopt professional roles. Lab reports typically are written to document completion and understanding of the engineering process. For the most part (and with good reason), first-year labs do not ask students to write as professionals but as novices demonstrating skills and knowledge.[5]

Educators have addressed engineering students' writing abilities for over a hundred years, with varying degrees of success and satisfaction.[6] Institutions have adopted a range of approaches to improve students' writing skills, such as writing-across-the-curriculum (WAC) courses that integrate technical content with rhetorical analysis. Despite good intentions, however, some of these WAC approaches have nevertheless failed to adequately prepare engineering students for the types of writing tasks that they will encounter academically and in their careers. As technologists and humanists often use different techniques to teach writing, it may be difficult for students to incorporate lessons from the humanities into their engineering coursework.[7] Engineers may also lack the language and understanding of composition studies to effectively teach the writing process. Offering a pedagogical balance between engineering and rhetoric is thus a challenging problem.

At Rensselaer Polytechnic Institute, the chemistry department employed writing consultants from the Department of

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Language, Literature, and Communication to work with junior-level chemistry majors on their lab reports in two required "writing intensive" courses. These consultants met with chemistry faculty to discuss writing practices in that discipline before they began offering feedback to students, who produced multiple drafts of their reports before submitting final versions for grading. The writing focus in this WAC effort targeted upper-class students and formal lab writing and resulted in better quality lab reports.[7] A WAC effort in the Department of Animal Sciences at the University of Kentucky similarly targeted upper-class students through a senior-level course, but by contrast it emphasized more "real world" assignments that would help students recognize the importance of writing in their discipline—an achievement that is often sought by WAC endeavors in engineering and technical programs. The Kentucky course stressed the importance of rhetorical context in writing assignments to improve student interest and to clarify assignment objectives.[8]

We started the course with a scavenger hunt that sent student teams to various faculty, the writing center, and some research facilities such as the electron microscope facility. Teams collected some technical information from each visit and gave an informal presentation on their findings.

A much broader, more programmatic approach to WAC has been undertaken by the Materials Science and Engineering Department at Virginia Polytechnic Institute, which integrates writing and speaking into eight core courses that students take over a three-year period. The sequence used a combination of formal and informal ("interpersonal") communication assignments, peer writing consultants, and supplemental writing workshops. Their efforts seem to have contributed to the establishment of a required zero-credit class for majors that asks students to create a writing portfolio containing their best work in a variety of modes from their required classes.[9]

Historically, attempts to understand these varying approaches to writing have resulted in two groups: in one, the expressivist model, writing is used as a means of teaching and learning, employing free writing and journals, and in the other, the "social constructionist model," writing pedagogy emphasizes disciplinary or workplace conventions. Such categorization oversimplifies the WAC process, with some researchers turning to an "interactionalist" approach that combines elements of both models. "An interactional approach. . . emphasizes that learning is a social process that necessitates active involvement on the part of both the learner and the teacher while also emphasizing the contribution of disciplinary knowledge in the transaction."[10]

At WPI, we attempted to adopt a scaled-down version of this "interactionalist" approach, which had been developed through a successful collaboration between humanities and engineering faculty at Michigan Tech University.[10] Our interactionalist approach involved using some writing activities that taught students to use writing as a means of understanding what they wanted to say and were exploratory. Other activities, by contrast, introduced them to conventions within the discipline and encouraged them to learn and reproduce those conventions. The balance, in part, is between teaching students what they need to learn to become practitioners of an inherited discourse while also giving them the critical thinking skills they need to question and challenge conventions. Leadership in any field requires individuals who can go beyond the mere reproduction of knowledge by continually reexamining the discipline and, when needed, reshaping it.

COURSE OBJECTIVES

Students often think of writing and speaking strictly in terms of evaluation, *e.g.,* the lab report or presentation that they must produce to "prove" that they completed and understood the science. They have a fairly limited understanding of what "communication" can be used for. At the same time, their knowledge of what chemical engineers actually do is equally limited. Because WPI does not offer freshman chemical engineering courses or require writing courses, we wanted to design a course that would actively engage students in the profession while improving their approach to and understanding of communication as a problem-solving tool. Additionally, we needed to recognize that although first-year chemical engineering majors do not take any chemical engineering courses, they carry one of the heaviest academic course loads on campus, a fact that challenged us to design a one-credit class that would achieve our pedagogical goals but still attract students.

THE APPROACH

Jointly taught by a chemical engineering professor and a writing professor, the course stressed collaboration between chemical engineering and communication in its design and its execution. We reasoned that the best way to teach that communication and chemical engineering should inform each other was to demonstrate the integration, so we collaborated on the design and delivery of every assignment. Both instructors attended every class, so the students would again see the connection between the two disciplines and not think of "communciation days" versus "chemical engineering days."

Course development was funded through a WPI grant (itself supported by NSF's Institute-Wide Reform Program) the first year and a Davis Educational Foundation grant the second year.

We offered the course three times over two academic years, revising it after each offering. About one-third of the declared majors took the course each offering (7-10 students per semester). We required portfolios each time we taught the course, but in the second offering we required the students to submit all of the assignments from the course. Ideally (in keeping with writing portfolio pedagogy), we would have allowed the students to select what they felt were their strongest pieces, but because we met only once weekly and the course was "low-stakes" (only a single credit), there weren't enough assignments from which to choose. We nevertheless were able to design assignments about chemical engineering that would give the students an awareness of audience, introduce them to group writing, peer response, and revision, and give them practice writing reflective cover letters that would initiate a metacognitive approach to writing—that is, get them to think about the process of writing. Additionally, we stressed class discussion so that students would receive practice communicating ideas, responding to others' ideas, and learning the language needed to participate in the discipline.

To assess writing gains and to assess the reliability of our portfolio assessment, we used an external writing specialist. A final evaluation measure involved student self-assessment as expressed in their portfolio cover letters.

THE ACTIVITIES

The course had several activities that covered a variety of engineering topics integrated with communication issues. For the purposes of this paper, we summarize a few of the activities, then follow with a detailed discussion of two. Our emphasis in this paper is on portions of the course dealing with ethics/professionalism and understanding audience.

We started the course with a scavenger hunt that sent student teams to various faculty, the writing center, and some research facilities such as the electron microscope facility. Teams collected some technical information from each visit and gave an informal presentation on their findings.

A visual-rhetoric activity had students describe an assigned visual element that was related to chemical engineering (*e.g.,* a pump) to a partner who had to draw it without looking at it. This activity gave students experience with precise verbal communication and active listening, while illustrating some basic chemical engineering principles. We then debriefed the class with their sometimes-humorous drawings, their guesses about what the devices were and what led them to their conclusions, and then an explanation about the real function of the visual element.

To connect visual and verbal skills, students went to the Unit Operations lab for a demonstration of a pilot-scale distillation column. Prior to the lab visit, they were asked to develop and sketch a process for production of fuel-grade ethanol from a fermentation broth. This exercise introduced basic separation principles, including staging. The lab demonstration was combined with a quantitative problem assignment and a writing task that integrated all the elements. This was the first time any of the students had observed the operation of a larger-than-bench scale piece of chemical processing equipment.

The follow-up activity to the laboratory visit involved visits to actual industrial facilities. We wanted students to experience chemical engineering in the workplace and to have an opportunity to talk with practicing engineers in a more active way than a standard plant tour allowed. Each team visited a different site and spent several hours with a WPI alumnus during a major part of their workday. Companies visited included an environmental consultant's site visit, membrane separations (Sepracor), and stem cell production (Viacell). After the trips, each group wrote a trip summary and gave a brief oral presentation to the rest of the class about the experience.

Although the activities described above provided some interesting exercises and opportunities for writing within a technical context, we really wanted to engage students at a deeper level. Course logistics and student background prevented going too far into the details of chemical engineering fundamentals, so we took a different route. Two activities, described below, resulted in some interesting issues and posed some particularly challenging problems for the instructors. Details about the course syllabus, assignments, and portfolios can be obtained directly from the authors at <dibiasio@wpi.edu> or <llebdusk@wheatonma.edu>.

► *Ethics, Racism, and Engineering Practice*

Civic responsibility, the interaction of technology and society, and professional and ethical responsibility are all part of WPI's educational philosophy, so in the first offering of the course we attempted to engage the class in issues of workplace racism. Wanting our students to realize that ethics and race issues have a place in chemical engineering and in their education as engineers, we used a campus event featuring a documentary about racism in Japan and a discussion with its director, and a real case-study involving a chemical company and allegations of racism. This exercise provided important data that only a collaboration would have provided.

The racial homogeneity of WPI, this class, and its instructors contributed to the impression that racism is something that occurs elsewhere and is perhaps not a real problem, and our all-too-brief treatment of the issue did little to counter

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that impression. Because the film examined racism in Japan, our students responded to the issue as if it were a symptom of Japanese culture in particular. Focusing on the lives of African-Americans in Japan and their isolation there, the film was interpreted by students as an instance of something that occurs outside the racial democracy of the United States. Our shift of the discussion to the Texaco racial-discrimination lawsuit[13] did little to alter students' perception that racism was something that occurred "out there." Although we pointed out that the Texaco executives who had been accused of making racist remarks might have been trained in chemistry or engineering professions, our students nevertheless discussed the issue as if it were something that couldn't happen here. When we shifted the discussion to subtle forms of racism that we have witnessed, such as unofficial segregation in the cafeteria or in fraternities, several students offered anecdotes about their best friends who were of color. We seemed to have created an atmosphere in which students felt the need to testify against racism and to represent themselves as among the enlightened, but our goal had been more to get students to consider the complexities of racism and to examine how they operate in the workplace. The exercise suffered from a larger cultural constraint in which "racism seems always to be an appendage to the classroom curriculum, something loosely attached to a course but not quite integral, even when race is the issue."[14]

We have not yet resolved the race issue to our satisfaction and will continue to explore ways to address it. We might consider, for example, having students explore how "whiteness" is often understood as a "non-race" or universal in the workplace. We might also consider examining race in the nonmanagerial levels of the workplace. At the same time, we consider the exercise successful because it provided us with information about our students' perceptions that traditional lab activities cannot provide. Additionally, because the exercise was presented within the context of a chemical engineering class, it sent the message that racism is something that concerns chemical engineers.

Scheduling logistics and the issues described above caused us to reconsider our approach to introducing the grayer areas of professional decision-making. We assumed that a shift from the larger but harder-to-concretize issue of racism to other more clearly defined ethical dilemmas might be easier for students to grasp as an entry point into the profession's complexities. So, in subsequent course offerings, we decided to focus on a very specific well-defined problem. Using an Online Ethics Center web site <http://www.onlineethics.org/>, we designed an assignment to introduce students to common chemical engineering ethical dilemmas. We used a case study on "Request to Falsify Data" to generate in-class discussion about how the engineer in the case study might have responded if her manager wanted her to falsify data about an environmental oil spill. The writing assignment followed up on this discussion by asking students to evaluate the problem from the perspectives of a member of the state's environmental protection agency, the CEO of the company, company attorneys, and members of the community.

Some students seemed surprised that engineering had an ethical component. As one student noted, "I never expected [a discussion about ethics] in a department other than Humanities. We discussed a dilemma between one's future career and morality as part of the human community. From this discussion, I learned how ethical issues were involved with chemical engineering . . . I liked the idea that we had to give opinions from different perspectives."

Another student found himself challenged by a situation that did not offer any moral certitude. By the end of the course, he described his dilemma: "It was hard to decide how other people would react and what they would do . . . Why would they want to jeopardize their career or the company and what qualities are needed to stand up for what is right?"

Because these exercises did not offer the students any answers, they introduced them to a significant but seldom-discussed component of chemical engineering as well as a language by which to begin considering the issues involved. The exercises provided practice in understanding and articulating multiple perspectives of the same scenario as well as the subjective context in which professional life across disciplines is situated.

► *Understanding Audience*

A major group-writing piece involved describing a current field of chemical engineering research to a general audience. Student teams were assigned a research area and provided with at least one technical article describing that research, major benefits that might come from it, and problems associated with it. Each team did additional reading and produced an article written for the campus newspaper that described the role of chemical engineers in the specific research area. Some groups interviewed appropriate faculty with expertise in the area. The writing process allowed us to introduce techniques for collaborative writing, revision, and peer review.

The difficulties of understanding audience in an educational

context emerged as the students struggled to write to an audience of peers while recognizing that their professors would be reading and commenting on drafts. One group was assigned the research area of obesity drugs—a topic involving an interesting combination of medicine, biology, engineering, and patient treatment. In an effort to engage their prospective peer audience early in the piece and to be funny, the first draft of their paper appeared with the title in large, bold font: "What's Up FATTY?" and a lead sentence of "Are you Fat? If so, read on." Other examples of their humor included statements such as "The diseases related to obesity include heart disease, stroke, diabetes, hypertension, and gall BLADDER disease (ooooh!)....Scientists were exstatic [sic] when they discovered that the drug accts [sic] on the brain like COCAINE!!! Fortunately, it does not have the harmful side affects [sic] (you dope fiend)....Some people who are slightly overweight (not obese) are very emotionally disturbed because of society around them projecting the image that to be thin is better. They could then abuse the drug to become overly thin. Drugs for the MASSES. New drugs: Fad or PHAT."

To a certain extent, the students' article demonstrated a kind of "institutional under life," which, in the writing classroom, is a productive assertion of identity against the one being taught. Robert Brooke, who adapted the sociological concept to explain student behavior in writing classes, notes that contrary to teacher responses that see such behavior as detrimental to instruction, such rebellion is actually productive because it indicates that students are acquiring a necessary critical distance from roles that are imposed on them. According to Brooke, such critical distance helps to form a more self-aware professional identity: "If the student in a chemistry class grew to think of herself as someone who thinks in certain ways to solve certain problems rather than as someone who must 'learn' equations to pass tests, then the student would begin to see herself as a chemist, and to act accordingly."[15]

The review process included in-class peer revision and instructor comments. Both of those audiences suggested the writers consider the effect of their language on readers. The student team needed to recognize that their article's message could be undermined by inappropriate humor. While some of the students' peers might have been attracted to an article designed to entertain them, some of their peers would have been offended rather than entertained. Additionally, many newspaper readers seek information rather than amusement. We tried to point out that the campus newspaper ultimately serves the entire community and that student writing should reflect an understanding of that community. Their final version was titled "Obesity No More?" and led with "Have you ever wondered why someone can pig out and stay thin, while someone else can never seem to maintain a healthy weight? If so, read on." The subsequent article replaced the earlier joking tone with one that was more formal: "If the drugs are approved, chemical engineers will be responsible for designing the necessary processes to produce the drug for the masses. Chemical engineers would also be working to produce the drugs more efficiently....Obese people could abuse the drug to become overly thin because of the influence of society. Society projects an overwhelming image that being thin is better."

This group's end-of-course portfolios indicated that they realized, in reflection, their initial drafts were offensive to some readers, but they also felt the revision process had taken the life out of the paper. Their cover letters pointed out that they were not interested in the topic from the beginning and had tried to find a way to make it interesting to each other: "Todd and I wanted to make it goofy enough for a college student, yet we all knew that some of our jokes would go over badly....We managed to put together a pretty crude paper full of stupid remarks." Rather than reflecting a lack of understanding of audience, these remarks suggest a kind of rebellion against it. Hence, their first draft was written suitably for their intended audience: their group. This draft also suited their purpose, which was to entertain and be entertained.

The subsequent revisions indicate a kind of capitulation to the educational system. As that same student noted in his portfolio letter, "The group got together again and took out all of the brazen humor to make what I thought was a dry article." His comments reflect an understanding of the educational game in which the faculty audience is the final arbiter as well as his refusal or perhaps inability to identify with that audience. At this stage, he knows what his audience wants, and given that a grade is at stake, he will give that audience what it wants, but he will not identify with it. Also, he cannot fathom how someone would find the subject of obesity drugs relevant or interesting, but he is willing to play the language game.

This activity also made us question our experiences with the racism discussion. Again, those activities reflect the students' desire to play the language game, which they interpreted as testifying against racism but did not reflect an understanding of what they themselves did not experience directly. These students could not imagine racism's existence any more than they could imagine how someone would want to read an article about obesity that did not make jokes about it. Ultimately, both exercises attested to the need for education that requires students to imagine conditions and groups other than themselves as part of their intellectual maturation.

EVALUATION

We used several measures to assess student gains in knowledge of the chemical engineering profession and writing approach. To assess student gains in knowledge of the profession, an external evaluator administered questionnaires and conducted focus groups that categorized "knowledge" in three dimensions: "activities of chemical engineers, industries employing them, and issues faced by them." To assess writing gains and to assess the reliability of our portfolio assessment, we used an external writing specialist. A final evalua-

tion measure involved student self-assessment as expressed in their portfolio cover letters.

After the first iteration of the course, the evaluator compared first-year chemical engineering majors who had taken the course to a control group of first-year chemical engineering students who had not. These pre- and post-comparisons were not useful due to the relatively small sample sizes. As a result, the evaluator turned to focus groups to provide a fuller understanding of what had happened.

We did not conduct any longitudinal studies, but it has been clear that students who took this course remained in the department. Many became active in the student AIChE society and others were academically outstanding. We believe this probably has more to do with the students' predisposition for chemical engineering as a major than the effects of a one-credit course.

▶ *Gains in Knowledge of the Engineering Profession*

The evaluator concluded that the project had succeeded in producing gains in student knowledge of the activities in which chemical engineers engage. One of the greatest struggles for the students involved the group writing assignments, which they found difficult to complete because of incompatible schedules. Some also felt the course required too much writing for a single-credit course. In the second iteration of the course we addressed the group logistics problem by giving them more instruction in collaborative writing, fewer collaborative writing assignment, and more in-class time to write collaboratively. We did not decrease the frequency of writing assignments as we felt they were crucial to achieving our objectives.

▶ *Gains in Approach to Writing*

To evaluate gains in student writing approaches, we designed a portfolio evaluation rubric that we provided to students at the beginning of the course. The rubric identified nine key criteria, each of which was ranked "Superior," Good," "Acceptable," or "Unacceptable." A majority of "Superior" rankings earned the portfolio an "A"; a majority of "Good" earned a "B;" a majority of "Acceptable" earned a "C," and a majority of "Unacceptable" earned an "NR" ("Not Recorded," which is equivalent to a fail grade; WPI does not have a "D" or "F" grade). The portfolio review criteria were

- *Demonstrates a robust understanding of the chemical engineering profession*
- *Shows sustained original, logical thinking*
- *Has strong organization at the paragraph and global level*
- *Demonstrates a strong sense of audience and voice; language is creative and appropriate; uses active voice wherever appropriate*
- *Uses grammar and mechanics to enhance meaning; has an interesting, credible voice*
- *Supports points thoroughly*
- *Takes risks that challenge the reader*
- *Is professionally presented*
- *Is complete and on time*

DiBiasio and Lebduska then evaluated each portfolio independently. That is, we did not share our evaluations until we had ranked all of the portfolios. Although there was some disagreement over the ranking of specific criteria for certain portfolios, our overall rankings of the portfolios corresponded exactly, suggesting reliability. To further assess the reliability of our measures, the external writing specialist evaluated the portfolios using the same rubric and without knowledge of our evaluations. With the exception of one portfolio, her assessments correlated with ours, again suggesting a fair amount of portfolio assessment reliability. In the case of the exception, the evaluator assessed a grade of "NR," while we had each assessed it as a "C." In reviewing the materials, we concluded that our assessments had been influenced by our knowledge of the student, his participation in class, and the effort we assumed he had devoted to a low-credit, voluntary course.

The external evaluator of the portfolios concluded that "this course experience, as reflected in the student portfolios [was] valuable in contributing to student learning,"[12] but noted that although the students' portfolio cover letters did reflect on their learning, they did not demonstrate an understanding of how the course's various assignments were related. We attempted to address this deficiency by giving clearer letter-writing guidelines in the second iteration of the course.

Perhaps the greatest insights about the course came from the students themselves. Most of them recognized the marketability of the skills the course provided. The following quotes, which validate our interactionalist approach, are representative of what students wrote in their portfolio cover letters. One student, for example, wrote

> *Unless an engineer is involved in solitary research and development, he or she cannot expect to survive in the job market without superior communication skills. These skills are needed to get hired via an interview, to coherently and precisely express problems to the brass of the company, and to write technical reports that management can read without first acquiring an engineering degree.*

Another wrote

> *On the field trip day I was very excited....The plant tour was unexpectedly amazing. It was nothing like those I saw in the movies. Another interesting fact was that the whole building was designed to be explosion proof, even inside the elevator....Chemical Engineering and Communications class was a very unique opportunity offered to me. It was nothing like other classes in WPI where I took notes on the lectures and discussed them in groups, I felt that I learned something new every class meeting. It was like a combination of different subjects that would help prepare a future Chemical Engineer for the real world out there.*

And finally

> *What did I learn from this course? Well, I was exposed to environmental conservation organizations and I saw equipment used at the industrial level being implemented to be environmentally friendly....I*

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> *was subjected to morally stimulating situations which made me think, which is novel and frightening. And finally I was presented with two projects that would be assigned to everyday chemical engineers. In my opinion I feel that I have learned something about the chem. eng. profession and that I must remember to communicate my ideas to others succinctly and clearly as I take the roller coaster ride of education towards the tunnel of real life working environments.*

CONCLUSIONS

For both students and faculty, this course experiment seemed to move in a promising direction. On a professional development level, the activity lessened the widening "gulf of mutual incomprehension" between scientists and humanists that C.P. Snow said threatened the quality of intellectual life.[16] DiBiasio and Lebduska each gained insight into how the other half lived, into the priorities informing engineering and humanities education, and on how the two sides, too often thought of dichotomously, might speak to each other in the classroom. Equally important was the opportunity to allow students to hear the conversation—that is, to experience chemical engineering as a practice that is informed by humanities values, including clear and ethical communication.

Our conclusion is that mixing writing and first-year engineering is certainly a stable solution when the experiment is properly conducted. In our opinion, the unstable solution, represented by segregated technical writing courses and engineering writing that emphasizes only lab reports, is not as productive. Ensuring stability takes energy, time, and commitment from the faculty, however—it's a challenging and difficult process, but it is rewarding and fun. The students will also be challenged, not just by trying to understand a profession they think they want to pursue, but also by being engaged in thinking through writing. Generally, that's a new concept for most of them.

For the most part, the activities we designed accomplished our original goals while providing us with greater insight into first-year students. In her evaluation of the portfolios, the external writing specialist noted

> *Such opportunities for students to reflect on their learning—what they learned, what it means, why it is important, etc.—are critical components of effective portfolios, and they distinguish portfolios from other kinds of student learned assessment (tests, essays, and so on).*[12]

The course experience, in other words, not only provided students with *information* about chemical engineering, but it offered them an opportunity to gain *knowledge* about it—that is, a means by which they could reflect about the information and place it within the context of their overall lives.

Despite problems such as course logistics, students' time constraints, and a kind of cultural resistance to writing, most students demonstrated growth in their knowledge of the profession and their use of communication as a learning tool. Additionally, we discovered that a collaboration between seemingly unrelated disciplines aids in faculty development (an opportunity to see how the other half thinks), but to be truly effective this approach needs to be transported beyond the two involved faculty members to a more globalized WAC endeavor.

Recently, the chemical engineering department voted to expand the course and now offers a full 3-credit introduction to chemical engineering on a two-year trial basis. The course counts toward graduation requirements and it is expected to become a permanent part of the department's curriculum.

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