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The University of Missouri-Rolla

The Academy of Chemical Engineers Lectureship

"Teaching Improvement Has Failed. Let's Improve the Learners!"

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West Lafayette, IN 47907-1283

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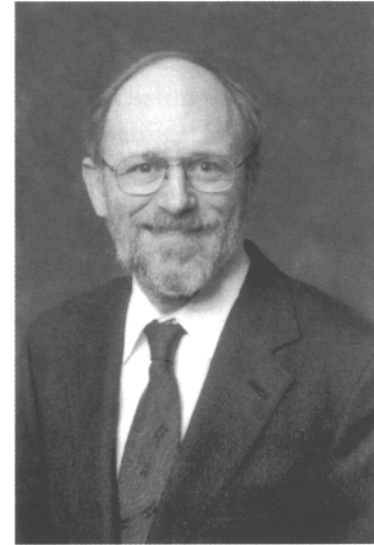
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"Teaching Improvement Has Failed. Let's Improve the Learners!"

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Abstract

There is mounting evidence that teaching improvement alone has failed. Students have high grades in high school for a modest number of hours worked. Active learning methods do show a significant difference when compared to standard lecture classes, but despite this, most engineering professors continue to lecture. Student ratings of instructors do correlate with learning, but the highest correlation coefficients that are observed are about 0.5. Thus, 75% of the variance is *not* explained by the students' perception of the teacher and their perception of what the teacher does in class. Even if we are successful in improving teaching, the effects on student learning will be modest. We can have more impact by focusing our attention on students to improve their learning.

A number of different studies have shed considerable light on how people learn, how students develop, learning styles, and student motivation. The purpose of this paper is to show how to incorporate this knowledge into an integrated engineering program to make students better learners. After exploring our students' time management and study methods with them, we need to help students develop a personalized system that will optimize their use of time. Closely coupled with this is improved advising. Students need to be encouraged or required to create a plan of study and keep it up-to-date. Professors have the responsibility to use teaching methods that involve students and result in increased learning. Various active learning methods including cooperative group learning, mastery learning, computer simulations, studio classes, guided design and problem-based learning result in increased student learning. Supplemental instruction helps students who are struggling learn material. Engineering departments can help motivate students by

organizing co-op or internship work sessions. Service learning, undergraduate research and tutoring others are additional techniques that motivate many students. Finally, parents can help motivate students, particularly if they are paying for the students' educations. Making students monetarily responsible often has a major motivating effect.

Improving student learning does not require further research and study. All of the necessary pieces have been studied and piloted. The challenge for engineering schools is to put these pieces together into a coherent program.

Evidence of Failure

There is mounting evidence that teaching improvement by itself has been insufficient to improve student learning. First, consider the percentage of first year students in college who have had an A average in high school (anon., 2002). In 1966 this percentage was 15.4, it increased to 19.7% in 1976, 22.5% in 1986, 31.5% in 1996, and an amazing 44.1% in 2001. These grades were earned with a small number of hours of study. High school seniors reported the following amounts of study outside of school: 35.7% $\leq$2 hr/wk, 29.3% 2 to 5 hr/wk, 19.7% 6 to 10 hr/wk, 8.5% 11 to 15 hr/wk, 4.0% 16 to 20 hr/wk, and 2.7% > 20 hr/wk (Bartlett, 2002). Since no one is complaining that there are too many brilliant students graduating from high school, this combination of statistics defines grade inflation.

College students do study more than high school seniors, but not a huge amount more. First year students in college reported the following study times: 20.3% $\leq$5 hr/wk, 24.2% 6 to 10 hr/wk, 19.6% 11 to 15 hr/wk, 14.7% 16 to 20 hr/wk, 9.6% 21 to 25 hr/wk, 6.2% 26 to 30 hr/wk and 5.4% more than 30 hr/wk (Bartlett, 2001). Perhaps surprisingly, college seniors did not report much more study time than the first year students. Including time in class, the average college student has a less than 40-hour "work" week. Of course, we believe that engineering students study more than these averages. However, anecdotal evidence at Purdue University strongly indicates that many first year engineering students are not studying much more than these averages. The hours per week for the average first year student in engineering are:

Class	13 (50 minute hours)
Recitation	3
Laboratory	5 In-class total 21 (actually closer to 18)
Outside class	10-15-20-25-30 ?
Grand total	31-36-41-46-51

In many cases the totals are not high enough. It takes time to break students of the bad habits they learned in high school.

Additional evidence of the failure of teaching improvement is the over-use of lectures in college teaching. Lectures have a place in

teaching, but too much lecturing is a problem because the students are passive, are often spoon-fed knowledge, don't learn how to learn, and lectures are a poor method for teaching complex skills such as problem solving, communication, teamwork and design. University-wide about 75% of the faculty relies primarily on lecture, with about 25% supplementing their lectures with active learning (Hansen and Stephens, 2000; Wankat, 2002).

But which teaching methods are better than lectures? It depends on what you want the students to learn. If differences are measured by a multiple-choice test, the most common result is no significant difference (NSD) when compared to lecture. Studies of students who watch a televised lecture versus tutored videotape versus live lecture usually result in a finding of NSD (Gibbons et al., 1977; Russell, 1999). Web-based materials are effective with older, more mature students (usually an NSD result), but are less effective with younger students (Sanoff, 1999). And students in web-based courses still need the availability of individual attention. The good news about technology is that the use of multiple teaching methods including face-to-face lecturing does result in increased learning (Dede, 1999). Active learning methods such as cooperative group learning and problem-based learning (PBL) do help students learn at higher cognitive levels such as problem solving and learning how to learn (Wankat, 2002).

There are two instructional methods that have significant increases in student learning based on multiple-choice tests. One of these methods is *mastery learning* and its variant the personalized system of instruction (PSI) (Bloom, 1968; Kulik et al., 1979). In a mastery class the students learn the material in the module using whatever teaching method – lecture, group work, homework, recitation – is appropriate. They then take a test on the material. A pass is preset at typically 80 to 90%. If they pass they continue to the next module. If they fail, the only penalty is they have to study more and then retake a new test on the same material. This procedure is continued until the students have passed all of the required modules. Passing the required modules often earns the students a C. Students are required to do additional specified work to earn a B or A. Bloom (1968) reports that 90% of the students benefit from mastery learning.

Only 5% stumble while another 5% will earn an A with any teaching method.

A second approach that has proven to be effective is *supplemental instruction* (SI). Suppose there is a core course (e.g., chemistry) that many students find to be quite difficult. This core course is supplemented with a separate, one credit, supportive, structured class – the SI course. The SI course meets between two and four hours per week. Students voluntarily register to take the SI course for a grade that is determined by attendance and participation. Perhaps the key to success is an advising process that successfully sells the benefits of SI to the students who will benefit from it so that they will *voluntarily* take the course. The SI instructor, who may be a trained undergraduate, is *not* involved in the grading of the regular chemistry course. The SI instructor gives hints on studying chemistry, taking notes during chemistry lectures, reading chemistry texts, the notation of chemistry, and preparing for chemistry tests, but doesn't lecture. The major part of every class meeting involves cooperative groups solving chemistry problems including homework (if group solutions of the homework are allowed) with the SI instructor available to provide personal attention to any group that is struggling. The students rapidly realize that the SI instructor is there to help them. The results from numerous trials are an increase in grades of the SI students in the core chemistry course by one to two letter grades (Martin and Arendale, 1994).

The bad news is that lecture tends to force out innovative teaching methods. For example, mastery and PSI courses in engineering, which were popular in the 1970's and 80's, have all but disappeared. Adoption of cooperative group learning, problem-based learning, and computer teaching methods has been very slow. Although they are more effective, these innovations tend to take more instructor time. Additional evidence that teaching has limited impact on student learning comes from student evaluations of teaching. Well-designed evaluation instruments are reliable and valid. That is, student evaluations do correlate positively with student learning (Centra, 1993; Wankat and Oreovicz, 1993). These studies are often done with multi-division courses. All the instructors agree on the course objectives, but an instructor who is not involved in

teaching any of the class sections writes the tests. Students evaluate all of the instructors using a standard evaluation instrument. The highest correlation coefficients are $r = 0.43$ between test scores and overall teacher rating, $r = 0.47$ between test scores and overall course rating, $r = 0.31$ between test scores and instructor's rapport, and $r = 0.50$ between test scores and instructor skill. Since an $r = 0.5$ means 25% of the variance is explained, 75% of the variance in learning is not explained by students' evaluation of teaching. Thus, it is reasonable to conclude that a considerable amount of learning (or failure to learn) does not depend on the instructor, and any improvements in learning based solely on improving teaching will be modest.

The final piece of evidence that the current system is not working is student retention. For example, at Purdue University the entering engineering students are, on average, the best in the university. Yet only about 56% of these students graduate with an engineering degree within six years. About 79% of the entering engineering students earn some degree from Purdue within six years. Although a larger number of students are lost during the first year, the percentage retention during the first year and the following three years is approximately the same (75%). Considering the quality of the students, too many of them drop out of engineering. Hewitt and Seymour (1992) found that students who leave engineering report the following reasons as most important (respondents checked multiple reasons):

1. Non-technical major more interesting, 59.3%
2. Lost interest in technical major, 55.6%
3. Rejected lifestyle of technical career, 51.9%
4. Conceptual difficulties in courses, 44.4%
5. Discouragement due to low grades, 44.4%
6. Curriculum overload and excessive demands, 40.7%
7. Poor teaching and unapproachable faculty, 37.0%
8. Degree will take longer than the expected four years, 37.0%

Diagnosis and Prescription

The current engineering curriculum is fundamentally illogical. When the students are in high school, their parents make sure they go to bed at a decent time and get up in time to go to school. The teachers also police their behavior and question them if they are absent or work is not turned in. In many ways their lives are structured. The students have some responsibility in a micro-sense of attending class and getting assignments done on time, but not in the macro-sense of being in charge of their lives. When they enter college, students are suddenly confronted with less structure and more freedom than they have ever had before or will ever have again. Since there is less accountability on a daily basis, students are often much less responsible than in high school. Accountability occurs at the end of the semester when grades are awarded, which is too late for students to adjust and learn from their failures.

Unfortunately, the current system simultaneously gives students too much freedom and spoon-feeds them too much. The system needs to be revised to have significantly more structure and less freedom in the first year. There should be a decrease in structure and an increase in freedom compared to high school, but the changes should be significantly less than they are currently. Then as the students progress through the four-year curriculum there should be increasing amounts of freedom with corresponding increases in student responsibility and decreasing amounts of structure. During the senior year students should have the opportunity to behave as professionals with feedback on their performance. Since students are not going to change the curriculum, the faculty and staff have to do it.

To improve engineering programs we must solve many of the problems that are highlighted by the evidence that the current system is not working. We need to increase student learning by increasing the amount they study and by making them more efficient when they study. Teaching techniques that increase student learning need to be employed (note that improving teaching is only part of a global prescription). We must work to increase retention without reducing student learning. Since the top three items on Hewitt and Seymour's list are related to advising, the retention effort must include an

advising component. Finally, we need to increase the students' motivation so that they will be willing to study and learn.

The prescription for change is described in four interconnected parts: student study, advising procedures, teaching and courses, and motivating students.

Student Study

Since learning is proportional to each student's amount of directed time on task (Bransford et al., 2000), we need to ensure that students spend sufficient time on task both in and out of class. In addition, this time on task must be "directed" -- the students must focus their attention on the tasks that need to be done and then do them efficiently. Engineering departments must work to improve students' study skills and time management skills.

First, the average amount of time students, particularly first and second year students, are spending on task must be increased. One approach is to increase regimentation in the first and second year courses. Many more of the courses should be "studio" courses and/or involve extensive recitations with students doing cooperative group problem solving (Wankat, 2002). If a modest amount of credit is given for attendance and participation, most of the students will attend and spend time on task. At the freshman and sophomore levels recitations can be staffed with juniors and seniors who have been trained in facilitating cooperative group work and are supervised.

A number of other approaches can be used to help students increase their time on task. Supplemental instruction is a very useful addition for students who need extra help on a regular basis in a structured environment. Tutoring is helpful for both the students who are tutored and the tutors. It works best if there are set hours when the tutors are available. Not only will help sessions before tests be well attended, but will also increase time on task and direct the effort to where students are having difficulties. Learning centers staffed by paid undergraduate staff are effective (Bieniek, 2002), but the staff must be trained to guide the students, not solve the problems for them.

Student study time outside of class also needs to be increased. One way to do this is to give the students assignments that they actually enjoy doing. An example is the use of simulations to solve realistic problems and ask "what if" questions. It is necessary to train the students in the use of the simulator so that they are not frustrated by their inability to get the simulator to work properly. Another way is to assign web searches, which most students enjoy, to find information. A third approach involves group course projects that let the student groups pick a topic that interests them. A fourth approach is to allow or assign groups to do the homework. Group work helps motivate the extroverts to spend time on task, and there will be less demand for tutoring and office hours when groups tackle the homework. Homework can even be disguised as "extra credit" or a debate between teams in order to spark interest and effort from the students.

Most students can increase their effectiveness during the periods they study. There are a number of books written for students on improving study habits (see references in Wankat, 2002). Any book that the students will read will be helpful. We need to teach first-year students and sophomores appropriate skills such as note taking, study skills, test taking procedures and time management methods (e.g., see Tables 8.1 to 8.4 in Wankat, 2002). A useful alternative is study skill or learning-to-learn courses, which typically increase students' GPAs by about 0.5 points (Weinstein, 1994). A combination of studying alone and then in groups appears to be optimal. Professors should encourage study groups – both for students in the same class and across years in school.

Advising Students

Advising students is important, but most college students rate their advising as unsatisfactory (Astin, 1993). Poor advising can lead to unsatisfied students who drop out. Since most professors are not trained to do professional advising and they don't have the time, professional advisors should be employed. They will do a better job advising and they are less expensive than engineering professors.

Students should work with their advisor to develop and regularly upgrade a plan of study. The advisor should use a computer to keep track of each student's progress and require students who fall behind to come in for a visit. There is no excuse for the common experience of students taking an extra semester to graduate because they took the wrong class and did not have needed prerequisites for a required course. Students who are having difficulty should be made responsible for their performance. The advisor can ask students to explain their personal time management systems. Probe to find out if they are working at a job for excessive hours – less than 10 hours per week is not a problem, but more than 20 will probably cause significant reductions in grades (Landis, 1995). Determine if the student is pledging a sorority or fraternity - a sure way to have a bad semester. Go over their weekly schedules and have them explain how they study. Teach simple time management principles such as goal setting, to-do lists, prioritization, and schedules (e.g., Wankat, 2002).

This procedure needs teeth or the students who most need help will not come in. Require students to see an advisor in order to register. Require students on financial aid to see their advisor on a regular basis if their grade falls below a given level. Someone should care about each student. Sometimes we need to show that caring by making students who are in difficulty face up to their difficulties. Provide for additional personal interaction if the student desires it.

Another approach to providing advising that has been successful at Princeton and MIT (Merritt et al., 1997) is the use of voluntary seminars for first year students. From 8 to 12 students sign up for an elective that is facilitated by a senior professor and an upper-class student who both volunteer for the assignment. The topics need to interest both the professor and the students and could include white-water canoe design, active geological processes, the Holocaust, the Franciscan order and so forth. The professor serves as the students' formal advisor and the upper-class student provides informal peer advising. When people work on a topic of mutual interest in a small group, interaction and personal attention are natural and the students soon feel comfortable talking to the professor and peer advisor.

Teaching and Courses

There are a number of teaching methods/learning activities that have been proven to lead to student learning (Astin, 1993; Bransford et al., 2000; Wankat, 2002; Wankat and Oreovicz, 1993). These include:

1. *Involve* the student. When my teenage son learns a new video game, he becomes totally involved. He tries the game, reads the manual, tries again, goes to the web site, tries again, asks friends for help and so forth. Sometimes, he doesn't even want to break for dinner or sleep. If our students will show similar involvement in their engineering courses they will learn.

2. Students actively processing material. Active processing could involve discussing the material, taking notes, doing hands-on experiments, reflecting on the material, and so forth.

3. Positive expectations. When teachers and students believe the students will learn, they do.

4. Time on task. Time on task is necessary, but *deliberate practice* is better. In deliberate practice a complex task is broken into a series of tasks. Groups try the tasks, receive feedback after each step, and correct their work before moving on to the next step.

5. Practice and feedback. The missing key element in the way professors usually provide feedback is in requiring the students to use the feedback. Try allowing students to turn in a paper or test they have corrected for more credit.

6. Challenged, yet successful. If there is no challenge, students will become bored. If they are never successful, they become discouraged and eventually give up. The challenge for professors is to maintain a balance for a heterogeneous class.

7. Some control over what and how they learn. Even within core courses some control can be given to students in choosing topics for course projects.

Enough is now known about how students learn that we can design teaching sequences to optimize learning (Bransford et al., 2000). One of the most important ideas is that students learning a new area must construct their own knowledge structures. Students always have some existing preconceptions. If these preconceptions are basically correct, they can be used to help the students learn. For example, if students know how to balance a checkbook they can easily learn mass balances. This preexisting knowledge can be used to write a simplified mass balance. By extending this balance to the government, which also prints and burns money, the complete mass balance equation (in words) can be developed.

$$Input - Output + Generation = Accumulation$$

However, if their preconceptions are incorrect, the faulty preconceptions must be explicitly attacked. This is easiest to do if an inductive teaching pattern is used. Have the students grapple with specific data (they can either collect it themselves or have it provided) *before* the lecture. Student groups can usually develop reasonable explanations for the data. Then present an organizing mini-lecture that defines terms, introduces jargon, reinforces their understanding, and uncovers any subtleties they are likely to miss. This pattern is more effective than the deductive pattern we normally use.

The curriculum needs to start with highly structured courses with a significant amount of in-class time where student groups have a chance to practice and receive rapid feedback. "Studio" classes or recitations can be used for these sessions. A very modest amount of credit needs to be given for attending and participating. Otherwise, the students who will benefit the most are likely to not attend. A few *key* courses such as calculus and mass and energy balances should be developed as mastery learning not lecture courses. Since this is a significant amount of effort, departments must decide to support the effort and not rely on the good will of a dedicated teacher. Computerization of mastery learning classes can pay large dividends for large courses. Other important courses such as chemistry, physics and thermodynamics should have a supplemental instruction course offered in tandem.

The misnamed "College algebra" course holds a special but very awkward place in engineering curricula. It covers key material for calculus, chemistry, physics and beginning engineering courses. Yet almost all engineering schools have delegated college algebra to high school. This would be fine if 99 percent of the students learned it, but many do not. The difficulty is that since college algebra is remedial in engineering curricula and does not count for graduation, students refuse to take it. If forced to do so, they are angry and resist learning it. If students who don't know college algebra are allowed to skip it, they struggle in other courses. Engineering colleges should reinstate college algebra as a required course for graduation by increasing the graduation requirements by the necessary three or four credits. Most students would test out and would be very happy because they had earned some college credits. Since those who were unable to test out would no longer consider taking college algebra to be a penalty, more of them would study and learn the material. Unfortunately, although reasonable and probably effective, this solution may be politically very difficult within universities that are trying to decrease graduation requirements.

In the junior and senior years the curriculum and courses should gradually reduce direction and control. Course should have less structure, less lecturing, more team exercises and projects, and communication skills should be built into the courses. Seniors, in particular, need experience in controlling both what they learn and how they learn it. Course projects and problem-based learning can be used to do this (Wankat, 2002). Projects will be improved if they are done as group projects with significant class time devoted to individual group meetings with the professor. Devoting class time to course projects integrates them into the course so that students do not see them as an irritating overload. Meeting regularly with student groups controls procrastination and is seen as personal attention by the students.

There are other alternatives to lecture classes for seniors. Many senior (and graduate student) electives are taught in small classes. With a dozen students or fewer consider using a modified Oxford style of tutoring (Smallwood, 2002). The professor sets the syllabus, course schedule and so forth. Then once a week the professor meets with groups of two students. One presents the material for that week while the other criticizes. The professor probes for understanding, critiques the students, and controls future directions. Since no lectures are prepared, the time commitment for a professor who has a thorough understanding of the material will be less than for a lecture course. And students will have a considerable amount of personal attention.

Another alternative is to use "Super PBL" (Wankat, 2002). This technique is appropriate for elective courses where there is not prescribed material that has to be covered. Student groups write advanced textbook chapters on topics that they select from a large list of topics. Over three-fourths of the class periods are dedicated to individual meetings with the student groups. With 24 students in groups of four, the professor can meet with each group for 15 minutes every other class period (for standard 50 minute classes). With a smaller class the groups can be smaller and meetings more frequent. In these meetings the students report on their results, and procrastination is minimized since reports of "no progress" are embarrassing. The professor listens, probes for understanding, serves as a cheerleader when student energy flags, and suggests additional material and approaches to the topic. At the end of the semester the professor evaluates the students' projects and assigns grades. Since there are few lectures, this style of course will take a professor who knows the material less time than a lecture course, and the students will learn more.

Motivating Students

Motivation is often the key ingredient that determines which students succeed and which fail. Motivation is commonly divided into intrinsic motivation – motivation from within the person, and extrinsic motivation – motivation from external sources. Since strong intrinsic motivation (or demotivation) can overcome external factors,

I prefer students to be intrinsically motivated. However, since many, perhaps most, of our students are not strongly intrinsically motivated, we need to use extrinsic motivators.

In general, the strongest extrinsic motivator is *personal attention*. With respect to interactions with people, "attention is all there is." (Bob Waterman quoted by Peters and Austin, 1985). Since students think that faculty is important, attention from faculty is particularly important. First, learn and use the students' names. Then get to know something about the students and show interest. For example, if you know a student is going on an interview trip, ask for a status report after the student returns. In relatively small classes personal interviews with every student in the class are a good way to get to know the students. One of the major problems with mega-sized classes is that faculty do not have the time to get to know many of the students.

There are a number of teaching methods that help to motivate students. Cooperative group learning motivates many students, particularly extroverts. Student challenge teams that compete for awards based on the grade point achieved by each team can be very motivating if the target seems to be achievable and the teams appear to be equal in ability. Service learning such as EPICS (Engineering Projects in Community Service) in which students can use their knowledge to help people motivates many students (Coyle and Jamieson, 1999). Engineering students tend to be motivated by equipment, processes and problems that will help them after they graduate. Thus, use up-to-date equipment and computers equipped with commercial simulators such as Aspen Plus or HYSIS. In general, any teaching method that involves students and gives them the opportunity to be successful will be motivating.

There are a number of outside-the-classroom activities that motivate students. Real world experiences such as co-operative education or internships motivate the vast majority of engineering students. And those who are not motivated often make a rational decision to leave engineering since they don't want to do what engineers do. Although many students will be motivated by the potential to make money, making money in three or four years may be

too distant for first year students and sophomores. Internships and co-op jobs in industry also motivate because the students can make money next summer or next term. Being a tutor in both informal and formal (paid) positions is motivating, and tutors are more likely to go to graduate school. The chance to do undergraduate research either individually or in teams is also motivating, and students who do undergraduate research are also more likely to go to graduate school (Tobias, 1992). Note that research is beneficial to average students, not just the superstars. Involvement in one extracurricular activity motivates, and leadership in extracurricular activities is highly valued by industrial recruiters as an opportunity to learn and practice leadership, team and communication skills.

Parents also have an important role to play in the college education of their children. Supportive parents can help particularly with first-year students when the students are feeling alone, homesick, or overwhelmed. It is helpful for professors to meet their students' parents by being available when parents visit such as during parent's day functions or homecoming. Meeting parents not only helps the professor get to know the student, but is also interpreted as personal attention by the student and helps connect the parents to the college. But parents can be too supportive. Students will benefit from having some control and responsibility for the money being spent for their education. Repeating a class that costs $2000 is much more painful if the students feel they have squandered their own money.

Summary and Challenges

The changes proposed in this paper hold the promise of increasing quality and retention simultaneously. Graduates will learn the introductory material better through mastery and supplemental instruction courses, and as a result they will have the background to learn the advanced material better. The graduates will be more mature and know how-to-learn since they will have been explicitly taught study and time management skills, and the curriculum will require them to gradually assume more responsibility for their own learning. The increased support and structure during the first two years and the conscious attention to improving advising and teaching and to motivating students will increase retention.

We don't need more research to develop this better education for engineering students. The individual parts are all known to work. The global challenge is to put together the pieces into a functioning curriculum. This will require substantial agreement and effort from the faculty, which leads to additional challenges. Most faculty are not trained in pedagogy, counseling, and facilitating student development. Such training as either Ph.D. students or as new faculty will be needed (Wankat, 2002). There will also be disagreements about how to best proceed, but these disagreements always arise when academic changes are proposed.

Another challenge is how to make the necessary changes without additional money. First, we can relieve faculty from duties that they are not particularly good at to provide them with time for curriculum revisions and teaching. Professional counselors who are trained in counseling can do routine and personal counseling better than professors and at lower cost. Better instruction in communication skills, which are critical for engineers, can be delivered at less expense by hiring people who are trained in communication skills as departmental staff. This might be a part-time or shared position. Second, we can use our students as peer counselors, peer tutors and peer instructors for supplemental instruction classes. Once the students in these peer positions are trained, they can perform at very high levels, and the experiences are extremely valuable to these students. Third, we can hire engineers with extensive industrial experience as adjunct professors and professors-in-the-practice-of-engineering (similar to clinical professors in medicine). These positions can be filled by engineers who still work in industry or by engineers who have taken early retirement. Since many of these individuals are not interested in tenure, we can be creative about the types of contracts used.

The biggest challenge at many institutions is that faculty rewards for doing research and bringing in research grants are much greater than the rewards for outstanding teaching and advising. Institutional leadership will be required to make this change.

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