Teamwork for a Quality Education:[1]

Low-Cost, Effective Educational Reform through a Department-Wide Competition of Teams

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1 Introduction

Curriculum reform is all around us. The NSF Coalitions (Coleman, 1996) are the most visible of the efforts, but reform is occurring both nationally and internationally, the direct result of a combination of higher demand for "fully assembled" engineers, the increasing availability of new information technologies, and increasingly difficult budgetary constraints. Many of the reform efforts are starting to pay off in prototype form with both anecdotal and statistical evidence of programmatic success, but increasingly a number of engineering educators—including those involved in the design and implementation of reform—are wondering if these efforts will ever—can ever—scale up to the real world of engineering education with its relentless time, curriculum credit, and budget pressures.

Time will tell which of the reform efforts make it to the everyday classroom, but this paper offers an incremental, low-cost, effective alternative to the wholesale rearrangements of curriculum topics, flow, and chunk size that seem to dominate the curriculum reform debate at the present time. A new program designed and piloted in the Department of General Engineering (GE) at the University of Illinois at Urbana-Champaign called *Teamwork for a Quality Education* (TQE) combines core ideas of time-tested industrially sponsored capstone design courses and total quality management methods into a cross-departmental program emphasizing individual, team, and departmental improvement.

Specifically, TQE creates a departmentwide competition of student-led teams, each team consisting of freshmen, sophomores, juniors, and seniors together with faculty and staff advisors. Each team is charged with obtaining the highest quality education possible for its members, and this goal is actuated through a series of competitions in three broad categories: (1) academics, (2) service and design, and (3) summer-job placement. Like little-league sports, TQE teams have corporate sponsors, usually employers of engineering graduates, with each corporate sponsor giving both in-kind and financial support toward the success of its team and the program.

The paper starts by exploring the motivation and environment of reform in the 1990s. It continues by listing a number of design principles for reform efforts, the larger vision of such a program, and the compromises required to pilot TQE in Spring and Fall 1997. The

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basic rule structure of the program is outlined, and some lessons are drawn from the pilot experiences.

Although it will take a number of years to fully integrate the lessons of this program, it appears that by combining, (1) minimal budget, time, and credit requirements, (2) competitive incentives, (3) student-centered cross-class teamwork, (4) worthy academic and professional learning goals and opportunities, and (5) faculty, staff, and industrial sponsorship, TQE is starting to create an environment for low-cost, effective engineering education reform. Because of its effectiveness, low barriers to start and expand, and the potential for corporate sponsorship and thus self-sustenance, this program may be attractive to other universities who are searching for ways to change without the luxury of large doses of federal or state monies.

2 The Need for TQE and its Principles of Operation

Another paper (Goldberg, 1996) has considered the environment, forces, and general shape of reform in engineering education. In this section, we examine both the driving needs for a program like TQE and establish important principles of operation that derive from those needs.

2.1 A Key Mismatch with Industry

Over the last two decades, industry has undergone dramatic shifts in organization. Functional organizations consisting of like-minded groupings of disciplinary experts (design engineering, manufacturing, accounting, marketing, etc.) are yielding to customer-centered, quality-driven organizations consisting of interdisciplinary teams devoted to achieving customer satisfaction on a given product or service (Creech, 1994). At the same time, the engineering academy remains largely committed to a functional model of "student processing" in which students are passed from specialized course to specialized course with minimal coordination and integration. This discrepancy between modern business practice and the academy suggests the adoption of the following design principle for useful reform:

Principle 1 (Pervasive Teamwork) *To achieve higher quality delivery of engineering education, integrated teams should be employed throughout the engineering academy as they have been employed in industry.*

The teaching and use of teamwork is not new in engineering education, but generally teamwork is localized to a classroom, a design project, or a single endeavor. In TQE, the idea is to straddle the curriculum with heterogeneous teams of students and faculty charged with the important mission of achieving a quality education for team members. More will be said about this mission in a moment, but first we examine a key element of reform that is ignored in many proposals.

2.2 Current Reform Proposals Too Costly

There have been a number of high profile efforts directed at designing the engineering curriculum of the next millennium—for example, the various NSF Coalitions (Coleman, 1996)—and

many of these are informed by the examples set in lean, agile, or quality organizations; however, much of the curriculum reform being suggested requires major overhauling of courses, facilities, teaching materials, and faculty. Such efforts are quite costly, and as a result, even when the proposed reforms "work" in pilot form—in the sense that there appear to be improvements in the delivery of a quality education—serious questions remain whether they can ever be implemented in the large, because the marginal costs are too high. In other words, many reform efforts only work because of their *subsidy by others*. The need for continuing subsidy is particularly serious at present, because university budgets, after years of substantial after-inflation increases, are increasingly coming under significant pressure. As a result, there is a need to bring sustainable reforms to the academy at low cost:

Principle 2 (Minimal Marginal Costs) *Whatever reforms are proposed for the engineering academy, they must be designed to use existing or reduced faculty-staff resources with a minimum of marginal costs.*

In fact, where possible, it is highly desirable that reform efforts generate new revenue streams to partially defray their costs:

Principle 3 (New Revenue Streams) *Widespread reform efforts should generate sufficient new revenue streams to ultimately cover a significant fraction of their marginal costs.*

Yet, even with the proper notion of what to install (pervasive teamwork) and with appropriate economic ideas of how it should be installed (minimal resources and new revenue streams), the focal point of application remains to be articulated.

2.3 Student Power and Light

In thinking about applying teamwork to engineering education, there are many sources to draw from, but Bill Creech's (1994) ideas on the implementation of total quality management techniques in the US Air Force Tactical Air Command (TAC) seemed particularly germane because he was (1) tackling a large bureaucracy resistant to frivolous change, and (2) addressing central (line), not peripheral (staff), concerns of that bureaucracy. In applying the second of these ideas to the academy, it is interesting to note that much academic quality improvement and teamwork activity has been used to dress up existing staff functions, but little progress has been made to get at the core educational mission of the academic enterprise. Even when teams are envisioned among the main players of the academy, students and teachers, either teams of faculty members are envisioned (as in team teaching), or teams of students are envisioned (as in design projects and other team coursework). Rarely, it seems, are teams of students put together to attack the primary educational mission of the university. Thinking along these lines leads to

Principle 4 (Student Power and Light) *Insofar as possible, students should be empowered to run new reform efforts, seek a quality education, and have fun.*

Of course, students are somewhat inexperienced in the ways of industry and the university. Thus, there must be a strong source of guidance and experience for each team in the process. This leads to two principles:

Principle 5 (Small Number of Carefully Constructed Rules) *A small number of carefully constructed ground rules is necessary to define the environment of activities and projects that is understood by all team members.*

This will determine the playing field upon which students strive to improve and innovate, but advice and guidance must come from a person with experience. This is the important role for faculty.

Principle 6 (Faculty Facilitation) *Each team must be facilitated by an experienced faculty member.*

Although faculty should not "do" the organizing of the reform effort, it is absolutely essential that there be a faculty member affiliated with each team, both to provide a source of guidance and experience for the team and to build personal ties between students and faculty. With these principles in place, we have almost all the pieces of the puzzle, but it seems that perhaps we are relying on a student's sense of duty and mission a bit too much. Although students are being empowered by the reform process, what will ultimately power the individual student?

2.4 Incentives, Friendly Competition, & Minimal Credit

Human beings being what they are, there is a wide range in what motivates individuals to excel. Maslow's hierarchy (1954) captures this fairly succinctly. Simply stated, human beings seek safety needs first, then social needs, thereafter ego needs, and finally developmental needs (what Maslow calls self-actualization). Although the first impulse might be to power reform through large dollops of credit, the engineering curriculum is already fairly full; it is not practical to add large amounts of required credit to "pay" students for participating in the reform effort:

Principle 7 (Minimal Marginal Credit) *Because of the fullness of the existing curriculum, an engineering education reform effort should require minimal additional hours of credit.*

What hours are added should be targeted at time-intensive activities such as concentrated team training or team projects. Regular team activities should be largely self sustaining on their merits.

When merit is not enough, however, we fall back on the Maslovian impulse to excel by rewarding outstanding team behavior through a system of friendly competition, which can be driven by a system of team incentives.

Principle 8 (Friendly Competition Among a Population of Teams) *Participation and excellence should be driven by a friendly competition among a population of teams to win team awards based on excellence in academics, projects, and other categories.*

The actual system adopted matters a great deal, and the team incentive system will be outlined somewhat later. At this juncture, we recognize that participation in the reform effort will largely be encouraged through social, ego, and developmental motives.

In the next section, we consider the pilot program started in the spring of 1997, and the modifications made as a result of that experience in the following fall.

3 The Vision and Two Pilot Semesters

The previous section considered the principles of operation for a viable reform effort. Here, we start by recapping the vision of a fully formed TQE effort, and continue by discussing the modifications necessary to the full program to permit the practical implementation of a pilot in the Spring and Fall semesters of 1997.

3.1 The Vision: Teams, Teams, Everywhere

The principles suggested in the previous section leads to a vision substantially different from the usual academic department of engineering. At present faculty, staff, and students are like billiard balls that collide with one another when a course, advising episode, or other asynchronous event calls for it. Under a fully implemented TQE program, these same collisions would take place, but the individuals would also be supported by a quasi-permanent interpersonal infrastructure of teamwork to attend to advising, support, and quality issues. Specifically, a fully formed TQE effort would involve the following elements:

1. Teams work fairly directly on achieving a higher quality education.
2. Quasi-permanent teams are created and work together over the course of an individual's academic career.
3. All students in a department participate in TQE.
4. Teams are composed of students of all class ranks.
5. Teams are student run with faculty in advisory roles.
6. Friendly competition is a prime-mover of the effort.
7. The use of class credit is minimized.
8. Companies sponsor teams with both financial and in-kind support.

Whether or not such a program can be implemented across an academic unit in a more-or-less permanent way, remains an open question; however, many of these elements were tested in the two pilot semesters, Sp97 and Fa97.

3.2 Differences in the Pilot Semesters

Specifically, the following differences were necessary in the pilot semesters to permit a practical trial.

A limited number of teams. In the original pilot semesters in the spring and fall of 1997, small numbers of teams were created over a limited subset of the General Engineering students.

All volunteers, no conscripts. In the pilot semesters, teams were composed of students who volunteer for the TQE course. In a full-scale operation, all students would be drafted onto teams. In addition, in the pilot, faculty advisors were volunteers, whereas in the full-scale implementation faculty advisors would be assigned.

Credit to all, and to all a good night. In the pilot, participants received one-hour of special-topics credit for participating in TQE. The original conception of the program was that it would work without substantial credit, except in large projects or standalone team-skills coursework.

4 The Rules of the Road

Since we were starting from a blank piece of paper, we felt that it was important to establish clear rules for (1) selecting teams and team chief executive officers (CEOs), (2) organizing teams initially, and (3) defining the competition and its evaluation. These items are covered in fine detail in the original *TQE Handbook* (Goldberg, 1997), and the remainder of the section briefly highlights the main ideas.

4.1 CEO Selection and the Team Draft

Team selection is essentially a more sophisticated version of that used in a pick-up baseball game. CEO candidates are chosen from among the TQE participants, and after giving short campaign speeches, an election is held with the top vote-getters elected team CEOs. Each CEO is then permitted to select a small number of team members called the *draft nucleus* in alternating picks. All the TQE members fill out a questionnaire regarding their motivation and goals for TQE as well as personal information, and each team's draft nucleus uses this information to determine their preferences for team members. A team draft is then held, in random sequence (and its reverse) until all TQE members are chosen for a team. Rules exist to permit subsequent trades and keep the teams roughly in balance.

4.2 Initial Team Organization

Part of the underlying idea of TQE is to give students freedom to innovate and do things differently and better than they have been done in the past. Nonetheless, we felt that it was important to require a minimum level of organization, primarily at a "constitutional" level. To that end, each team was required to submit (1) a complete roster, (2) established times for regular meetings, (3) a team name, (4) a team mission statement, and (5) a team organizational statement. The first four of these are self-explanatory, but the fifth item requires some elaboration. The organizational statement is essentially a constitution for the team, determining the rules of decision making. Each team is required to have a CEO, but otherwise, officers selection, sub-teams, and other choices are left up to the team members. The organizational statement is adopted by a simple majority vote, but the team organization is democratic (or not) at the choice of the team members. Subsequent organizational statement changes can be made, but require a two-thirds supermajority.

4.3 The Team Competition and Student Grades

Teams are charged with the overall mission of obtaining the highest quality education for their team members, but to spark what economists call the "animal spirits" of naturally competitive human beings, teams and individuals conduct projects and activities of various kinds, some of which are then evaluated and used to rank the teams in three categories:

1. academics
2. service and design
3. placement

Additional details of the scoring mechanism are available in the handbook. Some of the key measures and activities used in the competition are reviewed briefly below.

Academics. Teams are encouraged to organize themselves to help their members achieve academically. Although there are no required activities in this area, the team gradepoint average is computed at the end of the semester and used to rank each team, and this measure is weighted in the overall team score.

Service and design. Teams are encouraged to learn to work together and serve the university, the community, or local businesses in the service and design category. Within service and design a number of activities are pursued:

- large team projects (LTPs)
- moderate team projects (MTPs)
- individual activities (IAs)

A single large team project or LTP (either service or design) is required of each team, and all team members are required to participate. Project solicitation and choice is the responsibility of each team, and various oral presentations are required throughout the semester, including a final report oral presentation. The final presentations are judged by faculty outside the course, and these scores determine the LTP ranking.

Moderate team projects or MTPs are performed by no fewer than three team members and may be drawn from either service or design categories. The projects are usually of short duration (less than nine person-hours). The MTPs are not judged, but instead the MTP score is simply taken as the number of MTPs performed

Individuals are encouraged to participate in student activities within the department and college through the individual activity or IA category. Specifically, each individual can receive credit for assuming a student leadership role in a college or departmental organization (other than TQE) and for being a member of a college or departmental organization. Each student can receive a maximum of two points (one for leadership and one for membership) and the total number of points in the team is the team score in the IA category.

Individual grades. A fairly complex method of assigning individual grades was adopted in the original handbook. This method was abandoned during the first pilot semester, a matter which we will discuss in a moment.

In the next section, results from the two pilot semesters are discussed.

5 Results of Two Pilot Semesters

TQE has been run for two semesters now, Spring and Fall 1997, and this section details some of the salient experiences, midcourse corrections, and reforms introduced during that period.

5.1 The Inaugural Semester: Spring 1997

TQE was launched at the beginning of 1997 through a series of information meetings promoted with flyers and e-mail to the General Engineering student body. As a result of this recruiting effort, 42 students enrolled in the course, with 5 seniors, 14 juniors, 15 sophomores, and 8 freshmen. On the first day, three students ran for two CEO vacancies, and a male senior and a female freshman (Krussow) won the election. A draft was held, and the male senior led a team that called itself The Gerunds (sponsored by Bechtel Telecommunications and advised by Professor Goldberg) and the female freshman led a team that called itself Team Countersink (sponsored by Andersen Consulting and advised by Professor Hall). Initial icebreaking activities went well as did the preparation of mission and organization statements. Early in the semester, the course coordinator (Goldberg) was approached by an electrical engineering student (Lee) who was interested in taking the course. At the time, the course was restricted to General Engineering students, but Ms. Lee volunteered to act as an independent observer of the program. Many of the observations of this section are hers, and her detached perspective was helpful at a number of difficult junctures throughout the first semester.

During the early weeks of the semester, enthusiasm for the idea of TQE was enough to sustain the efforts, but by the fifth week when an informal feedback session was held, a lack of progress was frustrating both teams. Both teams complained that the large team size made it difficult to meet outside of class time, come to decisions, and make any progress.

The reactions of the CEOs to these difficulties was markedly different. The female freshman redoubled her efforts to get her team organized, and the male senior resigned as CEO and withdrew from the class. In departing, this individual complained that the course wasn't what he had imagined, that it was too structured, and that the individual grading procedures and recordkeeping requirements (the keeping of a journal) were obstacles to student participation; moreover, he made his complaints known to his team members. Upon returning from unrelated travel, the course coordinator designed a series of reforms to blunt this criticism. Individuals were given the option of taking the class for zero or one credit, for a grade or no-grade, and recordkeeping and individual assignments were relaxed accordingly. These reforms were presented at an emergency meeting following the CEO resignation, and the Gerunds stayed together as a team.

In fact, despite the emotional let down caused by the loss of their leader, the Gerunds held an election (electing a male sophomore—Walker) and redoubled their efforts, largely recovering from these difficulties before the end of the semester. At the time, the resignation

of the CEO seemed as though it could bring the whole program down. That it did not lends support to the notion that the program is fairly robust.

Following these incidents, the semester proceeded according to plan with each team performing their LTP and MTPs without incident. Team Gerunds' LTP was to prepare a recruiting program for high school students to make them more aware of the University of Illinois Engineering in general and General Engineering in particular. Specifically, they prepared a presentation for high school science and mathematics students, and they piloted the presentation by presenting it at a local high school. Team Countersink's LTP was to survey University of Illinois's engineering students attitudes towards General Engineering and prepare a recruiting brochure to persuade students to consider General Engineering as an option. A prototype of this brochure was completed by the end of the semester, and was recently printed professionally with some design assistance from the Engineering Publications Office.

Each team performed 3 MTPs. One team had a continuing program to volunteer in a local soup kitchen. Another team put together a bulletin board to highlight the personal side of a faculty member or teaching assistant. One team organized personnel to assist in the department's Engineering Open House (EOH) presentation, an annual college-wide event that informs high school students of the opportunities in engineering at the University of Illinois.

5.2 Fall Semester 1997

During the summer, TQE funds were used to hire one of the spring-term team CEOs (Krussow) to work on revising the course for the fall. Her efforts were particularly important, because the course coordinator was scheduled to go on sabbatical in the fall, and it was decided to proceed with a student-run and student-led operation. Thereafter in the fall, the other spring-term CEO (Walker) was hired and together the two CEOs from the first semester acted as student coordinators for the course, preparing the schedule, soliciting speakers and sponsors, and running the show. Individual faculty members advised each of the three teams, but the course itself was largely run by the students.

This change from faculty coordination to student coordination was one among a number of other significant changes made between the first and second semesters:

1. TQE changed from faculty coordination to student coordination.
2. Team size reduced from 20 to 8–10.
3. Number of teams increased from two to three.
4. Placement score removed from fall competition
5. Teamwork added as an explicit category within the competition with increased emphasis on explicit team training.
6. Team Challenge added to test teamwork under pressure.
7. Team scrapbook required as record of the semester.

As mentioned, the move from faculty to student coordination was born of necessity, but it seemed to have unanticipated benefits in terms of increasing student ownership of the program. Reduction of the team size was a response to the difficulty in arranging out-of-class meetings with the larger team sizes, and there was a notable improvement in team cohesion and activity during the second semester. Increasing the number of teams took us closer to the vision of a population of a large number of teams. During the fall semester, students are much less motivated to work on summer job and intern placement activity, and it made sense to remove that component from the score during the fall.

In considering the outcome of the first semester, we felt it was important to emphasize the T in TQE. Although the original plan was to have course time devoted to explicit team training, in the Sp97 semester this was largely not possible, because both teams were so busy getting their project work done. During Fa97, the course was kicked off by a teamwork retreat, which was followed by several team and interpersonal skills training sessions put on by personnel from the corporate sponsors. Teamwork itself was broken out as a separate category in the competition, and the Team Challenge, a half-day event where the teams were challenged to design, procure materials, build, and test an egg-drop device given fixed time and budget constraints, was introduced toward the end of the semester to put team skills to an explicit test. Student response to these changes seemed to be quite positive. In addition, one of the difficulties of the first semester was the lack of a physical record of what was accomplished and the teams of people who accomplished it. Rather than requiring yet another dry report or memo, it was decided that a team scrapbook with pictures, text, and other memorabilia would be a more vibrant way to capture the spirit of the teams.

The second semester proceeded more smoothly than the first. Although there was still some initial sluggishness, it was no where near the level as in the first semester. The existence of example mission and organizational statements was clearly a boon to the preparation of those documents the second time around. One interesting difference was that the LTPs of all three teams were outwardly oriented. Where the first projects had been oriented at helping the GE department, the projects in the second semester were oriented at helping outside agencies. Moreover, these project topics were more clearly aligned with the expertise of the team corporate sponsors. For example, a team sponsored by GTE wrote a manual for computer networking of fraternities and sororities. A team sponsored by Andersen Consulting, wrote a client database for the Women's Crisis Nursery. A team sponsored by Ernst and Young Consulting, wrote a curriculum for a new course on Information Technology Consulting. The new activities and tweaks to the course largely seemed to have their intended effect. One student reflecting on her experience with TQE wrote the following:

> My perspective on the importance of TQE is more in terms of surviving the assembly line here at the university, where they roll you down a conveyor for four years throwing difficult material at you. Very rarely does a student get the opportunity within academia to meet other students off of the conveyor. The relationship is very two dimensional. TQE took me off of the conveyor long enough to develop a more complex relationship with the factory itself—my department. I know almost all of the professors and finally have them as my instructors. I know nearly a third of all of the students in my classes. Three semesters of sitting in Loomis [a large lecture hall], staring at a man who could

only talk back from his prepared PowerPoint slides wore on my nerves. I can only imagine what it would be like for a student less prone to approaching faculty and attending office hours than myself.

With positive responses at humanizing the educational experience like these, our intention for future TQE offerings is to try to improve our delivery of these basic elements without radical surgery.

5.3 Spring 1998: A Time to Reflect

The original plan was to continue with the course into Spring 1998 as before, but despite student enthusiasm in both semesters, it was difficult to recruit students from one semester into the next. When students were asked why, the typical response was that they liked the TQE experience, but that it was fairly time intensive, and that they needed to spend some more time hitting the books. Moreover, many details of running the TQE program (rewriting the manual, preparing promotional materials, recruiting sponsors, recruiting students, etc.) were put on the back burner while the course was in progress. Therefore, it was decided that it would be useful to pause, reflect, plan, and consolidate before offering the program again as an active team competition in Fall 1998. During the Sp98 semester, students signing up for the TQE class will work on preparing the materials necessary to running the class in the fall. Plans for expanding the course to other departments will be considered, new sponsors will be sought, and promotional and instructional materials will be prepared. Whether or not a planning semester will become a regular part of the course is not clear, but some mechanism is necessary from time to time to get students to focus on building TQE so that it can improve during those semesters when it is actually run as an active team competition.

6 Lessons of TQE to Date

It is too early to tell whether TQE meets all its ambitious goals, but some lessons seem relatively clear:

Basic notion sound. The basic notion of an ongoing competition among teams appears to work. Students and faculty are enthusiastic about the program, useful projects get accomplished, and real lessons in leadership and teamwork are learned.

Stress teamwork, not individual grades. The "rebellion" of the first semester was "put down" by largely letting go of the punishment/reward implied in the usual notions of individual grades and credit. By thinking of the students as volunteers in an important mission, projects can be accomplished with carrots and little or no stick.

Smaller team sizes are more easily managed. Smaller teams were easier to get moving. We have not abandoned the idea of larger teams, but a more corporate structure would be necessary, and perhaps such a thing should emerge in response to tackling more complex projects rather than forcing it arbitrarily at the outset.

Students can take responsibility. The Fa97 experience demonstrates that this program can be largely student run with only advising input required from faculty at the margins.

Experience is time intensive for students. The TQE experience is time intensive for students, less so for faculty. This calls into question whether quasi-permanent teams can be expected to operate as the program is currently structured.

Outputs are valuable to the university and community. The projects (large and moderate) are ways to engage the teams in meaningful teamwork, and the products of these activities are often very useful to the project "clients."

These lessons largely point in a positive direction, but as we try to scale the effort up there are two issues that will affect the success of that effort. First, if such a program were to become a *required* part of some curriculum, it is unclear how well the change from an all-volunteer force to conscripts would work. It is likely that teams would have larger proportions of "slackers" and perhaps this could be partially overcome by enlarging the teams, thereby effectively discounting the helpfulness of those individuals. This approach ignores the negative effect on camaraderie and teamwork that shirking and slacker behavior engenders. The other issue that must be tackled is the "burnout" felt by continuous exposure to the full team competition. Students enjoy the TQE experience, but they need a break from its intensity. Perhaps it would be possible to designate quasi-permanent teams that compete on a less intensive basis (without the MTPs or LTPs) in most semesters and then go *active* from time to time, participating in the full-scale competition. Or perhaps teams would not be quasi-permanent, but would only form for a single semester. This solution would eliminate the burnout, but it would also eliminate the utility of quasi-permanent quality teams keeping an eye on larger curricular and advising needs. These matters deserve additional consideration and testing, but we remain optimistic about TQE as a positive force for change across the curriculum.

7 Conclusions

This paper has presented the principles, plan, and results from initial pilots of a program called Teamwork for a Quality Education or TQE. TQE is designed to incorporate teamwork and design across the curriculum at the same time it makes students more responsible for achieving a high quality education. It does this by implementing a competition among teams composed of students from freshmen to seniors in categories relevant to the academic and professional enterprise of engineering education. Early results are promising, and more work needs to be done, but we believe that TQE can form the basis for effective engineering education reform in other departments and programs at low cost.

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