Greenway College

How you can help build the school that engineers
OUR SUSTAINABLE FUTURE

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6 Teaching Philosophy and College Governance

I hear, I forget.
I see, I remember.
I do, I understand.

—Chinese proverb

"Tell me and I forget," Ben Franklin wrote. "Teach me and I remember. Involve me and I learn."

Introduction

We now address the educational program of Greenway College: its scope, pedagogy, curriculum, admission criteria, faculty profile, and governance. All these aspects of Greenway's program are designed to provide a challenging, personally rewarding educational setting for both learners and teachers.

A Broad, Narrow Mission

If Greenway tries to be all things to all people, it will fail. That is why its academic program, at least at first, will be limited primarily to engineering, technology, and the sciences, and why in its early years, all students will major in either "sustainable technology" or "sustainable engineering." The distinction between these two will be primarily based on course selection, with the technology degree having a much

broader set of options, less mathematical rigor, and different competency exams. Far from being suffocatingly narrow, these fields of study are staggeringly broad already and getting broader all the time.

But why a brand-new four-year undergraduate college? Why not a new department or graduate school in an existing university, a residential community, an industrial company, or some other arrangement?

A brand-new institution is called for, to begin with, because it will be easier to build an institution as pragmatically radical as Greenway without having to negotiate the habits, vested interests, and micropolitics of an existing institution. Second, we look to the four-year college framework because it offers an exciting array of opportunities for improving on the teacher-centered, lecture-based classroom model. This brings us to the question of pedagogy—how to teach.

Student-Centered, Active Learning

Greenway wants its graduates to make things happen. It must therefore confront the tendency of traditional programs to produce graduates who have mastered a lot of information but are too often ill equipped to put it into practice. A famous video shows graduating MIT engineers who cannot figure out how to light an incandescent bulb with a battery and a single wire.[1] Not all engineering graduates are this challenged—but it is clear that Greenway must address not only technology, but teaching methods.

From high schools to graduate and medical schools, lectures are by far the most common method of transferring knowledge from teacher to student. They are, however, a slow,

1 "Minds of Our Own," Annenberg Learner, http://www.learner.org/resources/series26.html?pop=yes&vodid=278761&pid=76#. The solution is to touch the electrical contact at the bottom of the bulb's stem to one terminal of the battery, then use the wire to connect the screw thread to the battery's other terminal.

unsure, and often sleep-inducing method of teaching, and are no good at all for inculcating practical skills. The lecture format of a typical college-level science course, supplemented with textbook problems, textbook laboratory experiments, and written exams, is ineffective for many students—one reason for the high attrition rate from such programs. A recent study of reasons for the high attrition from science, math, and engineering majors in colleges found that 90 percent of switchers (students leaving for other majors) and 75 percent of persisters said that the quality of instruction was low, raising issues of pedagogical effectiveness, assessment, and curricular structure.[2] Studies have found that high attrition is encouraged by large class sizes, inaccessible instructors, and uninspiring teaching methods, among other factors.[3] It may be just as effective to give students a textbook and let them read it on their own as to lecture them on its contents.[4] A prime advantage of the lecture method is its cheapness: one can (and many schools do) seat several hundred students at once in front of a single lecturer in, say, chemistry, and let 'er rip. This approach is at the opposite extreme from what is probably the most effective—and expensive—teaching method of all, one-on-one tutoring.

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2 Peter A. Daempfle, "An Analysis of the High Attrition Rates Among First Year College Science, Math, and Engineering Majors," Educational Resources Information Center, 2002, accessed February 13, 2012, http://www.eric.ed.gov/PDFS/ED465347.pdf.

3 D. W. Knight, L. E. Carlson, and J. F. Sullivan, "Improving Engineering Student Retention Through Hands-On, Team-Based, First-Year Design Projects," American Society for Engineering Education. (paper presented at Proceedings 31st International Conference on Research in Engineering Education, Honolulu, Hawaii, June 22–24, 2007), accessed February 13, 2012, http://itl.colorado.edu/images/uploads/about_us/publications/Papers/ICREEpaperfinalin07octJEE.pdf.

4 Lion F. Gardiner, *Redesigning Higher Education: Producing Dramatic Gains in Student Learning*, Report No. 7 (Washington DC: Graduate School of Education and Human Development, the George Washington University, 1994), accessed February 10, 2012, http://www.eric.ed.gov/PDFS/ED394442.pdf.

A classic image of the traditional method is found at the beginning of Dickens's novel *Hard Times*: "Now, what I want is, Facts. Teach these boys and girls nothing but Facts. Facts alone are wanted in life. Plant nothing else, and root out everything else. You can only form the minds of reasoning animals upon Facts: nothing else will ever be of any service to them. . . . Stick to Facts, sir!"

Since at least the 1950s, researchers have been scratching their heads over how to affordably improve on the obvious drawbacks of the lecture method. New teaching methods that attempt to break out of the lecture-based, teacher-centered scheme have in many cases (though not all) been successful. Yet these new methods remain rare, partly because their proponents are trying to introduce them *within* institutions committed for decades or centuries to the old lecture-based format. In the face of resistance from entrenched lecture-centered majorities, change is inevitably slow and difficult. Greenway sidesteps this problem: it will implement a flexible, nondogmatic range of the best evidence-based educational methods across the board and from day one.

The gist of our approach can be summed up in the phrase "student-centered, active learning." Despite negative stereotypes that contrast tough, old-fashioned methods with muddle-headed, permissive fads, student-centered, active learning does not mean lowering standards, coddling slackers, or inflating grades. It is completely wrongheaded—and the scientific evidence bears it out—to think that the suffering student learns more than the engaged self-motivated active learner. According to a 1999 National Research Council report,[5] a person's ability to recall "a rich body of knowledge in a subject

5 John D. Bransford, Ann L. Brown, and Rodney R. Cocking, eds,, *How People Learn: Brain, Mind, Experience, and School*, Committee on Developments in the Science of Learning, Commission on Behavioral and Social Sciences and Education, National Research Council (Washington DC: National Academy Press, 1999).

matter" is key to problem-solving ability in mathematics and the sciences. By themselves, though, crammed-in facts are practically useless. As educators, most of what we accomplish by such cramming is to weed out those students who cannot or will not absorb large masses of undigested fact. When we graduate the remainder, we congratulate ourselves on having taught a rigorous program, and the students are happy because they have their piece of paper that certifies their intelligence and work ethic. But can they light the light bulb?

According to the National Research Council, factual subject matter must be closely tied to an understanding of how that subject matter is interconnected, and how it is may be applied to solve new or difficult problems. The answer: *student-centered, active learning.*

Student-centered learning is designed around what students do, rather than around what teachers do. "Active learning" is a term of educational art for a class of student-centered teaching approaches. According to one review of the literature, active learning is "any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities [often in the classroom] and think about what they are doing."[6] Active-learning approaches can include lecturing, especially upon student request, but must break it up frequently (at minimum every ten to fifteen minutes) with activities and problem solving. They feature collaborative and cooperative learning, where students work in small groups toward a common goal, and problem-based learning, where problems are introduced *before* solution techniques to motivate self-directed study. For example, among other activities, students are assigned difficult problems that they

6 M. Prince, "Does Active Learning Work? A Review of the Research, " *Journal of Engineering Education*, 93(3) (2004): 223–231, accessed February 13, 2012, http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/Prince_AL.pdf.

must learn to solve on their own. They can consult textbooks or the Internet, perform experiments, or ask the professor to provide lectures, information, or clarification—but they must come up with a solution on their own.

A large body of research shows that active learning can be a radical improvement over traditional instruction (figure 6.1).[7] Many of these data come from introductory classes at large institutions, classes which tend to be large. At a small college with small class sizes, additional active-learning techniques that can further enhance learning and motivation become feasible. For example, in a smaller class, it is easier to notice when students are not learning, not engaged, or not motivated, and make midcourse corrections.

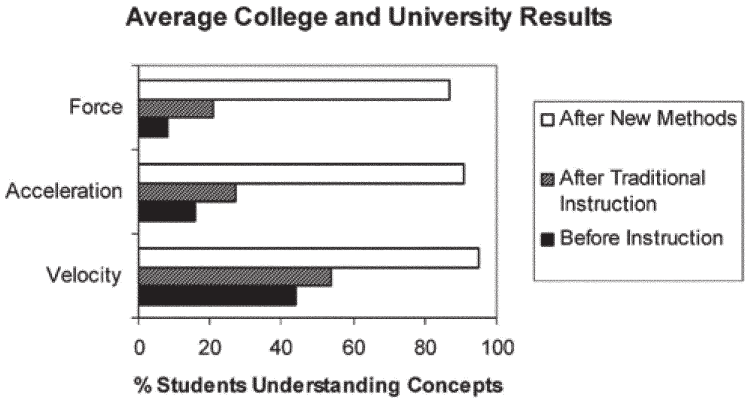

Fig. 6.1. Active-learning versus traditional instruction for improving students' understanding of three basic physics concepts (force, acceleration, and velocity).[8] The new methods produced very high levels of understanding for all concepts, regardless of understanding levels prior to instruction.

7 See the large annotated list assembled by J. E. Froyd, a professor at Texas A&M, at http://www.wmich.edu/science/facilitating-change/Products/FroydPoster.pdf (accessed February 13, 2012).

8 P. Laws, D. Sokoloff, and R. Thornton, "Promoting Active Learning Using the Results of Physics Education Research," *UniServe Science News* 13 (1999).

Finally, in a small-college setting, a focus on project-based learning and apprenticeship models offers additional forms of active learning. My personal experience in teaching project-based learning courses—building solar-powered boats and cars—for first-year engineering students validates the research: first-year students achieved remarkable results. Based on this experience, I feel strongly that many engineering topics could be taught in a project-based manner and that for many self-motivated, hands-on learners, this method is optimal. And, as active-learning proponents often point out, if one can't think of an application or hands-on project to teach an engineering concept, that concept will probably not be relevant to most future engineers anyway.

Involving students in engineering has a long history. In the 1930s, for example, mechanical engineering education at the University of Minnesota was highly hands-on. Students designed and built internal combustion engines from foundry to final assembly and testing. In keeping with the insights and principles of student-centered, active learning, Greenway's curricular design will be centered on a peer- and faculty-mentored, hands-on, project-based, problem/solution-centered approach to mentoring students within the frame of their individual education plans. Each student will be involved, starting with their first semester, in projects analyzing current methods in energy and other sustainability-related technology areas. (Research shows that hands-on design projects increase student retention.[9]) In later years of their program, students will be challenged to propose improvements on existing technologies or to perform depth analysis of the performance of current technologies, either on-site or working with industrial or municipal partners.

Students will all take required yearlong courses in "Engineering and Sustainable Technology" and will have the oppor-

9 Knight et al., op. cit.

tunity to take course modules similar to those in traditional programs—we describe the curriculum more fully below—but much of their learning will be independent or group-directed study modules. Lecture will be kept to a minimum; discussion-type learning will dominate in the classroom; students will be responsible (with help from faculty and peer mentors) for choosing many of their own projects and academic specializations. Students will continually modify their study plan with their mentor group and maintain a portfolio of their studies and accomplishments. Additionally, students will be strongly encouraged to seek apprenticeship arrangements in specific applied topics.

As Greenway College evolves, new sustainable facilities may be added or existing buildings modified to make them totally green—resource-neutral or even resource-positive (centers of energy or other production). These on-site events, though only a part of the college mission, will provide opportunities for new technologies to be explored by researchers and students. Collaborations within industry and public works will be extensive. Faculty research will be structured to bring teachers together with students, rather than draining teachers' hours from teaching.

Curriculum

Entering students will be provided copies of textbooks in core engineering disciplines. Students will take a common Engineering and Sustainable Technology course sequence through all four years to guarantee a shared core of competence, and will fill their remaining schedule with course modules that include standard faculty offerings; special-interest topics in either independent or directed-group study; project-based courses; and apprenticeship modules. Each student will have an advising committee that will assist them in laying out an individualized program of study. Students will also maintain work portfolios in concert with their plan

of study. Students seeking an engineering degree will take a set of required general-competency exams during their first three years (carefully timed and structured to minimize exam stress). Final decisions on the academic program will be determined by the founding faculty.

Below, we discuss each of these components in a little more detail.

Textbooks. In most teacher-centered, lecture-based settings, course content is compartmentalized by topic. Thus, students need only one textbook at a time, and learn material in a set order and hierarchy. Where students set their own educational path and undertake projects that call on material from many disciplines throughout their education, they will need access to many books at once. Students have complete access to the solution archives from their first day on campus, encouraging self-directed study.

Engineering and Sustainable Technology Course Sequence. All entering students will take a yearlong Introduction to Engineering and Sustainable Technology course that will cover topics important to all branches of modern engineering, such as common engineering solution techniques, software, instrumentation, mathematics, statistics, design, optimization, project management, problem solving, teamwork, ethics, history, current status, disciplines, and technical presentation/writing skills. Topics in green technologies, lifecycle analysis, design for the environment, and future challenges for sustainable technology will be addressed. Students will undertake several projects that connect these topics to practice. This course will provide a strong, consistent background for all students, introducing them to the major concepts of engineering and green technology while uniting the students as classmates.

Engineering and Sustainable Technology courses continue in every year. In addition to engineering and green technology topics and projects, the upper-level courses will cover

logistical material related to student plans, portfolio, curriculum, competency testing, and capstone projects.

Course Modules. All courses except Engineering and Sustainable Technology will be offered as multiples of three-week modules. A catalogue of standard modules will be available, but new modules may be introduced by students or faculty at any time when interest is garnered. Students will be expected to regularly meet with their advisory committee to set and evaluate their plan toward graduation. Students are expected to have a full schedule at all times, but are encouraged to sign up for independent study and off-site modules. Proposed modules include the following:

- *Traditional engineering topics*. Motion, Newton's Laws, Energy-Method Solutions, Geometrical Optics, Derivatives, Ordinary Differential Equations, Electric Fields, Basic DC Circuits, etc.

- *Special-interest technical topics*. Wind Turbine Science, Solar Photovoltaics Science, Flywheel Technology, Traditional Waste Management Systems, Wastewater Technology, etc. Some of these special topics will be set up as *project-based courses,* centered on building a device or system in the context of in-depth technical study.

- *Apprenticeship module.* Students can opt to receive credit for working closely with faculty, staff, or local (or remote) engineers or technologists to learn current practices, a technology, or an area of research. The student must propose learning objectives, format, and assessment criteria to an advising professor.

- *How Things Work sequence*. These qualitative introductory courses, including Motion and Mechanics, Thermodynamics, Electricity and Magnetism, Light, and others, will cover the qualitative content and ap-

plications of a topic through description, animation, demonstrations, reverse engineering, and small projects. More rigorous courses in each subject area will follow.

- *Nontechnical modules*. Students will be encouraged to take nontechnical modules based on their interests—history, music, art, languages, botany, literature, philosophy, psychology, religion, or others. These modules may be taught by Greenway College professors or local community residents with special interests, taken as self-directed study individually or in a group, or taken at neighboring colleges.

Plan of Study and Advisory Committee. A major part of the Greenway College experience will be each student's development of a *plan of study*, assembly of a *portfolio of work*, and completion of a *capstone project*. On arrival, first-year students will be paired with a teacher and upper-class mentor. Midway through their first year, the student will begin to write their four-year plan, and by the end of the year will have produced a draft plan and have begun to approach individuals to serve on their advisory committee.

The plan will specify between half and three-quarters of the student's courses in advance, providing structure while leaving space to explore new topics. Advisory committees will consist of three or four members, one being the primary advisor. Each student's committee will form midway through their second year and will include up to two faculty members, up to two outside professionals, and up to two peers.

At the end of their sophomore year, each student will finalize (with their committee's approval) a plan of study for their remaining time. Students will have broad freedom to shape their own study plans, but in all cases these plans must be approved by the students' advising professors.

Portfolios. The portfolio will be a collection of representative coursework, project reports, evaluations, presentations, software, and materials that summarize and demonstrate the student's knowledge, talents, projects, path of study, and work experience.

Capstone Project. In their senior year, each student will complete a capstone project. This will be similar to a senior or master's thesis, with course-module load adjusted to the depth of the investigation or project. Evaluation requirements for the project will be determined by the student in cooperation with their advising committee. The only universal requirements are midway and final progress reports and presentations.

Admissions

Greenway's success will depend not only on effective teaching, but on attracting and selecting the right students. Bright, hardworking students will be attracted to Greenway College by its unique mission and ambitious learning structure. But we must try not to admit students that would be better served by a traditional university setting—those who would thrive in lecture-based courses and whose style is not hands-on. (Greenway might not be the best place for a budding genius of pure mathematics.) Admissions policies may include one year of nonacademic, preferably post-high-school, experience—work, military service, volunteering, community theater, the whole range of meaningful nonacademic pursuits. We think that it is important for students to develop some experience outside of the academic bubble. This requirement will encourage selection of students capable of taking control of their own education.

We may also set our sights on decentralization of the admissions process through donor organization selection criteria. Here's what we mean by that: when endowment fundraising goals have been met, all students entering the college

will have direct sponsorship from a donor organization (or group of donors). The people or companies providing the donations have the option to provide a list of selection criteria and/or to provide a list of five to twenty qualified candidates. These must not discriminate on the basis of race, gender, religion, ethnicity, or political belief. Members of the college will make the final acceptance decisions.

The intent is to have companies and individual donors around the country (and perhaps internationally) helping us to select a diverse, unique set of incoming students without the need for a large, costly admissions department. This arrangement will give donors strong say in the makeup of the college while still keeping control over incoming class makeup.

Finally, we are aware that top-notch college applicants increasingly expect an international aspect to their college experience. Greenway will offer students the option of spending a half- to one full school year at another college or university, in traditional study abroad, or in nontraditional combined work study/volunteer programs. Greenway College will admit half- or full-year visiting students from other colleges, universities, and possibly industry on a competitive basis. Visiting students may make up at most 15 percent of the student body.

Faculty

The job of a good teacher is to help the student to discover their own interests, strengths, and abilities, channeling the power of curiosity to maximize learning and fulfillment. A good school encourages teachers to pursue their passions and share their excitement with the students—not corner a teacher into teaching boring material to bored students.

The first wave of faculty and staff will be hired one to two years prior to the arrival of the first student class, and will design the day-to-day details of the college before the college

opens its doors to students. Attendance by the first student class will coincide with near or full completion of the first campus buildings. We aim to open Greenway within three years of reaching the $80 million fundraising level; this timetable is short enough that, while the full contingent of faculty (about twenty full-timers) and staff will be on campus by the fourth student class, the first operating year may see as few as five to ten faculty and a first class of twenty to thirty students.

One sure-fire way to attract top faculty is to pay well. At Greenway College, pay for faculty members will be good—we project an average of $130,000 including insurance and other expenses—but not overwhelmingly so. Pay will also be relatively flat, with relatively small increases for experience and accomplishments. By not offering large monetary incentives, we will lose some excellent candidates, but we expect ample motivation to come from other sources besides money—such as the opportunity to have an extraordinarily effective teaching and research career with a discernible impact on the reengineering of the world. By making our pay system transparent—all pay scales (with names redacted) and financial policies will be available to all community members—we will discourage people from applying who see that Greenway does not meet their current or future needs.

Faculty and staff will be hired on a series of short-term contracts that sequentially increase in duration; we will not offer traditional tenure. The tenure system protects valuable faculty at institutions where powerful people can fire those who do not conform to their ideals; at Greenway, we will strive to create a democratic system in which no one person or small group of individuals has excessive power, to prevent such abuses and thus the need for their traditional remedies. We will retain, however, the ability to lay off persons who act to the detriment of the college. The proposed governance of the college will be discussed in more detail later in this chapter.

We add a word here about accreditation: recognition, by some recognized body, that a college or university meets certain standards. Accreditation by organizations recognized by the US Department of Education is the public's ultimate guarantee that a school is not a fraud or scam. All serious colleges are accredited, and Greenway shall be too. Certain alternative colleges, such as Hampshire and Marlboro, have already been fully accredited by the New England Association of Schools and Colleges; both are highly progressive, with students designing their own programs. We are therefore sure that Greenway College will be able to promptly meet the requirements for general accreditation without sacrificing its educational freedom and mission. Engineering accreditation through the Accreditation Board of Engineering and Technology (ABET) may not take place until the educational program is well in place and tested, likely several years after being established. Accreditation by ABET is not overly restrictive: the group modernized its requirements in 2000, and now encourages new engineering education programs and schemes. In many ways, the Greenway College curriculum is exactly what educational researchers in ABET would love.

Governance and Administration

Last, and hopefully not least, we come to the question of how the college will run itself. As with pedagogy, we propose to break with traditional methods in some respects, but reasonably, not rashly.

Many private colleges and universities today are set up in quasi-democratic arrangements, with a faculty senate and student senate. However, these entities typically have limited power to run the institution: real power rests with the board of trustees and the president. This setup actually works well in most cases, but it is only superficially democratic.

Our intent at Greenway College is to create a fair balance

of real, operational power among donors, faculty, staff, students, and local community members. Much care will be taken to keep the college's self-governance democratic, maintaining operational flexibility, fairness, and the ability to act quickly and decisively, and preventing "poisonous" elements (e.g., people who develop personal obsessions or grudges) from blocking up the system. Major donors to Greenway College will, we believe, appreciate the college's transparent administrative structure and democratic commitment, which echoes basic commitments of American governance. Indeed, the US constitution is a most effective plan for fair democracy, and on it we base our administrative proposal. A college is not a country—it is smaller, and different in nature—but much of the wisdom of the Founders can be transposed into this setting.

At Greenway, therefore, an Executive Council corresponds to the presidency in the US government—the top authority of the executive branch. The legislative branch consists of a Faculty Senate and a House of Representatives, the latter having members from the faculty, students, staff, and community. A Judicial Board will consist, in the college's early years, of five founders of the college, likely comprised of donors, designers, or early faculty. This branch is charged with maintaining and expanding on the original vision, goals, and mission of the college.

The day-to-day business of the college will be executed by a somewhat traditional administrative structure. Additional to the staff and faculty already listed elsewhere, administrative staff includes a provost, administrative assistant to the Executive Council, and half-time treasurer.

Executive Council. The Executive Council approves (or vetoes) measures passed by the Senate and House, proposes changes and courses of action, and generally leads the college. Also, it is the primary fundraiser and typically makes recommendations for hiring, expansions, and future plans. It can

take certain actions without prior approval of the Senate and House, but all actions will eventually require approval.

Faculty Senate. The Faculty Senate and House of Representatives have control over all legislative issues, including curriculum, community outreach, projects, and some finance. Bills must pass both the Senate and House and be approved by the Executive Council (with provisions for veto overturn). Decisions of the legislature are subject to review by the Judicial Board.

All faculty members are members of the Faculty Senate, with one vote each. The dean of faculty assumes a role similar to the vice president in the US Senate: presiding, but voting only to break ties. All voting rules, such as two-thirds override of a veto, impeachment, and association with the House, parallel those of the US Senate where possible.

House of Representatives. The House will consist of representatives from staff, faculty, the student body, and the local community, and will otherwise mirror the US House of Representatives. At the outset, we suggest four representatives from each group for a total of sixteen members. (As the college population grows, the House may grow proportionately, as does the US House.)

Judicial Board. Founding members of the college will populate a five-person Judicial Board. These members will elect a new member whenever a member wishes to step down; members can also be removed by impeachment by the Congress, in which case a new judge will be selected by the Executive Council. The Board's job is to make sure the college sticks to its mission and course. It can strike down measures that it sees as outside of this mission. In this manner, it acts as a watchdog for the long-term interests of the college. It is charged with keeping the college government lean and responsive, preventing overlegislation and promoting academic freedom.

We believe that a democratic, checks-and-balances form

of college government modeled on the world's oldest functioning, written constitution, that of the United States, will benefit our educational goals. Students and faculty will know themselves as stakeholders of Greenway College, academic citizens rather than mere customers or employees. We believe that as such they will act more responsibly while members of the Greenway community—and donate more generously as alumni of it!

Concluding Thoughts

Some students always manage to learn regardless of teaching style and curriculum, and some teachers always manage to teach rigorous, enjoyable courses even in the most straitjacketed, lecture-based settings. But this doesn't mean that pedagogy doesn't matter. Many students—some of them apparent success stories—are embittered and discouraged by tedious, abstraction-stuffed, needlessly harsh science and engineering programs. It is not even unheard-of for programs to announce to first-year students that it is *policy* to drive a third of them to drop out in despair by the end of their sophomore year. And even the most entertaining professors fail to reach large numbers of students who go on to become fine technical professionals. The cumulative human and monetary cost of generations of such waste is staggering!

Therefore, we must not settle for old methods because they do not fail completely and in every case: that is not good enough. We must provide a learning framework that minimizes useless stress while promoting rigorous excellence. At Greenway we will do our best to help every student we admit to meet our high standards for graduation; we will strive to build an educational program that encourages students to perform at their best while finding their studies fulfilling, enriching, enjoyable.

At the same time, Greenway will attract the finest teachers and support them in integrating teaching with

research. Nothing is more satisfying to a good teacher than to see students become engaged, self-motivated, and interested in the material. Thus, we strongly believe that Greenway's proposed program will bring out the best in both students and faculty.

Greenway will not be a degree mill. It will be an accredited four-year college, yes, but also a center of technological excellence, a thought leader in an explosively growing field, a catalyst for change, and a vibrant, democratic community.

Through applied know-how, a better world is possible.