



A Whole New Engineer

The Coming Revolution in Engineering Education

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with Catherine Whitney



Douglas, MI

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To all engineers who embrace challenges and opportunities
with passion, courage, connection, and skill

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Introduction

An Improbable Journey

This book was not supposed to happen—at least, that’s our conclusion as we review the improbable events that brought it into being. It emerged out of several extraordinary circumstances: the collaboration of people who ordinarily never would have been working together, the establishment of a college that never should have been built, and the creation of an incubator that didn’t have permission to exist but went ahead anyway. In the wake of these unlikely occurrences, a bunch of engineers found a surprising key to engineering education transformation. And it, too, was unexpected. This book is the story of unlikely events that led to a surprising conclusion.

There have been plenty of organizations and individuals trying to change engineering education in recent decades. There have been dozens of books, research papers, and reports. The idea has great traction. The National Academies have been working on it seriously, as reflected in reports such as *Rising above the Gathering Storm*. The National Science Foundation has poured millions of dollars into efforts to change engineering. The National Academy of Engineering produced an ambitious project, the Engineer of 2020. The Duderstadt Report, *Engineering for a Changing World: The Millennium Project*, received wide interest. The President’s Council on Competitiveness focused on engineering education as a key initiative. Across the United States and internationally, more and more people are taking engineering education reform seriously. And things are starting to happen. Both of us have worked with institutions around the world, and we see the energy that people are bringing to curriculum change efforts. We’ve also seen increasing levels of

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institutional support for change. Nonetheless, advances have been slow to come. Too often, exciting initiatives that looked promising have slid back into business as usual. Against that backdrop, a small group of engineering educators began doing some unconventional things and made some surprising discoveries.

Our story of the journey begins with the founding of Olin College in Needham, Massachusetts. Like any start-up, Olin was born in an atmosphere of enormous energy, with the bold and somewhat hubristic goal of reinventing engineering education. Mistakes were made, and sometimes the process was messy—even embarrassing. But despite the bumps along the way, Olin has been enormously successful. By conventional metrics (e.g., quality of incoming students, placement rates and salary levels for graduates, national rankings), Olin performs extremely well. In addition, Olin is now internationally recognized for its thriving, innovative, student-centered educational environment, which values intrinsic motivation; collaborative, project-based classroom settings; and a “whole-mind” approach to learning. Not even a decade old, Olin is widely seen as a beacon for other engineering schools.

However, the nagging concern among those at Olin, as well as those who were inspired by Olin, was that by its nature this rare start-up was unique and could not be replicated in existing schools. Olin, with its large endowment, tiny student body, and explicit focus on engineering education, didn't look anything like their institutions. We often heard the skeptical refrain from other educators, “If you gave me a \$500-million endowment and kids with 1500 SAT scores, I could do that too.” We wondered about the extent to which it was true.

Meanwhile, in a very different setting, at the University of Illinois, a group of faculty was starting up a small incubator called iFoundry to experiment with what seemed to be minor changes. They, too, were struck by what was occurring at Olin and even formed an institutional partnership with Olin—something that had never been done before. Still, they realized it was one thing to start a college from the ground up and quite another to change a huge bureaucratic university from within. With extremely

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limited curricular space, very few financial resources, and no power to compel academic departments to take part in the reform effort, we referred to iFoundry initially as a “peashooter of a program.” The shock came when iFoundry’s initial small-scale approach, which consisted of one course and an extracurricular program, achieved a tremendous rippling effect of student engagement and innovation.

How did that happen? How could iFoundry, working on a shoestring, get an effect similar to that of Olin? Olin had spent half a billion dollars to create a transforming vehicle for engineering education—and Olin started with a blank slate. iFoundry spent maybe a couple hundred thousand dollars, within the confines of a huge research institution. It seemed impossible, and yet it happened.

As we reflected on these experiences, we came to recognize that our initial thinking about the keys to educational reform was wrong. The key variables weren’t pedagogical. They weren’t financial. They weren’t curricular. They weren’t research. They weren’t any of the usual things we’ve always talked about as the engines of change. The variables were deeply *emotional* and *cultural*.

In *A Whole New Engineer*, we’ll tell the story of our improbable collaboration and what we, along with like-minded colleagues, discovered about the importance of these components in transforming engineering education. We’ll describe how our experiences at Olin and iFoundry led us to uncover five pillars of engineering education that create both the spirit and the results we were looking for. Rather than focusing on content, curriculum, and pedagogy—which are the typical areas where these discussions start and finish—we go off the beaten path to explore the emotionally intrinsic values that enable students to accomplish great things and to experience meaning in their lives and work. Using these pillars as a guide, we highlight some of the manifestations of the educational transformation we’ve witnessed and describe these experiences through the voices and reflections of many faculty, students, and educational innovators.

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The emotional transformation of engineering education isn't magical thinking. Nor is it a vague abstraction or a series of touchy-feely practices. It is based on a philosophy of education that is grounded in the real world and in the lives of the students we serve. It's available to everyone. It isn't expensive. It can't be accomplished in the old paradigm under the old assumptions about how education change happens, but in the right atmosphere, the change flows organically from the students themselves. That atmosphere requires systematic language change, culture change, and personal change by students, faculty, and all the stakeholders in education.

To read this book is to join us on a journey into the mind, heart, and body of engineering—illuminating the possibilities that exist when we begin to shift our thinking and feeling about our field. We'll show living examples of educational breakthroughs, provide a window into our own failures and successes, and raise the most critical questions for engineering education: How do we produce the innovators that are needed for our times? How do we inspire students to become intrinsically motivated to learn? How do teachers step down off the stage and involve themselves as coaches inside and outside the classroom? How do we renew the culture of engineering education to make it relevant, creative, and fulfilling? How do we harness the best ideas about change and make use of them in educational settings?

This is not a theoretical exercise but a lively engagement of ideas and stories demonstrating what it is like to be on the front lines of an educational revolution. We are eager for those on the journey to make their voices heard, and we hope this book gives people permission to talk about emotional variables—which many find hard to do. We open the conversation in the spirit of learning and sharing, to find the meaningful breakthroughs that will transform the field we love so much. The journey continues, and we welcome the surprises that are still in store.

David E. Goldberg
Mark Somerville

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Engineering Happiness The Olin Experience

M.A. Rosenoff: *“Mr. Edison, please tell me what lab rules you want me to observe.”*

Thomas Edison: *“There ain’t no rules around here. We’re trying to accomplish something.”*

The year was 1885. A new outfielder for the Detroit Wolverines, twenty-five-year-old Franklin W. Olin, had acquired a more than respectable batting average of .316 playing for Washington and Toledo in the major leagues of the day. He would only play one game for Detroit, and baseball would not become his profession. Another vision called to him. At the same time he was playing ball, Olin was a student of civil engineering at Cornell. While there he combined his love of baseball and engineering, inventing the first indoor batting cage in college baseball. Ultimately, his achievements in engineering, not sports, would put him on the charts.

Olin was an innovator and a problem solver. In 1892 he started a company to manufacture blasting powder for mining. From this start, he built his fortune by modernizing ammunitions systems and delivery,

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something that was in great demand during World War I and World War II, where his contributions were heralded as being decisive. By the end of the Second World War, Olin's companies employed more than sixty-two thousand people.

It is a great gift to be as distinguished and prosperous as Olin became, but he never lost sight of his humble roots as the son of a rural working-class machinist. He was drawn to the plight of young people who could not afford good educations. He often recalled his own long struggle, noting that his short-lived professional baseball career was actually a summer job to earn money for college. Seeking a higher mission, in 1938 Olin plowed a large portion of his fortune into the charitable F. W. Olin Foundation. His goal was to provide opportunity to those who were less fortunate. Among his early grants was the creation of a vocational high school in his hometown of Alton, Illinois. The superintendent recalled how the elderly Olin showed up on his doorstep one evening and to his astonishment asked whether he'd like a school. As Olin put it, "I don't want the youth of the present generation to encounter the same difficulties in obtaining a useful education that I had to overcome when I was a boy."

For sixty years, the F. W. Olin Foundation awarded grants totaling more than \$300 million to construct and equip seventy-eight buildings on fifty-eight independent college campuses. The majority of the grants were for engineering and science buildings, but there were also grants for libraries, information technology, business, the humanities, and the arts. The foundation continued its work long after Olin died in 1951 at the age of ninety-one. However, by the 1990s problems of planning, succession, and purpose were taking hold, and the board felt beleaguered.

In particular, Lawrence Milas, the foundation president, was experiencing an identity crisis. As the problems in engineering education grew increasingly apparent across the nation, with a continuing decline in enrollment, he worried that the foundation's funding wasn't having a real and measurable impact on educating engineers. Milas felt that something different was required. But what? He brooded about it so much that his wife, Marjorie,

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grew exasperated. “Why don’t you just start your own damn college?” she asked. Milas laughed off the remark, thinking a person would have to be crazy to do that.

But the idea would not let go. It seemed a fantastic dream, to start something from the ground up instead of supporting and tweaking programs in existing schools, with all their inherent strictures. Looking for inspiration from the founder, Milas went back and began reading foundation board minutes from the 1940s. There he discovered that not long before his death, Olin had floated the idea of starting a new institution. For Milas this was a sign that creating a school would be true to Olin’s ideals. In early 1993, he approached the board with a radical idea—that it take the entirety of its endowment and pour it into a visionary new entity that would change engineering education, going out of business in the process. The board viewed Milas’s idea as a high-risk proposition. What if it didn’t work? Did they dare to put Olin’s legacy on the line with such a scheme? Despite their concerns, however, the board members voted to allow Milas to investigate the matter further.

The coming years were devoted to study and consultation with leading educators, businesses, and organizations such as the National Science Foundation and the Accreditation Board for Engineering and Technology. They kept encountering the same feedback: engineering education was desperately in need of a renovation, but no one seemed to have an answer as to how that might happen. They first considered giving the money to an excellent engineering school, then to a fine private university with everything in place except an engineering school. Both options would have had little effect on changing education. Finally, they concluded they had no option but to start over and create an entirely new entity.

In 1997 the board voted to launch a school as a laboratory to test a new direction in engineering education. Free of encumbrances from the past, it could be anything they imagined. The Franklin W. Olin College of Engineering was chartered in Needham, Massachusetts, with an initial commitment of around \$200 million, one of the largest grants in

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the history of American higher education. Of the school that was his brainchild, Milas said, “The new school will be dedicated to developing

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—Lawrence Milas

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With the imprimatur of the Massachusetts Board of Higher Education and a scheduled date of opening for the fall of 2001, Olin College was in the works. The foundation purchased seventy-five acres of woodland from Babson College, adjacent to the school on the Needham-Wellesley town line, and began construction. A 1997 statement of purpose for the charter to the Massachusetts Board of Higher Education defined the bold dream:

We envision a 21st Century in which the industrial and commercial community is truly a global marketplace. . . . We believe that modern engineering education provides the optimum basic preparation for the leaders of the future we see. We believe that engineers will continue to be expected to practice their profession in the traditional technical capacities. In addition, however, we believe that engineers will be called upon and must assert their leadership as managers of technology-based commercial ventures and governmental agencies, as senior corporate leaders, entrepreneurs, political leaders, and as specialized professionals in the fields of medicine and law. We believe that engineers will be so important in this future society

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because their education uniquely provides them with the essential knowledge, skills, processes and perspectives to understand the complex system that modern life has become. Many educational programs provide graduates with either the “know how,” the “know why” or the “know when.” The Franklin W. Olin College will enable its graduates to develop within themselves the necessary synthesis of these three ingredients to emerge as the effective leaders needed to chart our course through the future. In short, we see a future in which an undergraduate engineering education becomes the true “Liberal Education,” i.e. an education which liberates one to lead a personal and professional life of full citizenship in one’s local, national and global communities.

The founding precepts stated the goal more directly: “Olin is intended to be different, not for the mere sake of being different, in order to become an important and constant contributor to the advancement of engineering education in America and throughout the world. . .”

Employee number one

Richard K. (Rick) Miller, then dean of engineering at the University of Iowa, had a revelatory experience early in his career. While teaching at the University of California, Santa Barbara, and trying to raise a family on his meager salary, he took on a consulting job with Astro Research Company that lasted fifteen years and changed his life. The task was to design a spacecraft for chasing Haley’s comet. It was a real and important program, and it challenged everything Miller knew. “I thought I was an engineer,” Miller reflects, “but I discovered I wasn’t. There weren’t answers in any engineering textbook about how to do what we were doing.”

During his experience, Miller learned that what engineering was really about was designing—“not a body of knowledge but a process, a way