THE WHOLE STORY

How whole-brain thinking revolutionized the McCormick School of Engineering philosophy, curriculum, and community
Never mind that he doesn’t remember when or how the whole-brain philosophy occurred to him, or that he never experienced an aha moment or sudden flash of insight about the concept. Julio M. Ottino, dean of Northwestern Engineering, has lived and led as a whole-brain engineer for decades.

Born in Argentina, Ottino grew up with a passion for both the physical sciences and visual arts. As a long-time painter, he finds catharsis in creating new works of art. In his experimental and theoretical pursuits as a chemical engineer, he strives to discover the connection between chaos and fluid mixing. This work not only affects the fields of complex systems, fluid dynamics, microfluidics, and geophysical sciences, it has also produced swirling images with an undeniable aesthetic appeal.

“I have always had a math side and an art side,” Ottino says. “I’m fascinated by the role of visualization and imagination in chaos and complexity.”

He flips through a copy of a book he co-authored, The Mathematical Foundations of Mixing (Cambridge University Press, 2006), points to the schematics, figures (all of which he drew), and photos, which are sprinkled throughout to illustrate the chaotic flow structures of mixing fluids, and adds, “For me, math and images go together. Math can be explained in terms of pictures.”

Revealing itself piece by piece, Ottino’s vision for merging art and science eventually became the backbone for Whole-Brain Engineering, the McCormick School of Engineering’s guiding principle for more than a decade. His non-linear approach to developing and implementing the whole-brain philosophy mirrors the philosophy itself. Whole-Brain Engineering avoids finding shortcuts to produce quick answers. Instead, it embraces taking time to frame the problem correctly, trying often and failing repeatedly, and collaborating with diverse groups of people who might debate and disagree.

That Ottino cannot recall when he coined the term “Whole-Brain Engineering” or initially outlined his vision is also fitting. “There are lots of pieces in a complicated network,” he says. “It may be work for some people, but I can see the pieces of the puzzle. The final piece isn’t special. It’s different only because it is the last one.”
PRIZE-WINNING PHILOSOPHY

Whole-brain engineers merge the analytical and technical components of engineering (left brain) with creativity, design, and divergent thinking (right brain). Since Ottino articulated it definitively in 2005, this interdisciplinary approach for developing leaders has led to new Northwestern programs and initiatives for engineers and non-engineers alike and has attracted the attention of other engineering schools and communications media worldwide.

The accolades peaked in January 2017 when the National Academy of Engineering awarded Ottino the Bernard M. Gordon Prize for Innovation in Engineering and Technology Education. Established in 2001, the Gordon Prize is the nation’s highest honor for engineering education.

The Gordon Prize recognizes leaders in academia who have developed new educational approaches to engineering. In Whole-Brain Engineering, Ottino has delivered much more than a new approach; he has completely reframed and reimagined how engineering is taught and practiced.

Northwestern President Morton O. Schapiro notes, “Julio’s leadership and vision have helped form a new culture of collaboration at McCormick with far-reaching effects across the University and beyond. He has made engineering central to numerous initiatives across the University’s disciplines—music, journalism, social sciences, and law—and led collaborative partnerships with premier institutions.”

In response to receiving the award, Ottino says, “It’s an incredible honor to be recognized on behalf of the outstanding faculty and staff for the work we’ve done. From the beginning, we set out to reframe engineering, emphasizing that engineers should be defined by how they think, not just by the things they make.”

WHY WHOLE-BRAIN ENGINEERING?

The Whole-Brain Engineering philosophy, however, encompasses more than combining different ways of thinking. Ottino views it as a tool to tackle many of life’s greatest challenges, including environmental degradation, hard-to-treat diseases, the future of work, and economic disparities.

Take the Great Recession, for example. Ottino quotes an International Monetary Fund that attributes many of the world’s major crises, including economic downturns and rising unemployment rates, to uniformity of thinking. “Economists couldn’t predict the crises because they all said the same thing,” he observes. “They operated in an echo chamber. Without different modes of thinking, they were subject to paralyzing biases. They couldn’t see the problems in a complete way.”

While he says that engineers are “excellent problem solvers,” Ottino says not much is gained by solving correctly the wrong problem. That’s where right-brain thinking comes in. Using human-centered design, for example, engineers must interact and empathize with clients to pinpoint the clients’ often-unarticulated needs.

“The world is constantly changing, with new needs and challenges emerging every day,” Ottino says. “We cannot continue to use old ideas to address new challenges. We want to produce students who are best suited for this new reality.”

WHOLE-BRAIN THINKING combines non-negotiable left-brain skills to solve problems with right-brain skills to see those problems through a new lens. Dean Ottino says that this combination of skills helps engineers imagine—and build toward—an ideal future. Here’s a side-by-side look at the different right- and left-brain skills that make up whole-brain thinking.
“THE WORLD IS CONSTANTLY CHANGING, WITH NEW NEEDS AND CHALLENGES EMERGING EVERY DAY. WE CANNOT CONTINUE TO USE OLD IDEAS TO ADDRESS NEW CHALLENGES. WE WANT TO PRODUCE STUDENTS WHO ARE BEST SUITED FOR THIS NEW REALITY.”
Northwestern Engineering puts its whole-brain philosophy to work not only in the classroom, but also in its research, in collaborative initiatives on and off campus, and in the world at large by educating and inspiring the leaders and entrepreneurs of tomorrow.

Our whole-brain approach to engineering encompasses five elements: analysis, leadership and personal development, collaboration, design, and entrepreneurship. Here’s how we integrate those elements and set them into motion.

**THE WHOLE-BRAIN NETWORK**

**ANALYSIS**

- Engineering First, with its innovative Engineering Analysis and Design Thinking and Communication courses, introduces first-year students to the fundamentals of a rigorous engineering education alongside practical applications and experiences that emphasize the power of communication.

- Engineering Analysis engages students with engineering concepts from the beginning of their first year, including linear algebra, engineering mechanics, physics, differential equations, and MATLAB programming.

- Design Thinking and Communication challenges students to work on solving real clients’ problems while strengthening communication skills so others can better understand and use the results.

- Collaborative and cross-disciplinary research is most apparent in the dozens of research labs that continually produce the innovations of tomorrow. We are making strategic investments in research areas that will drive our progress in the coming years. Our award-winning faculty, including several national academy members, work across disciplines to create new knowledge while maintaining a solid grounding in the fundamentals.

**LEADERSHIP AND PERSONAL DEVELOPMENT**

- The Center for Leadership helps students improve their skills in an environment that nurtures experimentation and innovation. The center’s portal offers them opportunities to assess and advance their leadership and teamwork capacity through two innovative tools:

  - The 360° Leadership Assessment collects insights from professors, classmates, and others to help determine a student’s leadership strengths and weaknesses.

  - The Teamwork Assessment, based on industry best practices and proprietary research, identifies typical teamwork problems at the individual and group levels and provides a process for solving them.

- The Office of Personal Development empowers students to take ownership of their learning and personal growth by fostering five core competencies: awareness, optimization, fidelity, resilience, and self-reliance. It offers several innovative courses that pull engineers out of their comfort zones.

- Emotional Intelligence 101 gives students skills to manage stress, express themselves, build interpersonal relationships, and make decisions.
**COLLABORATION** means working with partners across disciplines to tackle complex problems from multiple angles. Northwestern Engineering actively pursues formal collaborations with nearly every school at the University to enable students and faculty to explore different modes of thinking, break free from stereotypes and academic silos, and brainstorm new ideas.

Northwestern Engineering, with an eye toward combining left-brain and right-brain thinking, has established several ongoing collaborations with artists.

The Dean’s Seminar Series has developed a popular partnership with the Mary and Leigh Block Museum of Art that features artists as guest speakers. The series recently included Jen Bervin, a multidisciplinary artist who used nanofabrication techniques to print an original poem on a silk biosensor.

Data as Art, led by faculty at Northwestern Engineering and the School of the Art Institute of Chicago, challenges engineering and art students to work together to visualize complex data as works of art that communicate numbers in new ways.

Northwestern Engineers often collaborate with researchers in the humanities, medicine, and law.

**DESIGN** is essential for whole-brain engineers. Our view of design is broad, extending seamlessly from research and product design to systems and services design.

The Segal Design Institute, a foundational part of Northwestern Engineering, educates the next generation of design thinkers and leaders. It provides a variety of immersive, interdisciplinary programs for undergraduates, graduate students, and working professionals.

Courses such as Design Thinking and Communication help hone students’ problem-solving and communication skills through practical experiences. A DTC team of four first-year students working with Chicago’s Shedd Aquarium recently designed the Roll N Wash, a wheelchair-activated foot pedal that turns on the water at a hand-washing station outside the aquarium’s Stingray Touch exhibit.

PhD students at Segal work in the Design Cluster, which brings together dynamic faculty to discover, develop, teach, and practice the common principles and techniques underlying design and idea creation.

Design for America, founded at Northwestern, is a national network of campus studios where students work in interdisciplinary teams with local community partners to design solutions that promote social good. A Northwestern DFA team recently tackled cycling safety in Evanston by designing road signs that encourage bikers to use hand signals.

**ENTREPRENEURSHIP** is innovation brought to life. Entrepreneurship and innovation thrive everywhere at Northwestern, from centers and institutes to coursework and student groups. Northwestern Engineering strongly supports entrepreneurship by offering highly focused coursework, valuable resources, and mentorship.

The Farley Center for Entrepreneurship and Innovation brings together faculty from multiple disciplines and various University schools to develop courses and student experiences across the entire innovation lifecycle, from ideation to prototyping to business plan development.

NUvention brings the world of startups into the classroom through a suite of courses in which students design, plan, and launch their own businesses. The courses bring together students from nearly every school at Northwestern. NUvention: Medical, the first course developed nearly 10 years ago, brings together students from engineering, law, medicine, and business to develop new medical technologies.
“Northwestern was my number one choice because it emphasized the whole brain. You can have all the data and technical skills in the world, but that’s not worth anything unless you can communicate your ideas and apply them to the real problems. The creativity that I use in ceramics is the same creativity that allows me to brainstorm in a design session. And that same creativity helps me apply my understanding of physics to solve a math problem.”

MAXWELL LEEF
mechanical engineering sophomore, ceramics artist

“I love that McCormick requires us to take courses outside of engineering so we can gain a broader perspective and knowledge. In French, I have to consistently rework what I’m saying to make sure that it fits the French language structure. In engineering, I am similarly reworking designs or altering my point of view.”

BOBBIE BURGESS
manufacturing and design engineering junior, minoring in French

DTC: THE ENTRY POINT

All Northwestern Engineering first-year students know the letters DTC.

Launched in 1997, Design Thinking and Communication forms the cornerstone of the Northwestern Engineering experience. Dean Julio M. Ottino views it as the “entry point” to Whole-Brain Engineering. For students who have temporarily suppressed their creativity or focused solely on left-brain capabilities, DTC may very well be the first time they can reactivate whole-brain thinking.

Co-taught by faculty from the Cook Family Writing Program, DTC challenges students to attack potentially unsolvable problems by using design thinking to study problems from multiple perspectives, frame the problems correctly, communicate their ideas clearly, and ideate, prototype, and iterate solutions.

DTC: A STUDENT’S POINT OF VIEW

“I could never draw like the students in studio art classes, so I thought I must not be creative,” says junior Bobbie Burgess. “I thoroughly enjoyed DTC and learned most of my shop skills through the class.”

During her DTC experience, Northwestern Memorial Hospital challenged Burgess and her team to solve a common communication problem. Because trips to the emergency room are sudden, unexpected, and emotional, patients rarely bring phone chargers. Their phone batteries ultimately drain, making it difficult or even impossible to contact family members.

Burgess’s team attempted to solve this problem by designing a waterproof, tamper-proof, easy-to-use, portable cell phone charging station for hospital rooms. The students vacuum-molded a plastic covering over an electrical plate to make the charging station secure and added a shelf to keep the phone from dangling.

The elegant solution resulted directly from the whole-brain process: a team of students from different backgrounds collaborating on framing the problem correctly and iterating solutions with feedback from the outside client. “Diversity of thought has helped me grow,” Burgess says. “Having different perspectives is always important for your overall sense of how the world works and operates.”

She adds, “I do think I am creative now. I’m digging out that side of me.”
THE WHOLE-BRAIN FUTURE

First, the individuals. Next, the systems and the masses.

Dean Ottino’s whole-brain vision has moved well beyond the walls of Northwestern Engineering to encompass collaborations with other Northwestern schools and programs, increasing the centrality of engineering within a comprehensive university.

New courses and partnerships with local institutions, such as the Shirley Ryan AbilityLab and the School of the Art Institute of Chicago, unite students from myriad disciplines in collaborative endeavors.

Ottino believes that the next chapter lies in developing whole-brain organizations, where different types of thinkers—left-brain, right-brain, and whole-brain—converge to create more balanced, innovative, and productive hives.

“When people integrate with others not like them, they create possibilities,” Ottino says. “They might look at things in new ways and see a more complete picture.”

Some of Northwestern Engineering’s students and graduates have launched their own whole-brain companies. Two successful start-ups from Northwestern’s Design for America chapter, SwipeSense and Sproutel, combine right-brain design with data and medicine, two traditionally left-brain subjects.

When Mert Iseri (‘11) and Yuri Malina (‘12) met as undergraduates at Northwestern, they embodied very different schools of thought. Born in Turkey, Iseri studied industrial engineering. Malina, who was raised in France, studied physics and mathematics. Their company SwipeSense, which aims to redefine hand hygiene to reduce hospital-acquired infections, emerged from merging their different ways of thinking. Iseri, now CEO, and Malina, senior vice president, have raised more than $16 million in funding for SwipeSense.

Founded by Hannah Chung (‘12) and Aaron Horowitz (‘12), Sproutel makes interactive learning games for children with chronic illnesses. With Chung as chief creative officer and Horowitz as CEO, Sproutel has enjoyed significant success, having sold its signature Jerry the Bear, a platform for interactive health education, to 4 percent of the children newly diagnosed with type 1 diabetes in the United States.

Each year, Northwestern Engineering accepts new students, educates them, and sends them out into the world as whole-brain thinkers. Many take paths they never expected, following careers that they had never considered before college. Taking such a non-linear pathway can bring disappointing failures and great challenges as well as transformative experiences.

Ottino believes that setbacks, when they occur, are only a natural result of trying, which ultimately leads to significant rewards.

“If students work hard enough and really want it, then they will be successful in reaching their goals,” Ottino says. “At the end of the day, only great things will come.”

ACROSS THE UNIVERSITY AND BEYOND

The WHOLE-BRAIN ENGINEERING VISION and its integrated way of thinking are having an impact throughout Northwestern and beyond. Here are some of the ways:

Design for America, which was founded at Northwestern, now includes studios at 36 colleges and universities across the country and has spurred several successful, socially responsible startup companies.

Shirley Ryan AbilityLab: Nearly every engineering student works on a project to enhance the quality of life of a patient with a disability at the rehabilitation hospital. A DTC student team, for example, developed an adaptive fishing tool for a patient who had lost the ability to move his hands following a spinal cord injury.

NUvention, Northwestern Engineering’s flagship interdisciplinary suite of courses covering the entire innovation and entrepreneurial life cycle, has grown from one track to eight tracks, ranging from arts and analytics to transportation and therapeutics.

The Segal Design Institute and the Farley Center for Entrepreneurship and Innovation attract students from across Northwestern to their events and courses.

Written by Amanda Morris

The Whole Story