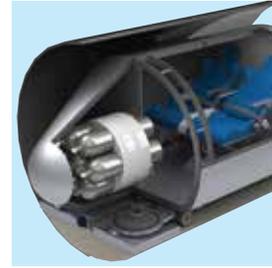
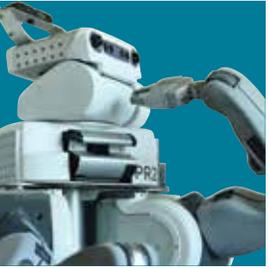
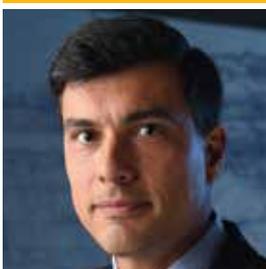
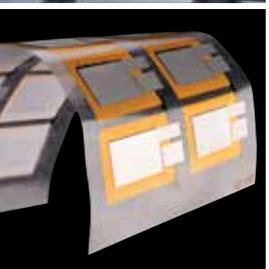


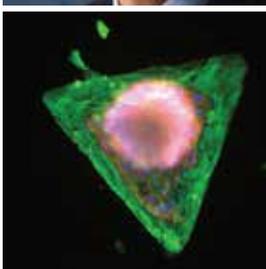
BerkeleyENGINEER



INVENTING



THE FUTURE



THE NEW ESSENTIALS

The future of engineering education

Engineering education at Berkeley isn't what it used to be

BY PHIL KAMINSKY

I recently met with bioengineering alumna Ann Lee-Karlon, senior vice president at Genentech and past president of the Association for Women in Science. We had a conversation about things that had changed on campus since she graduated in 1989. Some things, she told me, were the same at Berkeley — exceptional students, cutting-edge research, and, she was delighted to say, the same commitment to changing the world.

However, she said, the way we educate engineering leaders today has an entirely new look.

She is absolutely correct. To meet the needs of the 21st century, Berkeley Engineering has made critical and meaningful additions to our academic culture. We still provide the best, most rigorous technical education in the world — that will never change. Today, however, that's not enough. We are working to make sure that Berkeley engineers graduate with a new suite of essential skills and characteristics: leadership skills, an appetite for risk, flexible mindsets, the ability to integrate knowledge and experience working in diverse teams.



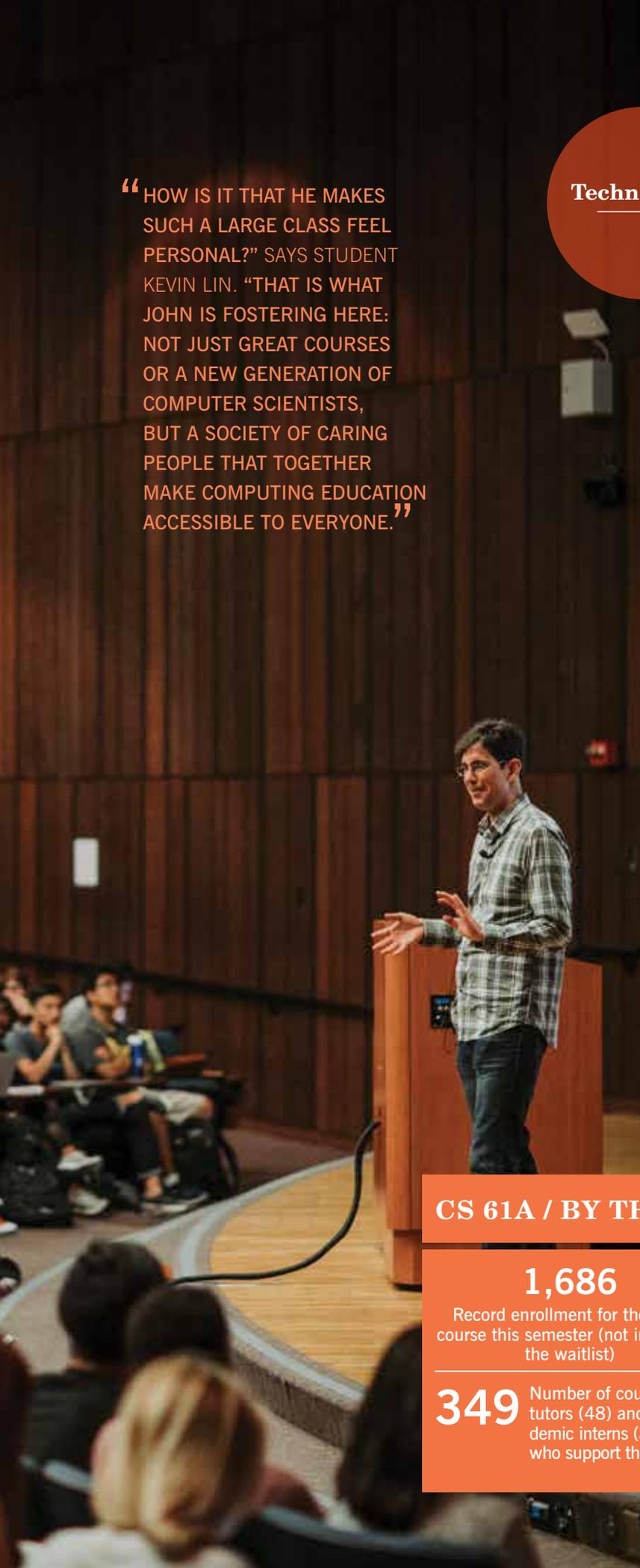
Phil Kaminsky is the Executive Associate Dean as well as a professor of Industrial Engineering and Operations Research.

THE NEW ESSENTIALS

To develop these qualities, we immerse our students in design thinking and the entrepreneurial mindset — fresh ways of looking at engineering challenges — and we do this starting on day one.

Imagine how a design problem engages creative students. In Jacobs Hall, the college's new design hub, some 3,000 students enrolled in courses last year to grapple with real-world problems and dream up solutions. Examples of these design-centered courses are intriguing. In the course Bringing Biomedical Devices to Market, students bridged the gap between proof-of-concept for a new device and landing an FDA-approved product in the marketplace. In the class Designing Technology to Counter Violent Extremism, students worked with the Department of State and other federal agencies to design and prototype ways to dispel extremism — including technology to enhance civic engagement, identify early signs of radicalization, remedy issues of discrimination and improve relationships with law enforcement. The students in Reimagining Mobility took on issues of how we interact with new modes of transportation, from car sharing to automation.

Today's Berkeley engineering curriculum also helps students develop an entrepreneurial mindset. Entrepreneurship is already a hallmark of the University of



“HOW IS IT THAT HE MAKES SUCH A LARGE CLASS FEEL PERSONAL?” SAYS STUDENT KEVIN LIN. “THAT IS WHAT JOHN IS FOSTERING HERE: NOT JUST GREAT COURSES OR A NEW GENERATION OF COMPUTER SCIENTISTS, BUT A SOCIETY OF CARING PEOPLE THAT TOGETHER MAKE COMPUTING EDUCATION ACCESSIBLE TO EVERYONE.”

Technology

Teaching tech with tech

When John DeNero first started teaching an introductory computer science course — CS 61A: The Structure and Interpretation of Computer Programs — in 2011 as a part-time instructor, the class had an enrollment of about 500. Since then, DeNero has joined the electrical engineering and computer sciences faculty and this year was named the inaugural Giancarlo Teaching Fellow. And the course has grown dramatically. After a complete revamp to make the intro to computer programming more accessible without sacrificing rigor, and by fine-tuning how the course is managed, 1,686 students are enrolled this semester. The course is not only popular, but the learning experience also receives rave reviews from the students. To keep pace with the growing demand for computer science education, DeNero uses automated technologies and a small army of student instructors to make the course run. Grading software gives students feedback in real-time, so they don't have to wait for evaluations and instead can fix coding errors immediately while working through assignments. There are over 400 students involved in teaching the course: 55 teaching assistants are employed to lead course discussion and lab sections, and 48 course tutors are hired to lead small-group mentoring sections, grade assignments and host drop-in office hours. Another 301 academic interns help answer questions during lab and office hours. “One of the secondary goals of the course is to involve undergraduates in the teaching process,” DeNero says. “The world is going to need a lot of computer science educators, and I think students really master the material when they teach it.”

CS 61A / BY THE NUMBERS | TEACHING AT SCALE

1,686

Record enrollment for the intro course this semester (not including the waitlist)

349 Number of course tutors (48) and academic interns (301) who support the course

55

the number of teaching assistants employed to lead course discussion sections and lab sections

1 *The Daily Californian* named longtime CS 61A instructor, John DeNero, best faculty member in 2016

Top 5

CS 61A was listed among the top 5 computer science courses in the country by Bloomberg



Noah Berger



Roland Saekow



Roland Saekow



Roland Saekow

Design

Designing a new narrative

Two years ago, the Jacobs Institute for Design Innovation began offering courses in the new Jacobs Hall, attracting students from across campus interested in the intersection of art, technology, design and engineering. One of the major draws to Jacobs Hall is that students get to work with tools and machines to prototype and build their ideas and projects. “Students like hands-on education,” says mechanical engineering professor Grace O’Connell. “It’s fun to watch students throughout the process. In the traditional lecture style, the instructor gives an assignment, and then students turn it in and they are done. With design education, the process is more iterative. You have to figure out how to improve the assignment and then do it again, which I think is closer to life after college.” This semester O’Connell, who studies the biomechanics of musculoskeletal tissues, taught an undergraduate course at Jacobs that focused on building medical devices. Forty-five students from various engineering disciplines partnered with Bay Area companies and nonprofits such as e-NABLE, a nonprofit that brings together individuals from around the world to create free 3-D printed prosthetic hands for those in need.

California; since 2010, 536 Berkeley students have launched 468 companies — by far the most of any public university and second among all universities. Although founding a company may not be the goal of every student, all of them will benefit from the ability to think like an entrepreneur: to strive for innovation, take risks, see value, rely on teams, learn from failure and question the status quo.

Our Sutardja Center for Entrepreneurship and Technology is a nexus for this training. There, students learn the traditional cornerstones of entrepreneurship — case studies, frameworks and tactics to give students a broad toolset to recognize opportunities, design products for market introduction, raise funds, devise business models and understand sales and marketing.

But we go beyond that, through a uniquely Berkeley method of teaching entrepreneurship. Over years of study, we have found that the best entrepreneurs share a set of behaviors — they give and accept help, collaborate, communicate through stories, trust others, seek fairness, are resilient, have diverse personal networks, understand that “good enough” is fine when time and resources are limited and believe that they can change the world. Students develop this mindset at Berkeley through games and exercises that teach trust, risk assessment, effective communication, overcoming social barriers and dealing with rejection and failure.

How does this work? In one exercise, students take to the streets of downtown Berkeley with an assignment: convince random strangers to give you their shoes. This is a sure-fire way to learn how to deal with failure. With a video recorder running, the students make their pitch and, if rejected, they move on, refining their appeal for the next person. One of our teams encountered Berkeley professor and former U.S. Secretary of Labor Robert Reich — he was so impressed with the students that he actually agreed to hand over his shoes.

TEACHING, TODAY AND TOMORROW

Design, entrepreneurship and other teaching innovations are now foundations of a Berkeley engineering education — and we continue to build on that foundation.

New interdisciplinary courses are emerging, many that make use of the studio and maker spaces in Jacobs Hall. At the Sutardja Center’s new “collider

space” at California Memorial Stadium, ideas are born through the “collision” of students, entrepreneurs, venture capitalists and managers — different people from different worlds. In challenge labs, student teams compete to find solutions to big challenges, from alleviating the refugee crisis in Greece to developing the best mobile health app. Undergraduate research opportunities are on the rise; one program in civil and environmental engineering, funded by donors, offers top freshman admits a chance to work alongside faculty and graduate students in a lab — a great experience for a budding engineer and a terrific tool for recruiting the best to Berkeley.

Our journey toward inventing the future of engineering education is far from over. At Berkeley we’re working to answer big questions for tomorrow’s students:

- *How can we integrate engineering with other fields?* Technology today is critical in every field. Understanding it and embracing the new essentials needs to be part of the core curriculum for all 21st century students. We’ve begun to explore the idea of “Engineering + X” majors that combine engineering with unexpected disciplines across campus. Our new Management, Entrepreneurship, & Technology (M.E.T.) program is giving us experience with the power of such combinations, allowing exceptional students to earn Berkeley degrees in both business and engineering in four years of (hard) work.

- *California and the world need engineers — how do we meet the demand from students and employers?* Today’s students don’t see their instructor as the “sage on the stage” but rather as the “guide on the side.” Some prefer to view lectures online, later exploring the material in depth with instructors in small classroom sections. We’re getting very good at this way of teaching, and it helps us meet the burgeoning student demand in many of our popular courses. For example, CS 61A, The Structure and Interpretation of Computer Programs, enrolls up to 1,700 students a semester, yet it is always top-rated. How is this possible? We deploy one of the campus’s top teachers, innovative technology to give students instant feedback on their work and creative approaches to discussion sections and advising.

Entrepreneurship

Creative teaching

Today, many dominant and innovative big brands — such as Amazon, Tesla and Google — are led by engineers. So it makes sense to teach engineering students how to build and run companies. But for Ken Singer, managing director of Berkeley Engineering’s Sutardja Center for Entrepreneurship and Technology (SCET), the need to educate engineers about entrepreneurship has a more urgent reason. “Recent advancements in technology — AI, autonomous vehicles, blockchain — will change the entire topography of employment,” says Singer. “If we don’t teach students to adapt to the future, then we are training a generation of unemployable engineers.” Traditional education is often about knowledge transfer, with systems designed to reinforce, test and evaluate based on existing knowledge. But for Singer and his SCET colleagues, just transferring information isn’t enough. Instead, they designed the curriculum to foster self-directed learning and creativity. “Students are comfortable being creative if they feel like they won’t be judged for failing,” he says. “We measure the attempt, not the outcome, and we grade them on what they say they learned, not if they can recite back our lecture notes.”



Noah Berger

- *How do we prepare our students for the changing future of work?* Technology being invented today will dramatically and rapidly change the way we work. To prepare for this uncertain future, we must produce lifelong learners with strong, adaptable skills. The people who succeed in this environment will be connected, flexible, creative, smart, entrepreneurial — and will have deep technical competence. Our teaching must help today's graduates react to technological shifts during their careers. And it's not just engineers who will face this changing future — we are gearing up to educate not only the finest engineers but to expand our reach across the Berkeley campus and beyond, offering training for non-engineers that will make for more technology-literate and savvy citizens.

- *In a world in flux, how do we continue to educate engineers throughout their careers to use the latest technologies to benefit the public good?* At Berkeley, we are committed to deepening our focus on continuous education for working professionals and on offering professional master's degrees like those we have pioneered in our Fung Institute for Engineering Leadership. Through both professionally-oriented graduate studies and continuing education, we must teach engineers not only to conceptualize new technologies but also about their impacts and consequences; equitable use and availability; legal and ethical implications; and their successful integration into existing or new industries. To be sure, our new directions in teaching design, entrepreneurship and innovation can serve us well in these arenas. Our students must also learn how design systems that incentivize behaviors to benefit society, and to embrace the important legal, ethical and moral responsibilities that come with implementing new technology.

We believe in the transformative power of a Berkeley education, and we're excited about the new directions we've forged for Berkeley engineers. Innovating the future is what Berkeley Engineering does best: with innovations in how we educate engineers, our graduates will have the tools to shape that future. **EB**



Roland Saekow



Matt Beardley



Golnaz Shahmirzadi

“DESIGN, ENTREPRENEURSHIP AND OTHER TEACHING INNOVATIONS ARE NOW FOUNDATIONS OF A BERKELEY ENGINEERING EDUCATION — AND WE CONTINUE TO BUILD ON THAT FOUNDATION.”



Noah Berger