

Michael Prince

... of Bucknell University

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Michael Prince has an affinity for the unorthodox.

When he examined an unfamiliar teaching model, he immediately gave it a try. When he later studied a “radical” teaching method, he gave that a try. And eventually, he took an eyebrow-raising mid-career turn that would redefine him in the conventional world of academia: He dropped his technical research in mass transfer in biological and environmental systems and dove fully into the science of teaching engineering.

“I gave up engineering research 12 years ago,” says Prince, who came to Bucknell in 1989 as a chemical engineering professor. “I was doing mediocre technical research and mediocre educational research. I dropped the thing I liked and kept the thing I loved.”

Prince is known for shaking up traditional classrooms. Eventually, he would be partly credited for changing how engineering is taught in many universities. But early on, he made mistakes, both when he applied active learning in his classroom and when he lobbied colleagues to do the same. In a way, his journey to becoming an active-learning advocate reflected an exercise in active learning itself—figuring out



what he needed to know was the first step in solving a widespread problem of faculty and student resistance to the model.

In 1998, Prince found himself attending an American Society for Engineering Education workshop in Seattle offered by the National Effective Training Institute (NETI). The NETI co-directors at the time, Richard Felder and Rebecca Brent, queried universities for potential attendees and Prince’s dean at the time, Tom Rich, made the connection.

“It was a transformational experience,” Prince says. “It’s what you hope a workshop will be but seldom is. It was probably the single most influential thing that happened in my career in terms of getting me to change direction.”

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Growing up in Leominster, Mass., Prince was inspired to study chemical engineering by a high school chemistry teacher. After earning a bachelor's degree at Worcester Polytechnic Institute, Prince got the idea to teach when he was a graduate student at the University of California-Berkeley. But how to teach was not part of what he learned. And Prince says examining his teaching methods wasn't an early career focus.

"I was always passionate about my teaching, but I had no formal training," he says. "The premise is, if you understand thermodynamics, you can teach it."

At the time, what appeared to be merely an opportunity to strengthen his teaching at a three-day workshop was actually the prompt for a controversial shift in Prince's career toward studying the best way to educate future engineers. And that shift would one day lead him right back to NETI as a presenter of the very workshop he attended.

"As Mike jokingly describes it, the workshop ruined his life," says Felder, the Hoechst Celanese Professor Emeritus of Chemical Engineering at North Carolina State University, who designed the NETI workshop in 1989 with colleague James Stice of the University of Texas. "Up until then, Mike had been a pretty conventional chemical engineering professor. What he learned in the workshop struck him as more interesting and maybe even more important than the technical work he was focusing on at that time."

The NETI workshop hit at just the right moment for Prince. He had recently been tenured at Bucknell and suddenly had freedom to explore new ideas outside his technical research in biochemical and environmental engineering. As he considered what he would do with that freedom, he was stirred by the workshop concepts of stepping out from behind the lectern and integrating active-learning techniques into engineering classrooms. The promise was simple: Students would learn with greater efficiency, engagement and retention if they worked with the material in class rather than passively receiving it in a lecture.

"The NETI workshop was about structuring an undergraduate engineering class to take advantage of what we know about teaching and learning," Prince says. "On the teaching end, I learned lots of things. In terms of student learning, the premise behind traditional lecturing is that as long as the instructor knows their stuff and students show up and pay attention, they will build up their knowledge. But the data shows that's just not the way it works. Students will not develop the expertise you have through that route."

After the workshop, Prince returned to Bucknell and eagerly started integrating active learning into his classes. In typical Mike Prince fashion, he fearlessly dove in, packing as many active-learning tricks into the bag as he could. And it worked. Prince says students responded well and his student evaluations improved.

"[Students] were happy, but I still wasn't happy with the gap between what they were learning in my class and what I thought they needed to know to be successful engineers," Prince says.

Over a couple of years, he gradually incorporated advanced problem-based learning exercises into his classes. This was where he stumbled—at first. He presented a problem to students: design a heating system for the classroom, followed simply by, "Any questions?"

Felder and Brent still remember Prince's vivid description of the ensuing disaster.

"The way Mike tells it, it was a pretty grim experience," Felder says. "Before knowing about the learning curves on problem-based learning for instructors and students, he just went in for the full monty and sprang it on his students. After that first time, he learned what not to do and what support he needed to provide to make the transition less drastic for students. Now, after years, he has learned his craft and is one of the best in the business."

Feedback was key to improving. Prince says inviting an observer into his class gave him another set of eyes and objective feedback that he used to smooth transitioning students to problem-based learning.

"It was also helpful to carefully read student feedback," Prince says. "What I eventually learned was that I had underestimated how much support—academic and emotional—students need to make a successful transition to the new paradigm. That recognition is what has led to my successful use of the more 'radical' methods now."

STUDENT RECEPTION

Felder says the move to more challenging team-based teaching methods, such as cooperative learning and problem-based learning, was daring on Prince's part.

"Mike went further than I did—he is fearless," says Felder, an engineering education heavyweight who retired from North Carolina State in 1999. "Problem-based learning is the teaching method that puts the greatest burden on students to think for themselves, and it gets the most pushback from them. Mike now uses it more extensively than anyone else I know in engineering education. He picked up that torch and ran with it."

Felder says the kind of student-centered learning that Prince utilizes often leads to resistance from students, who are used to playing a passive role in highly structured classrooms.

"Many students are not really thrilled with it," Felder says. "They complain violently.... Teachers really have to be strong and knowledgeable to keep that from turning into a full-scale riot with students marching into the dean's office. I'd be nervous about teaching that way, frankly, but Mike regularly takes it on and makes it work."

Prince became one of those professors about whom stu-

dents warn each other—his hands-off teaching style would boggle their minds and make them work harder. And because he teaches required courses, exposure to his full-on, student-centered learning could not be avoided.



Mike in first grade (Catholic school uniform).

Eric Dybeck took two of Prince's classes before graduating from Bucknell in 2011. He remembers Prince as his most effective teacher.

"But I was definitely in the minority in that experience," Dybeck continues. "With active learning, we just got straight to the work and learned how to solve new problems. I learned much more efficiently because I didn't have to pore over my notebook—it was a much more streamlined process."

Andréa Bourgal graduated from Bucknell in 2016 and remembers being warned about Prince's heat and mass transfer class. Students were shocked when Prince gave them a problem to solve and little direction.

"He just gives you a problem, like, 'Determine the amount of heat needed to heat this classroom,'" she says. "You really had to search and do a lot of research, but I learned more than I ever have from a class. It definitely put into perspective what we actually had to do as engineers when we got out of college. This style lends itself to our transition into the real world where you won't have all the facts to answer all your questions."

Bourgal believes most classmates warmed to Prince's approach by the end of the semester, especially because their grades improved. Dybeck isn't so sure. But as a teaching assistant at the University of Virginia, Dybeck found himself emulating Prince's teaching style.

"He definitely influenced how I approached teaching and mentoring other people," Dybeck says. "I more often had somebody work through a problem in front of me and tell me where they were stuck rather than me just marching to the dry-erase board to write the equations. I know they will learn better if they work through it first, and I just help them through the 10 percent they don't know."

Prince says, if executed thoughtfully, the effort to incorporate team-based learning can pay off all around. While students might grumble during the challenge of mastering material, Prince's course evaluations improved—his heat and mass transfer class consistently earns "excellent" ratings for the course and the instructor.



College and graduate school roommates helped Mike and Denise celebrate their wedding day.



Mike's family includes Denise, Tommy, Julia, Ben, and the dog.

"It's true that almost everyone struggles during the course, but by the end, the feedback is very positive," he says. "[Educators] should be thoughtful about adopting these techniques and they should be aware of possible pitfalls, but they shouldn't be given the message that most students will rebel and not come around."

FACULTY RESISTANCE

Early on, some of Prince's Bucknell colleagues balked at the notion of active learning. Fresh from his NETI workshop, he wanted to spread the word about the benefits of active learning, so he began a weekly learning series for Bucknell faculty to talk about topics in teaching.

The learning series was a winner, but active learning was not entirely embraced. Prince says the subject made colleagues uncomfortable. And this is when Prince learned two more lessons (the hard way) about active learning: it made colleagues uncomfortable not on an intellectual level, but an emotional one. And that meant his delivery needed consider-



Clockwise from top: NETI teammates Rebecca Brent, Mike, Cindy Finelli, and Richard Felder; Mike in the classroom; Mike leading a teaching workshop.



able refinement to be successful.

“When I talked about it, people heard, ‘You’re telling me I’m a bad teacher; you’re telling me I’ve been doing it wrong for 30 years,’” Prince says. “It hadn’t occurred to me that people would react that way. Over the years, I’ve become much better at being sensitive to that.”

Prince worked on his delivery, but was still met with doubt. Student resistance was one thing. But faculty resistance posed a greater problem. If Prince could convince faculty of the merits of higher-yielding experiential teaching, he could then show them simple ways to transition to it in their own classrooms.

“To have a larger impact on students, you have to impact faculty,” Prince says. “Some faculty aren’t aware of the research [supporting active learning] or they’re skeptical of the research. Faculty are data-driven people, so you would think if you show them the data, they would do it. But that is not how change works. Change is a much more emotional process. You must help faculty work through their concerns and anxieties.”

In 2004, Prince published, “Does Active Learning Work? A Review of the Research,” his first paper marking his shift into educational research. Published in the *Journal of Engineering Education*, it contained, Prince says, no original data, but is still the most cited paper ever published by the journal. He attributes that to collating the data into an easily usable form and the universality of the subject.

“People had been talking about active learning and whether it really worked,” Prince says. “It was hard for faculty to access that literature because it was scattered and not easy to understand for an engineering professor. So I tracked down 100 or so studies and collected them so you could see all the patterns and what it meant and then wrote the paper in a way that would make sense to an engineering professor instead of a cognitive psychologist. If I’m known for anything besides NETI, it’s that article because the problem it dealt with is a fundamental, broadly applicable topic to almost any engineering educator. That’s what made it very popular.”

EARLY WORKSHOP DEVELOPMENT

Even with the evidence at hand, Prince says some instructors are still reluctant to adopt active learning. Some professors worry students’ objections to active learning will result in poor student evaluations at the end of a course. Others don’t want to do the work to integrate active learning into courses because they aren’t necessarily rewarded for teaching well. And some instructors have a practical concern that an unscripted classroom prevents pertinent material from being covered because the pace isn’t as controlled by the instructor.

Using multi-year grants with funding from the National Science Foundation, Prince and a team of Bucknell collaborators designed Project Catalyst: How to Engineer Engineering Education, a summer faculty workshop addressing some of these fears. Prince turned to Brent and Felder for guidance and designed the workshop that stresses meaningful learning objectives, reducing lecture time, and introducing small active-learning techniques, such as moving from a “sage on stage” position behind a lectern to a “guide on the side” among

students as they helped teach each other. As Felder predicted, the workshop was successful—today it’s a national workshop still held every summer at Bucknell.

Soon Prince was adapting workshop material for different audiences and delivering workshops off Bucknell’s campus. Active Learning for Busy Skeptics teaches simple two- or three-minute activities that can be easily incorporated into traditional lecture classes to boost student performance and retention.

Prince’s workshop evaluations glowed and showed the material was especially influential for younger teachers. Joel Berry, an associate professor in the Department of Biomedical Engineering at the University of Alabama at Birmingham, had been teaching for a decade when he took Prince’s workshop at Bucknell last summer with a goal of improving his student evaluations and engaging students in their learning.

After the workshop, Berry integrated simple active-learning techniques into his teaching. He converted a traditional circuits and instrumentation course into a hands-on laboratory, reduced lecture time, and “flipped the classroom” by providing online instruction for students to learn outside the classroom and then reinforcing that material with in-class active-learning exercises.

“The results have been startling and pleasing,” Berry says. “My teaching style prior to taking Mike’s workshop was just standing up there lecturing and hoping students understood the material. I generally lectured for an hour and 15 minutes. Now I lecture for about 10 or 15 minutes and rather than just telling students what to do, they are figuring it out. I don’t cut them loose completely, but there’s a lot of exploration they have to do themselves. The students have been very enthusiastic, and it’s been a transformation for me as a teacher.”

ABANDONING TECHNICAL RESEARCH

Twelve years ago, Prince made a controversial decision he hadn’t seen coming, even though it was long in the works: focusing solely on education research. His new normal had gradually become juggling education workshops, pursuing two veins of research, parenting three kids with his wife, Denise, and his notorious passion for consuming and cooking gourmet food—a process he admittedly finds more intriguing when burdened with as many complexities as possible to extend the process.

“I found I didn’t have the bandwidth to do all that well,” he says. “But the decision was evolutionary. In the beginning, I started sharing some of what I heard at NETI. Then I started doing some of the stuff in my own classes. I began reading about it, and that just grew. The first pieces I wrote were literature reviews because I wasn’t an education researcher. But after that, I started doing some research and got funding to do more research.”

In a way, the path chose Prince by virtue of his curiosity. But he sensed unease in colleagues who questioned whether his new direction was serious scholarship.

“There was lots of pushback,” Prince says. “By and large, people think of academics as a group of free-thinking liberals. The truth is we’re very conservative. We don’t like change more than anyone else. Some were very enthusiastic and supportive, but a good chunk of my colleagues were saying, ‘What are you doing? You’re an engineer. You should be doing engineering research.’ There was a lot of concern about that. Now they’re happy that I bring recognition to the institution, but they’re a little worried that I’m doing it through education research and not engineering research. People don’t know what to do with me because I don’t fit into the mold.”

Bucknell’s Keith Buffinton, former dean of the College of Engineering, says Prince’s new direction took time to be accepted.

“When Mike was changing the direction of his research, there was initially some concern. There can be a tension, even at a place like Bucknell, between disciplinary research and exploring new areas that are less focused on technical research,” Buffinton says. “When Mike was thinking about pursuing engineering education research, there was a question about whether that research was as in-depth as what one typically does as an engineering professor—it’s not necessarily viewed as deep-science research. It’s social science research, but it’s definitely as intense and rigorous and as carefully reviewed and scrutinized. To understand the importance and rigor of that research has taken time for people to fully appreciate.”

But Buffinton says Prince was onto something earlier than most—some proof lies in the number of universities now establishing departments solely devoted to engineering education.

“There are very few things best learned from a professor standing behind a podium lecturing to a thousand students,” Buffinton says. “We want students to be motivated, inspired, and energized. Mike and others are really changing the expectations for engineering education and maybe for education more broadly. They are creating a future where active learning will be the norm and expected of all students.”

CONSULTING BUSINESS

Prince has parlayed those first workshops into Michael Prince Consulting, offering a slate of workshops, not only for faculty around the globe, but also at The Boeing Company, where he regularly trains staff on course design.

“It was not strategically planned—I am clueless about marketing,” Prince says. “It was all word of mouth. And there are not a lot of organizations giving engineering teaching workshops, so that part of my work has grown tremendously. If you had asked me 10 years ago if I would be giving active-learning workshops for engineering, I would have said, ‘No, I’m an introvert.’ So it’s still mindboggling for me.”

But universities like the results. Five years ago, Prince collaborated with Juan Morales, manager of mechanical engineering at Puerto Rico’s Universidad del Turabo. The proposal was for Prince to train physics and engineering faculty in five annual workshops over five years covering



Mike is well known for his passion for cooking—always in the best of company: top, with daughter Julia; right, with extended family.



active learning, writing effective learning outcomes, and assessment. Morales says 60 to 70 percent of classes now utilize self-directed active learning.

“In terms of grades, we have not seen much difference; however, the classes are much more engaging,” Morales says. “There has not been much student resistance—on the contrary. If the activities are well planned and interesting, the students will engage. They actually appreciated the effort since we also added real-world scenarios. Students no longer complain of ‘too much theory without practical context’ in the exit survey, which used to be a consistent criticism by 16 to 20 percent of seniors.”

In 2008, Prince came full circle with NETI. Co-director Stice announced his retirement and Prince was invited to fill the role.

“We had kept in touch with Mike since he first attended the NETI, and we knew him to be an excellent, innovative teacher and a first-rate workshop presenter, so he was a natural choice,” Felder says. “I always made a practice in my workshops of making personal contacts with participants who seemed to be having difficulty with ideas we were presenting and seeing if I could help resolve their concerns. Mike gravitated to that role and fills it expertly.”

In 2015, when Brent and Felder retired from the NETI, they consulted with Prince to select two new co-directors: Susan Lord, of the University of San Diego’s Department of Electrical Engineering, and Matt Ohland of the School of Engineering Education at Purdue University.

Prince says these days, his typical year includes presenting two or three NETI workshops, the summer workshop at Bucknell, about four corporate workshops; faculty development work in Puerto Rico, and usually another five to 10 consulting workshops. He credits Bucknell colleagues for providing support when needed. They credit him with bringing recognition to the university in Lewisburg, Pa.

“In terms of visibility and name recognition, he’s probably one of the most well-known faculty members outside of Bucknell,” says Timothy Raymond, chair of Bucknell’s Chemical Engineering Department. “He’s one of the most active researchers at Bucknell in terms of writing grant proposals and obtaining funding. He’s had a very large impact in the engineering education field, and his expertise in running workshops is sought nationally and internationally, by both universities and private companies.”

Brent, Prince’s former NETI colleague, sees the bigger-picture influence Prince has made since exiting technical research. She especially cites his effort to mainstream active learning in engineering education and its trickle-down effect on hundreds of faculty to whom he has presented workshops.

“Mike has had an amazing impact on the faculty-development side,” Brent says. “Mike’s gift has been looking at it logically and defusing people’s resistance to making changes. Each faculty member you touch goes out and is more effective in the classroom. That’s a huge ripple effect and a tremendous contribution.” □