



The rewards of teaching

My

A personal journey from applied math major intent on an industry job to a rewarding career in academia.

By Alexandra Newman

My first formal foray into teaching was as an applied math major at the University of Chicago. My roommate and cross-country teammate had decided to give me her calculus section, and I found myself differentiating and integrating to a group of unsuspecting students. I don't remember anything going particularly wrong that spring quarter of my senior year, so I suppose things went fairly smoothly. I did learn one thing: After seeing me win a few awards at the student-athlete banquet, my student-athletes had a newfound respect for me, and I interpreted that as: The better one can relate to one's students, the better teacher one will be.

While "calculusing" along, I found myself in Professor Kipp Martin's optimization courses in the Graduate (now Booth) School of Business. When he demonstrated how linear programs could be graphed and solved in two dimensions, I knew I would become an optimizer. I took two courses from him in my senior year, and, from the second, much material found its way into his subsequent book, "Large Scale Linear and Integer Optimization: A Unified Approach." The course was not for the faint of heart. Sometimes Professor Martin pounded on the board for emphasis. We were not to "party too hearty," he told us, if the Bulls won the championship on the Friday night at the end of the quarter, because on Saturday, we had a three-hour bonus class. On top of that, we coded Fourier-Motzkin elimination and wrote a 20-page take-home exam while the rest of the seniors were enjoying "senior week." But Professor Martin encouraged me to go to graduate school and wrote letters of recommendation.

It was my third year in graduate school in the Industrial Engineering and Operations Research (IEOR) Department at the University of California, Berkeley, when I found myself teaching again, this time in front of graduate students taking linear programming. Professor Ilan Adler had chosen me as his teaching assistant, which surprised me, as I had not been a standout in the class I had taken from him two years earlier. However, he must have seen something I didn't.

He handed me an AMPL book, and said: "I'm trying something new this semester; please learn this modeling language and teach the students." I kept waiting for a crisis — some problem I couldn't do or some code I couldn't correct. To my surprise, the biggest crisis was my inability to use the copier to collate and staple the solution sets (there was no Blackboard back then!).

After that experience, I served as a teaching assistant again and again for Professor Adler, and he gave

me increasing responsibilities, much to my amazement and much to my adviser's chagrin. Professor Adler had an eclectic style, but said one thing in particular about handling students that I will never forget: "If it's no skin off your nose, and it makes them feel better, then just do it."

Office Hours

In my final semester in graduate school, I was given the opportunity to teach linear programming ... and was provided with both a teaching assistant and a grader! I knew that the students waited until the last second to do their homework, due every Friday. Accordingly, I had office hours Thursday night. The students loved those office hours, and I continue with the habit to this day. On some of my course evaluations, students note that the "best thing about the class is the office hours!" (which can, admittedly, become rather animated). Some students show up just to help other students, while others really do need help. Still others simply like to have concepts reinforced. My late office hours always remind me of the following story.

One evening, my adviser was in her office with some students. One of her colleagues came by and said: "Oh, you are working late tonight." (This is not new; she works late every night.) She replied: "Yes, I am working late because they are working late." One cannot underestimate the importance of the example set and the level of engagement demonstrated by the adviser (in this case) or the teacher (in general).

Interspersed with semester-long teaching activity within the IEOR Department were a couple of stints involving teaching industrial engineering to high school minority students. One day, we were relegated to a field trip to some far-away and not-too-interesting place. After a long bus ride, we went to the door of the power plant we were to visit, and an officious woman said to us, "Stay here until we are ready for you." ("Here" was a small, uncomfortable foyer.)

"Oh my goodness, she is acting so white!" exclaimed one of the students.

"You can't say that. Our teacher is white!" retorted another.

The first responded, "She's not white!"

The second said, "Oh," in a bewildered manner.

As I thought back to my University of Chicago days, it seemed clear that I was relating to my students.

My adviser (Candi Yano), noticing and orchestrating all of this and more, started saying things such as: "You need to attend the INFORMS doctoral colloquium; it will be good for when you look for an academic position." At first, I took no notice. Then it occurred to me that she was using the word "when," and not "if." Hmmm. I had thought I was



Colorado School of Mines Professor Alexandra Newman, with Diesel the Dog.

going to go into industry. I had thought, as it turned out, incorrectly.

Colorado School of Mines

Ph.D. in hand, I headed off to the position of research assistant professor at the Naval Postgraduate School under the auspices of Rick Rosenthal, then chairman of the Operations Research Department. Rick always presented opportunities to junior faculty, and he determined that I could teach linear programming. That I did, followed by developing and teaching my own class in integer programming. Before this was through, my adviser stepped in: "Alexandra, you must apply for a tenure-track position at the Colorado School of Mines. Gene Woolsey is there; he is a bit eccentric, but you will fit right in."

"Hmmm," I thought. It was bad enough being wrong about going into academia, but I was planning to rebel by skirting the tenure system, i.e., remaining on the research professor track. Not so. The following year, I found myself as an assistant professor at the Colorado School of Mines.

My then-department head Rod Eggert, a mineral economist, was not entirely sure what to do with a specialist in operations research, so he let me do what I wanted. I taught linear programming, I revived and taught network models, I revamped nonlinear programming and taught that too, as well as integer programming. In a cookie monster sort of way, I devoured (so to speak) the optimization classes. I then launched the grand unifying theory course, the one that would bring subject matter from all four of my optimization courses together. The problem was, the

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Rewards OF TEACHING

cookie monster had bitten into too big a cookie. Three-quarters of the way through the semester, I announced to my department head that I was simply not going to get through all the material – I would finish the integer programming section, but I couldn't even start the linear programming section. He said, "What! You are not going to give the students grades at the end of the semester?"

Seizing the opportunity, I said, "Well, the *only* way I can assign grades is if you let me teach a follow-on course with the rest of the material next semester." He said, "Fine, fine, just assign the grades." And so the advanced integer programming and advanced linear programming classes were born.

The Colorado School of Mines now offers an interdisciplinary Ph.D. program in operations research with engineering (ORwE). Coursework includes classes in statistics (taught with the software R), algorithms, engineering design, stochastic modeling, simulation and the mathematical programming courses listed above.

The students who study O.R., either in the ORwE program or by taking the courses as electives for another degree program offered at Mines, come from a variety of backgrounds. Many are active-duty military officers, primarily from the U.S. Army and Air Force. Others have had work experience in the private sector. One of them was a master's thesis student of mine at the Naval Postgraduate School who, after retiring from the Marines, came back for a Ph.D. Another was an inner-city high school teacher of math. Others are in non-O.R. programs, and realize that they need operations research to fully address their research question. All of the students are energetic and eager to learn, and they have included at one time or another: a national collegiate heavyweight boxing champion, a Division II 800 meters champion, a former cross-country runner from Brown who ran in the world championships, a Chicago White Sox draftee and a guy who likes to wear orange daily (he also has orange dress shirts) – and he's not even Dutch.

Woolsey-esque Applied Work

In Woolsey-esque fashion, many of the dissertation topics are applied in nature and result in an *Interfaces* publication, among others. In our university, with its origins in earth science, topics emphasize mining and energy. We have contacts with the National Renewable Energy Lab and mining companies such as Newmont. Other students work on logistics or military applications. All of the students learn algorithms and theory, but they also are required to have several programming classes; they use software extensively; they

interface with companies; and they present their work in both industrial and academic settings. They learn how to write and publish. In the process, there is much wailing and gnashing of teeth. But the work gets done, and they continue in military careers or obtain jobs in national research labs, at universities or in the private sector.

To conduct applied work in an academic setting, certain criteria are basic:

1. **Structure courses appropriately.** I use AMPL/CPLEX in my optimization classes. The advanced ones are very computational in nature, addressing issues such as derivation of cuts and mitigation of numerical instability.
2. **Pay attention to students who come from the "real world" with a problem.** It took me a long time to understand my Army student's necessity for optimizing counterinsurgency operations. In fact, he had worked in Afghanistan and knew that the Army needed a better tool to determine the number of troops to employ.
3. **Work in an interdisciplinary fashion.** For example, the counterinsurgency work contained aspects of social science, statistics, and optimization.
4. **Engage with subject matter experts regularly.** We often visit companies multiple times per month to keep them apprised of our progress and obtain up-to-date information.
5. **Persevere and develop long-lasting relationships with companies or industries.**

As Kipp Martin once told me, "Some people will tell you that the theory is the only difficult aspect of our field. Applied research is also hard. All research is hard."

Drawing on these personal experiences, from educating high school through Ph.D. students, I offer the following remarks:

- Good teaching is a function of one's environment and experience. Colleges and universities are institutions of higher education. All faculty members should ask themselves if they are setting an example in the classroom that will result in a good educational experience. I was very lucky to have had good examples set for me, and I try to pass that along to my students.
- As one of my colleagues says, "You have to have a working model." In a university setting, everyone should strive to educate at some level, even if it is through specialized graduate courses or as an adviser. I recently heard a colleague state that publishing with students shouldn't be emphasized among faculty, because it tends to diminish the



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university,
with its origins in
**earth
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quality of the faculty members' work. In my opinion, this is not an attitude appropriate to a university.

My parents are retired classics professors at the University of Illinois, Urbana-Champaign, i.e. their expertise lies in Latin, ancient Greek and classical civilization. They have years of both high school- and university-level teaching experience. Despite the fact that I questioned my father's pedagogical approach – at the age of eight (my brother was seven) he decided to teach us ancient Greek, complete with the conjugation of various verbs – I have clearly benefitted from my parents' example.

Prompted by a recent conversation with a colleague, I looked up my father's resume. After lines and lines of publications and awards (he won a medal from the Pope for a Latin poem he wrote), the resume modulates into paragraphs, which begin: "The most important things I have done are missing from this list. They derive from my teaching, begun in September 1952. In England, over a period of 16 years, my students gained more than 100 open awards at the Oxford and Cambridge Colleges. Here in Urbana, I guided 12 Ph.D. dissertations to a successful conclusion in Classics and one in Compara-



Alexandra Newman (center), winner of the 2013 INFORMS Prize for the Teaching of OR/MS Practice, flanked by Prize Committee member Michael Gorman (left) and then-INFORMS President Anne Robinson.

tive Literature. Three of my former students became heads of department."

Perhaps we should all take a leaf out of my father's resume. **ORMS**

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