

INTERVIEW

A Long Academic Journey

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In this case study, an early-career electrical engineer interviews an established translational biomedical engineer. The discussion covered topics such as challenges associated with the merging of fundamental engineering science with the pursuit of clinically informed research, how best to train engineering students for future innovation, and how to establish international partnerships.

Case. I am Erkin Şeker, a 33-year-old assistant professor of electrical engineering at the University of California, Davis (UC Davis). I grew up in Turkey, where my parents practice medicine. I came to the United States after high school to study electrical engineering at Virginia Tech. During my third year, I received a summer fellowship from the Virginia Microelectronics Consortium for a 10-week mentored research project on microelectronics at the University of Virginia (UVA). This experience encouraged me to pursue graduate studies on microtechnology in the Ph.D. program at UVA, where I engineered miniature mechanical test platforms to study fundamental material properties of nanoporous metals. After receiving my Ph.D. degree, I began a postdoctoral position in the chemistry department at UVA in order to extend my microfabrication skills to the development of bioanalytical devices and flow-control methods in microfluidic systems. With a growing interest in applying my engineering expertise to biomedical problems, I joined the Center for Engineering in Medicine at Harvard Medical School and Massachusetts General Hospital. There, for the first time, I interacted directly with biologists and physicians and applied my experience in microdevice engineering and materials science to the development of effective tools to monitor, modulate, and repair the nervous system—major goals of the neuroengineering field.

In the Fall of 2011, I began my independent research career at UC Davis. As an assistant professor, I lead a research group that aims to develop high-throughput screening techniques for biomedical materials, with an emphasis on multifunctional materials

for neuroengineering tools. A key research interest of my group is to apply these approaches to the development of technologies that can be used in the study of the human nervous system and in the treatment of neurological disorders. Now that I have a good handle on my teaching responsibilities and my research group has matured, I am thinking about how to best manage my resources so as to bridge my training in fundamental engineering science with clinically applicable technology development.

In this commentary, I interview Banu Onaral, Ph.D., the H. H. Sun Professor & Founding Director of the School of Biomedical Engineering, Science & Health Systems at Drexel University in Philadelphia, PA. Dr. Onaral has training in electrical and biomedical engineering with expertise in biomedical signal processing. She has been highly successful in extending her engineering training to applications in biomedical ultrasound and functional neuroimaging applications. In addition, Dr. Onaral has applied her expertise and experience to the commercialization of academic innovations and to effective teaching and outreach activities, making her an excellent academic role model. My goals for the interview were to gain advice on how best to (i) construct a research plan that merges fundamental science with translatable engineering-based biomedical technologies and (ii) train students to contribute to the development of such technologies.

SCIENCE AND SOCIETY

Q. Erkin: “*Translational medicine*” currently is a much-used term when describing biomedical research, and “translation” is an overarching goal in many disciplines. What is your definition of translational research, particularly as it applies to the fields of engineering and medicine?

A. Banu: Simply put, translational research leads to commercialization of aca-

ademic innovation. This way we convert our knowledge, our discovery, or our know-how into something good for society. Because we are biomedically oriented, the end user is the patient. Looking at it from a different angle, as academics we have three major responsibilities: We conduct research to expand the scientific knowledge base, we teach to disseminate our knowledge to the next generation, and we serve society by using our knowledge to create innovative products that improve lives (1). The service component drives us to responsibly translate solutions for health care. Therefore, we need to be action-oriented in translating our knowledge into innovations that have societal and possibly economic value. In support of this goal, our School of Biomedical Engineering at Drexel has the mandate to remain relevant to the clinic, to the patient, to industry, and hence, to society.

STAY FOCUSED AND COLLABORATE

Q. Erkin: Although I am interested in the translational aspect of academic research, I am struggling with the building of a translational arm in my laboratory. Because my training, although multidisciplinary, focused on fundamental rather than translational research, one challenge I face is the tendency to continue my fundamental materials science research. This tendency stems in part from feeling confident that I can publish strong papers in this research area; however, I want to expand the impact of my research to applications, particularly in medicine. When you started your research career, did your work have a translational focus?

A. Banu: You should definitely stay in the area of your core strengths and focus on the fundamentals of a specific problem. People that are on the applied side will seek you out for your expertise (2). There is a constant iteration between applied and fundamental science. You will find yourself coming back to doing fundamental research as you work toward translation. I was at a similar point when I started as a junior faculty member. I continued doing fundamental research in signal processing, while reaching out to colleagues on the applied side of biomedical signals and imaging and those in relevant clinical disciplines. In time, we formed partnerships that allowed us to tackle challenging problems. It is important that you have a clear mission toward something of value to society and join forces with people who are passionate about this mission. But at the end of the day, you need to be very honest with

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yourself about where your heart lies. If you are truly interested in the translational outcomes, your fundamental research will be informed by the applicant at hand or clinical end-point (3). This will give meaning to your research.

Q. Erkin: *I must admit that I am interested in many aspects of research and am tempted to learn the necessary techniques (despite them being outside my core area) for executing a research project myself.*

A. Banu: I know the temptation, and I know the trap—that approach could lead to a very superficial career. You have to be scientifically defined so that people can see your true contribution to the scientific knowledge base. In order to gain depth and develop expertise, you should focus, during the first decade of your career, on a specific scientific domain, question, or technology. Instead of spreading yourself too thin, you should shape your career by partnering with others that share your mission. It takes much discipline to stay sharply focused while also initiating mutually fruitful research collaborations in which the give-and-take requires a “special personality” (4, 5).



Piecing together solutions. It takes strong, cohesive, multidisciplinary partnerships to solve biomedical puzzles.

Q. Erkin: *This surely requires fruitful partnerships. How did you join projects and start collaborations? What pitfalls are you usually on the lookout for when joining a collaboration or team project?*

A. Banu: To accelerate translation of your technologies, you will need to interact with people who are from different disciplines yet share similar goals. These can be engineers, life or computational scientists,

physicians and entrepreneurs, lawyers, and even investors—the latter are especially different than the people we typically encounter in our academic circles. Our laboratories should be places that welcome all those who add value to the translation of our discovery or technology. I advise my younger colleagues to name their labs to reflect their academic mission. Once people see that your mission is clearly defined and that you are not only passionate about your mission but also welcoming, collaborators will converge on your lab and potentially help you achieve your translational goals.

I must add that one person or a small team is not typically equipped to solve challenging problems. A group of many dedicated people from complementary backgrounds working toward the same mission is better positioned for success. Sometimes it is difficult to break through the boundaries of a conventional electrical engineering department. I was an electrical engineering faculty member for many years, yet I was fortunate also to be affiliated with the Biomedical Engineering Science Institute, which we later reorganized to form our

School of Biomedical Engineering, as an interdisciplinary academic unit that actively interacts with all amenable units across the university. I always made a conscious effort to initiate many collaborations, not only outside my department, but also outside my institution. You can facilitate meeting your ideal collaborators by becoming a member of a community that is passionate about the problem you are after so that they are aware of your expertise and you are up to date on the

current advances.

The key to a successful collaboration is to be consistently fair and just. I mean intellectually fair and just—that is, what you do should add and enhance others' work, and what they do should likewise benefit your work. All members of a partnership should be better off for being part of the group, rather than fighting over ownership of ideas, projects, and resources. We should always

remember that our shared mission to solve a scientific problem or address an unmet medical need transcends us as individuals. This is the key trait of the “special personality” I referred to earlier.

ENJOY THE JOURNEY

Q. Erkin: *Managing a lab is something that few assistant professors have experience with prior to their first academic position. I am at times overwhelmed by the slow progress of research and the lengthy road to achieving my overarching vision of translational impact.*

A. Banu: You need to learn to be patient and certainly philosophical. It is all about the journey. Your main purpose as an academic is to add to the knowledge base, to mentor your students, and to serve society with your knowledge. The concrete application that may originate from your fundamental work may take years to materialize, but you should never be overwhelmed. Instead, enjoy the process and cherish your interactions with your students and your colleagues as you ride the scientific roller coaster all across the globe! Be mindful that you are on an expedition in uncharted scientific territory. Always remember that you are part of a vast team of academics-on-a-mission who are all in this together. Again, it is not about you, it is about the scientific legacy...about the lives that will be affected because of your research.

Q. Erkin: *That is refreshing to hear. Did you have project failures, and how did you handle them? How do you decide to give up on a project?*

A. Banu: Of course. I believe that, most of the time, failures and rejections clear the scientific pollution and allow us to see more clearly into fruitful directions. This is the truth and reality of the scientific process. Things don't go as desired multiple times before something actually works. It is important to move on if the problem you are after requires expertise or tools that you don't have. My research partners and I were once onto a very promising discovery in systems theory, but we did not have the mathematical depth to complete the result. We had to give up despite trying very hard to identify those who would assist us. There will be points in your life when you will be within arm's length to a solution, but you won't be able to reach it, because neither you nor your collaborators have the necessary knowledge or tools to do so. This can be sad and frustrating, but such is academic life. You can, however, be sure that there will be

a future scientist or engineer who will pick it up and reopen the path. Scientific literature is replete with such hopeful examples.

Q. Erkin: *How about changing your research direction? Did you take the initiative to become proficient in research areas that interest you but lie outside of your core strengths?*

A. Banu: I taught for many years and published papers on signal processing, especially in relation to biomedical signals. I initially worked on ultrasound imaging applications. When a new modality, optical functional imaging, emerged with similar but more complicated processing demands, I redirected my expertise. This is an example of the evolution of research problems and solutions that you experience during a long career. This constant change constitutes a core thread in the fabric of an academic journey that I truly enjoy. We carry a huge responsibility on our academic shoulders, but I never think that there would be another line of work that better suits me. I even wonder how fortunate we must be to do what we love and make a living doing it.

LEAD BY EXAMPLE

Q. Erkin: *When my graduate students receive their degrees, I would like them to have the necessary skills to conduct translational research even if their thesis research was basic in nature. Are there specific approaches that you find helpful in cross-training your students? Do you have thoughts on how graduate education might be reimaged in this translational era?*

A. Banu: Immersing students in mutually beneficial collaborations and an interdisciplinary environment enriches their training tremendously. However, as I emphasized for your career, a student needs to have a fundamental focus. Such focus is required for developing an expertise, and you can't get away from that. In our school, we assemble an interdisciplinary dissertation committee early in our students' thesis research. The student becomes the center of this advising team. We recruit members who are passionate about the core research that defines the thesis. During the process, the student and the committee develop the sense that they are in it together, working toward a common goal. Of course, there needs to be a main advisor or co-advisors, but the other committee members should be excited about and own the project as

well. Remember that academics is mainly about the next generation: preserving and adding to the knowledge base and transferring it to our students. Our graduates must develop a deep mastery of core competencies, but should be encouraged to innovate at the edges of the current knowledge base. I confess that, most of the time, I learn more from my students than the other way around! We become mutual learners and, eventually, colleagues—a research family.

Q. Erkin: *Speaking from my own Ph.D. experience, I remember that I became more productive when I owned my project and was dedicated to making it work. I think that sense of ownership is a good sign for the academic maturation of a student.*

A. Banu: That is definitely a very good sign, and you should always encourage students toward this feeling of ownership. But you must also empower them to contribute toward the mission and to defend their ideas in the course of tackling their research question. In other words, you should be their enabler. Instilling this self-confidence in our students is a big part of future academic success. Enlightened universities value this type of academic success: Their faculty's success is measured by the accomplishments of their students.

CIRCLING BACK HOME

Q. Erkin: *It seems that as our careers progress, the circle of colleagues can expand not only beyond our own institution but internationally as well.*

A. Banu: That is very true. I have a lot to say about international partnerships, particularly in the context of emerging economies (4, 5), which can be the topic of another conversation.

Q. Erkin: *I have a question directly related to this. On a personal note, I came to the United States for college directly after graduating from high school in Turkey (our mutual country of origin), and I feel as if I did not have a chance to experience life there as an adult. I want to establish an academic connection with Turkey. How can I achieve this?*

A. Banu: I work very closely with Turkish universities and would be happy to help you make connections. It may be better to take on outreach projects after your tenure, because building mutually productive and long-lasting international partnerships takes some time and energy (4, 5). You may start by visiting campuses and by joining



Raising partnerships to an art. Myriad threads must be woven together before a productive and lasting partnership emerges.

events and activities that specialize in your particular areas of interest. We are indeed in exciting times for neuroengineering research. Numerous initiatives are dedicated to understanding the brain in Europe and the United States, as well as in emerging economies such as China and Turkey. I would be pleased to introduce you to our neuro-partners and networks when the time is right and you are ready to engage globally. This will be the token of my appreciation for giving me the opportunity to share my experiences with you and your generation of junior academics.

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