Title
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Journal
Technology & Innovation, 19(4)

ISSN
1949-8241

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Publication Date
2018-06-10

DOI
10.21300/19.3.2018.765

Technology and Innovation, Vol. 19, pp. 765-771, 2018

ISSN 1949-8241 • E-ISSN 1949-825X
http://dx.doi.org/10.21300/19.3.2018.765
www.technologyandinnovation.org

THE NAI FELLOW PROFILE: AN INTERVIEW WITH DR. MICHELLE KHINE

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All-star engineer, researcher, and inventor Dr. Michelle Khine, the subject of this issue's NAI Fellow Profile, discusses her new work on wearable health monitors and point of care technologies, the importance of supporting junior faculty and graduate students in the early stages of their careers, and how we might go about addressing the gender gap in invention.

INTRODUCTION

This issue's NAI Fellow Profile features Dr. Michelle Khine — visionary biomedical engineer, inventor, and entrepreneur. After starting her career as assistant and founding professor at the University of California, Merced, Khine joined the University of California, Irvine, where she is currently professor of biomedical engineering, chemical engineering, and materials science; director of faculty innovation; and director of BioENGINE, an engagement and education program dedicated to developing impactful digital health solutions.

Khine received her B.S. and her M.S. in mechanical engineering from the University of California, Berkeley, and her Ph.D. in bioengineering from the University of California, San Francisco, and the University of California, Berkeley. She is the author of over 50 peer-reviewed publications, inventor on over 20 patents, and founder of four start-up companies, Fluxion Biosciences, Shrink Nanotechnologies, TinyKicks, and Novoheart. Although she has only just started the second decade of her career, Khine has received numerous awards and recognitions, including fellowship in the National Academy of Inventors and the American Institute for Medical and Biological Engineering, the NIH New Innovator's Award, and the MIT Technology Review TR35 Award (top 35

(photo courtesy of Michelle Khine)

Accepted: March 1, 2018.
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innovators under 35). She has also been named one of Forbes' '10 Revolutionaries,' one of the '100 Most Creative People in Business' by Fast Company, and a 'Women on Top: Top Scientist' by *Marie Claire*.

Two of the major areas in which Khine works are point of care technology and wearable health monitors. In the former area, Khine is working diligently to improve point of care (POC) diagnostics to make these early detection systems available to people without the current high costs associated with the use of expensive equipment and the collection of blood for use in testing. To that end, her team is developing POC technologies that can provide effective lower cost testing options, allowing for the use of non-invasive collections methods (e.g., saliva or urine), improved sensitivity for better detection, and less expensive equipment. In the latter case, Khine's team has been working on Internet of Things technologies to collect vital health data from patients to monitor and provide alerts for a wide range of health concerns. By tracking an often-complex set of vitals, these wearable monitors can warn of asthmatic attacks or cardiac incidents in time for early intervention and more effective treatment. In all of her work, the theme is clear: better and more cost-effective health solutions for all people.

Dr. Khine recently granted an interview to *T&I*, in which she discusses her new work on wearable health monitors and point of care technologies, the importance of supporting junior faculty and graduate students in the early stages of their careers, and how we might go about addressing the gender gap in invention.

INTERVIEW

T&I: Let's start with having you talk a little bit about some of the current projects that you're working on.

Khine: Sure, so my lab has been interested in trying to figure out how to democratize healthcare. For a long time, we've been working in the point of care diagnostics space, typically in trying to bring down the cost of diagnostics technology so that it can really be deployable in low-resource settings.

More recently, we've moved over to developing wearable monitors to actually try to monitor before the person gets sick. We have developed a sort of Band-Aid-like sensor that has the form factor and is disposable like a Band-Aid, and it can be worn on the body for several days and then be thrown out.

The idea is to use the sensors to be able to get measurements of the person for various applications. We're working on a sensor to be able to detect an asthmatic attack before it actually comes on. We put it on the chest, and, basically, it measures the person's breath rate as well as lung volume, and we've correlated this with the medical grade spirometer and are getting really high correlations. We are working on using this information to be able to look at patterns of abnormal readings before children actually have a full-blown asthma attack so that you can stop the attack before it actually escalates.

T&I: How long will the sensors be able to last in the body, and how often would they have to be replaced?

Khine: They are meant to be disposable; their lifespan is a function of the battery life, so we imagine you could actually replace and recharge the battery and the Bluetooth unit every couple of days. It goes on like a little Band-Aid, so it's not invasive, and it's not difficult to put it under children's' clothes. It wouldn't really impede their movements or be noticeable, but parents will be able to track more effectively.

I was shocked when I learned that the gold standard in monitoring children's asthma is manual reporting. So, when you journal, you basically write when they have symptoms or you give them a peak flow meter. A peak flow meter is an apparatus that they have to breathe into several times a day, and you're actually tracking their lung volume based on how well they breathe into the peak flow meter. However, it's manual tracking, and it takes about 40 days to actually be able to discern patterns to be able to predict when an asthmatic attack might be coming on. These peak flow meters are really known to have a lot of user error, as children need to blow 'maximally' into the meter. It's very hard for a child, and especially an asthmatic child, to be able to breathe into the peak flow meter accurately.

T&I: Yes, those apparatuses can be quite difficult to use correctly. Also, as you mentioned concerning people in low-resource areas, this assumes that someone has a lot of time available to be able to take these measurements and track them over time.

Khine: Right, and there is a huge health disparity. There's a disproportionate number of children in lower-income geographical areas with asthma. Asthma is a condition that needs to be controlled — it's a chronic condition, but these deaths and the visits to the ER are all preventable, but people don't monitor, and they don't take care of their asthma symptoms until it's exacerbated to a point where they have to actually go to the ER.

T&I: Now I'm going move back in time a little bit here. You've talked about your Shrinky Dinks a lot, but it was really a viral moment for science in a media context, and we don't really get that many of them, so I was hoping we could dig a bit deeper there. What do you think it was about that idea that captured the popular imagination so much and made people think more deeply about science and more specifically about the nature of innovation and where ideas come from?

Khine: First of all, I think it was unexpected, right? The juxtaposition between a technical term like microfluidics and Shrinky Dinks caught people's eyes, but then the concept caught people's imaginations because I think that we get into this status quo of taking for granted how things are made and don't really think of alternatives. When you do think of alternatives, you don't think of something as wacky and out-of-left-field as pairing a low technology children's toy with something so high tech. So, I think that is probably what caught people's interest. I think what is exciting to me is that a lot of the interest is actually leading to real pursuits. This has become a platform for many labs to actually develop nano- and micro-structures that otherwise are extremely difficult or impossible to create.

T&I: So, in a sense, it demonstrates that same democratizing impulse that you talked about with your monitoring technology.

Khine: Yes, I'm very interested in being able to create technologies that can get out to people, whether it's lowering the barrier for researchers in biology to be able to do microfluidics without having an engineering lab to make their chips or making sure that children in low-resource settings are able to be monitored in the same way that more affluent children are.

T&I: One surprising thing about the whole Shrinky Dinks microfluidics story was the pushback you received on that particular innovation, with some people showing skepticism about the potential for it to really be an effective or viable substitute for what had previously been very expensive, sophisticated equipment. How did you handle that kind of pushback and move forward despite a lack of buy-in from others?

Khine: It was hard in the beginning because I was a very young junior faculty. I didn't do a postdoc, and I'm a female in a predominantly male field, so I was already being discounted because I was young and female. Then I came up with a thing that was so wacky, people just didn't know what to do. I think all those things made it difficult to be taken seriously, but that also really motivated me. People asked, "Why are you still pursuing this platform? Why are you still trying to test the limits of it?" I think that really was a motivator because I wanted to show that this was not some gimmicky thing. Rather, this concept of being able to pattern inexpensively at low resolution and then shrinking to create the resolution you needed really had merit and had legs.

Also, there were additional factors at work: It got a lot of media and press, and my institution at the time was also brand new, so it wasn't recognized, and most people still associate top researchers with the more established and top universities. So I was an outsider in that respect, and in every respect really, because I was a woman, I was young, I didn't fit into any of the parameters that most people would think of as an inventor, and I wasn't even at a recognized university. However, I was very lucky because a few people really took me seriously. I remember being reached out to by one of the legends in the microfabrication world at Stanford, someone who is very well established. He sent me an email, and he said, "This is the coolest thing I've read in a really long time." It just makes all the difference when somebody of that stature reaches out to you to offer a little bit of support. I think that was amazing. Now that I'm more established, hopefully I can pay that back in some way.

T&I: It's nice to see that people who are senior in their fields reach out to junior faculty members in that way.

Khine: It started a great friendship. We're friends to this day, and, you know, I keep him posted on the things that we're working on. I think that when you hear a lot of laughter and people not taking you seriously, but there are a couple of established people you've looked up to who are taking you seriously, it makes all the difference, and that keeps you going.

T&I: You've been quoted as saying that you're an impatient person, but, at the same time, you've also said that sometimes you need to just let things percolate. How do those two traits, which seem to be in tension, work in tandem to make you such an effective problem solver?

Khine: I think you always try to come up with a solution as fast as possible, but what I've learned over the years is that the best ideas evolve and get better over time. It's difficult to wait on things, but it's best to let things simmer. My workaround is that I have a portfolio of different projects I'm working on, so I'll come up with some ideas, work on them with my students, and then we'll go work on a different project and discuss that and work on that for a while. Then, over time, I think the simmering and the bringing in of ideas from disparate fields and disparate realms really enhances that initial seed of a solution.

I think that people think that innovation is kind of a lone sport that a scientist does by himself in a basement, but it's actually very collaborative. It's testing out different things to see what works and what doesn't work. Then, it's coming back together to regroup. I think the thing that I do that is effective is to create an environment where the students feel very safe to throw out any idea as wild as they may think it is. They feel like they're safe and they're not going to be judged and nobody's going to call their idea stupid or discount it. I think that every voice needs to be heard, and they have to feel like they're taken seriously so that they can feel like they can contribute and develop ideas. In my lab, everybody gives input on an idea until it gets to be a really good idea.

T&I: Speaking of students, you're a professor and a mentor as well as a scientist researcher, so you're obviously trying to instill innovative thinking and problem solving skills in your students. In addition to keeping that open innovation environment where people can blue sky and throw ideas out there, are there any other things that you have formalized or institutionalized in your classes or in your lab to promote those kinds of skills?

Khine: I actually run a program called BioENGINE (Bioengineering, Innovation, and Entrepreneurship), with over 120 students in the design class. It's open to all majors, and we actually walk them through the innovation and design process. We have working prototypes of medical devices based on unmet needs. Many times, the students work off the university intellectual property (IP), but they really have to identify an unmet need as they go through the whole process of brainstorming and developing a prototype. Then, they match it back to the needs of the patients or practitioner and figure out go-to-market strategies for that. We started this class two years ago, and we support the best teams to move forward with a little bit of money over the summer. Our first graduating class had a team of students that just secured their first National Institute of Health (NIH) and Small Business Innovation Research (SBIR) grants of $300,000. It is really unusual for a team of undergraduate students to be awarded an NIH grant, so I am so proud of them.

T&I: I saw that some of your students also went on a reality invention show.

Khine: Yes, one was a grad student, and the other was an undergrad, both from my lab. They went on a show called *America's Greatest Makers,* and they made it to the semi-finals based on a project that we worked on in the lab. I try to encourage my students if they're interested in pursuing anything entrepreneurial. I also teach, at the graduate level, a class called Opportunity Recognition at the Interface of Medicine and Biology. This program is to help train students to think because we, as academics, tend to have this way of training people to be academics where we teach people how to be researchers. But the reality is that most of our students do not become researchers, so I really want to teach students real-world skills that they can apply whether they want to go on to work in industry or whether they want to start their own companies or whether they want to go into academia. I think that these entrepreneurial and innovation skills are skills that really span all of those disciplines and would benefit them, and that's the goal of this program.

T&I: That really speaks to the idea of inspiring people at an early stage, and you, of course, were recognized by the *MIT Technology Review* in their list of great innovators who are under the age of 35. Why is this kind of recognition so important for young scientists and innovators?

Khine: It's that validation early on that you're being recognized for your work and you're not crazy because, in our work, you question yourself a lot. So getting that validation, for me, meant that I was really being recognized because somebody I did not know very well but who had seen my work nominated me. He was at a prestigious university, and he did not have to go through the trouble to nominate me, but he went through this whole process. He reached out, and he thought that what I had created was really cool and deserved recognition. And then there's the peer-review process that evaluates these nominations to select the awardees. I think that that makes a difference in terms of providing that support for younger people starting off saying, "You guys are on the right track," which I think is really important to hear every once in a while. You get a lot of rejections with grants and stuff, and you doubt yourself a lot, so getting these kinds of recognitions is very positive. When you do get something like that, it's really nice, and it keeps you going.

T&I: Since this interview will appear in the gender gap in invention issue, let's turn to the disparities that exist in that space. Have you or other women that you know faced gender discrimination in the invention and innovation space, and how have you handled those situations?

Khine: I think every woman has faced it. Certainly, as an entrepreneur, I've faced it. You walk into a room for investor pitches, and I would say a lot of times, I'm the only woman in the room. Maybe, if I'm lucky, there are two other women. You get a sense that your ideas are discounted or you're not taken seriously. I have a colleague who is an electrical engineering professor who is very well established and who has done a lot of work in her particular field. She gave a pitch to an investor group, and they said "No, that, that's not right. that's not possible," until she sent them the papers that she had written basically proving what they told her was not possible.

Investor pitches are hard enough whether you're a man or a woman because the majority of time you're going to get a rejection, but I do see a difference when my male colleagues and female colleagues present, and I don't think it's actually apparent even to the person who is guilty of prejudice—I think these are unconscious biases. I don't actually think most people mean to be prejudiced; they just don't think very much about the implicit biases that might be affecting their decisions. I think it's about time that we change that, and that's what I want to do with these programs and by training these young women to take on leadership roles and start companies.

I see this generation of students as different. My male students don't look at their fellow female students differently. They don't talk down to them. They don't discount their ideas, and that reassures me that we're moving in the right direction. I think we're cultivating that in our young people. We make these outreach tools to reach kids as young as five years old. We start with children because I really think that they're our future, and I think that we have to start there to make things right. I think it is very difficult to even tell somebody who is older and established who's used to talking a certain way that they are demonstrating bias because they don't even realize they're doing it, but we can easily make a difference with our young people.

T&I: What are a couple of things that we could be doing in the lab, classroom, or industry to more effectively reduce the gender gap in invention?

Khine: Traditionally, classroom lectures in engineering have appealed to men; have been taught by men; and so are taught in a way that engages men. Most of the people in those classes were men, so it feeds on itself.

The majority of students in my lab now are female, which has been a shift. I had my first female graduate student five years ago, and now it is predominantly women. I think women care about the world, and they like to solve problems that are meaningful to them. When you contextualize engineering problems in terms of solving social, world issues and not just solving the problem because it's technically interesting or because the math is cool or because there are gears in it, women tend to care more because they prioritize doing good in the world. I think that they

are also maybe more social, so I like to have teams of students work on things. I think that just recognizing what your students need and supporting that is a way to be more inclusive in the classroom and to engage students and to keep them engaged.

T&I: Final question. You were recently included in a list of the hottest scientists, and I couldn't help but wonder how you feel about that. Do you think that's a good thing or a bad thing?

Khine: I have mixed feelings about that, and I guess it goes back to when I was starting my academic career in graduate school. I never wore makeup, never wore heels. I wanted to blend in as one of the guys very desperately because I wanted them to take me seriously. I didn't want them to discount me. Then, one of my first friends in academia was a junior professor, and she wore makeup and was very feminine. She said, "Just be yourself because this is too tiring. You don't want to blend in. If you want to wear a skirt to work, if you want to put on makeup, you should feel at liberty to do that because that is being taken seriously: when somebody looks at your work for itself, and not because you're fitting in and conforming."

The list itself is a conversation starter, and people bring it up sometimes. There are men on the list, which is nice. I don't actually know if it is a positive thing or a negative thing, but what's neat about it is it actually highlighted scientists on social media, which is nice. I think the more visibility that scientists actually get as human beings is good because I do think that they stereotype us to be very much like Sheldon on *The Big Bang Theory*. So if they said, "Well, this is actually what scientists are like, they're both male and female and they can be attractive, they can come in all different colors," I think that's a good thing.

CONCLUSION

There is perhaps no better way to wrap up this profile on Khine than to revisit the National Academy of Inventors induction ceremony in April 2017. When her name was called, Khine came up to the stage to receive her medal with her young son strapped around her in his baby carrier, at which point the whole crowd erupted in applause and sprang to their feet collectively in a heartfelt standing ovation. When asked if that moment was a conscious decision or not, Khine turns reflective, "I thought about that in advance because I looked around the room, and it was predominantly distinguished men, and so I was a bit intimidated – but I also just wanted to share this special moment with my son. I also wanted to make a statement that working moms with young children could be inventors." Her support for working moms is consonant with her body of work, as she is true to the principles of equity and fairness in all things, from equal access to health care to eliminating disparities in health outcomes to leveling the playing field for scientists of all genders. On that last point, Khine adds, "I'm lucky right now because I have freedom to juggle my days, but I think that we need to figure out how to support all inventors because the creativity is there, but we need to figure out how to allow women inventors the time to be a mom and to also be an inventor. I think that is the statement that needs to be made." It would be hard to disagree with either Khine's assessment or with the fact that her success in academia and her ability to translate that success to a larger lay audience is helping to make equity for women inventors a more reachable goal. As this piece goes to print, Khine is currently pursuing her fifth company and recently had her second baby.

FURTHER READING

1. Park SJ, Kim J, Chu M, Khine M. Flexible Piezoresistive pressure sensor using wrinkled carbon nanotube thin films for human physiological signals. Adv Mater Technol. 2018;3(1).
2. Park SJ, Kim J, Chu M, Khine M. Highly flexible wrinkled carbon nanotube thin film strain sensors to monitor human movement. Adv Mater Technol. 2016;1(5).
3. Pegan JD, Zhang J, Chu M, Nguyen T, Park SJ, Paul A, Kim J, Bachman M, Khine M. Skin-mountable stretch sensor for wearable health monitoring. Nanoscale. 2016;8:17295-17303.
4. Lee EK, Kurokawan YK, Tu R, George SC, Khine M. Machine learning plus optical flow: a simple

and sensitive method to detect cardioactive drugs. Sci Rep. 2015;5:11817.
5. Sharma H, Digman M, Felsinger N, Gratton E, Khine M. Enhanced emission of fluorophores on shrink-induced wrinkled composite structures. Opt Mater Express. 2014;4(4):753-763.
6. Lin S, Hedde PN, Venugopalan V, Gratton E, Khine M. Multi-scale silica structures for improved HIV-1 Capsid (p24) antigen detection. Analyst. 2016;141(13):4181-4188.
7. Chen A, Lee E, Tu R, Santiago K, Grosberg A, Fowlkes C, Khine M. Integrated platform for functional monitoring of biomimetic heart sheets derived from human pluripotent stem cells. Biomaterials. 2014;35(2):675-683.
8. Wang J, Chen A, Lieu DK, Karakikes I, Chen G, Keung W, Chan CW, Hajjar RJ, Costa KD, Khine M, Li RA. Effect of engineered anisotropy on the susceptibility of human pluripotent stem cell-derived ventricular cardiomyocytes to arrhythmias. Biomaterials. 2013;34(35):8878-8886.
9. Pegan J, Ho A, Bachman M, Khine M. Flexible shrink-induced high surface area electrodes for electrochemiluminescent sensing. Lab Chip. 2013;21:4205-4209.
10. Lin S, Sharma H, Khine M. Shrink-induced silica structures for far-field fluorescence enhancements. Adv Opt Mater. 2013;1(8):568-572.