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Turning Practicing Surgeons Into Health Technology Innovators: Outcomes From the Stanford Biodesign Faculty Fellowship

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Abstract

Background. The Stanford Biodesign Faculty Fellows program was established in 2014 to train Stanford Medical and Engineering faculty in a repeatable innovation process for health technology translation while also being compatible with the busy clinical schedules of surgical faculty members. *Methods*. Since 2014, 62 faculty members have completed the fellowship with 42% (n = 26) coming from 14 surgical subspecialties. This eight-month, needs-based innovation program covers topics from identifying unmet health-related needs, to inventing new technology, developing plans for intellectual property (IP), regulatory, reimbursement, and business models to advance the technologies toward patient care. *Results/ Conclusion*. Intake and exit survey results from three years of program participants (n = 36) indicate that the fellowship is a valuable hands-on educational program capable of improving awareness and experience with skill sets required for health technology innovation and entrepreneurship.

Keywords

health technology, medical technology, medtech, innovation, innovation education, biodesign, surgical innovation education

Background

Stanford Biodesign was founded in 2000 with an explicit goal to train the next generation of leaders in health technology innovation—defined in this context as medical devices, device-based diagnostics, digital health solutions, and health information technology. Its initial educational program was a full-time, 10-month Innovation Fellowship targeted at postgraduate and postdoctoral engineers, physicians, and business professionals. Working in multidisciplinary teams, these fellows learn and practice a need-driven process for developing new medical technologies and delivering them into patient care (see Figure 1).

Over time, Stanford Biodesign added new educational offerings to its portfolio, including courses for Stanford students, global partnerships, and an executive education program for leaders from the health technology industry. For each offering, the primary learning objectives continue to focus on training participants in our need-driven approach to health technology innovation, but the teaching approach, depth of content, and expectations regarding how the trainees apply their learnings are adjusted for each target audience. All educational offerings involve a project-based curriculum that seeks to address real unmet clinical needs. To date, Stanford Biodesign trainees have launched more than 50 start-ups based on projects initiated during their time in our programs. These companies, in turn, have created more than 1400 full-time jobs and raised more than US$860 million in funding. More importantly, their technologies have been used to help more than 3.4 million patients.[1]

Despite this expansion of our programs, the leaders of Stanford Biodesign recognized that we were overlooking an unmet need within the Stanford community——training

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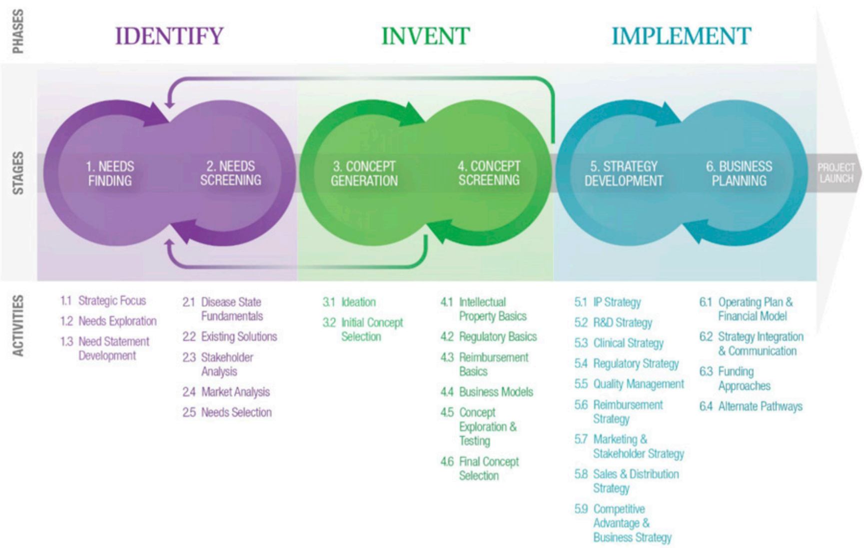

Figure 1. Three-Phase Biodesign Innovation Process. *Source.* Yock, et al, *Biodesign: The Process of Innovating Medical Technologies*, Second Edition, Cambridge University Press; 2015. Reprinted with permission of the authors.[7].

faculty members from the schools of medicine and engineering who had a desire to be involved in health technology innovation. Accordingly, in 2014-2015, we launched a pilot—known as the Biodesign Faculty Fellows (BFF) program[2]—to identify physicians and engineers on the Stanford faculty with a strong interest in health technology innovation, train them in our innovation process, and support their efforts to develop health-related technology-based solutions in the university environment.

Over the past six years, the BFF program has trained 62 Stanford faculty members who have translated multiple technologies into projects and companies on their way to patient care. While not exclusive to surgeons, 42% of all participants (n = 26) have come from surgical departments. The purpose of this study is to outline the structure of the program, describe the outcomes achieved to date, and share surgery-related case examples of how the program has benefitted our faculty trainees. The authors hypothesized that the BFF program would significantly improve the health technology innovation skill sets of practicing surgeons.

Biodesign Faculty Fellowship Program Structure

Each year, the BFF program begins with a search for faculty members passionate about health technology innovation. Our focus is on recruiting from the Stanford Schools of Medicine and Engineering. Because we only have 12 spots in the program to fill each year, most participants come to us via referrals from faculty members who have participated in the program and/or department chairs recommending faculty with a health technology focus. Importantly, we have found department chairs to be supportive of the program because it helps them recruit and retain high-performing faculty members in their groups. Many individuals with an interest in health technology join the Stanford faculty to become involved in the Silicon Valley health technology ecosystem. The BFF program provides a mechanism for them to access this community, as well as training specifically intended to jumpstart their health technology innovation activities and research.

In recent years, we have received approximately 20-35 applications for 12 spots in the program. When making selection decisions, preference is typically given to those who have demonstrated initiative in launching or participating in health technology innovation projects (even if they have been unsuccessful), as well as those who have a clear career interest in developing and advancing new technology-based solutions toward patient care.

The BFF program launches with a nearly daylong kickoff session. The objectives of this initial meeting are to enable participants to get to know one another, expose them to the Stanford Biodesign process via an interactive workshop, and to introduce them to "alumni" of the program with deep technology translation experience in the health tech field who can share perspectives on how they incorporated innovation activities into their career pathways and how they interfaced with the university to bring their ideas to market. Following the kickoff, the BFFs embark on eight months of programming that spans October through May each academic year. During this period, their training is centered on the first two phases of our innovation process—identify and invent (See Table 1).

Table 1. BFF Program Timeline and Activities.

	IDENTITY		INVENT	
May-June	Oct-Feb		Mar-May	
Recruiting/Selection	Needs Finding	Needs Screening	Concept Generation	Concept Screening
BFF leadership team Identifies faculty members with an interest in health tech innovation Meets one-on-one with prospective applicants and holds a group information session Collects and reviews applications Conducts interviews Selects participants Coordinates with department chairs to reconfirm participation/ support	*BFFs* Participate in the kickoff program Conduct first-hand clinical observations (while not delivering patient care) Identify at least five compelling unmet health-related needs Conduct preliminary need research to narrow down to their top two needs to advance through more in-depth screening	*BFFs* Take a deep dive into the top two needs, investigating the disease state, competitive landscape, stakeholder landscape, and market opportunity through primary and secondary research Conduct an objective comparison to select the top need Define the most essential requirements that a new solution must meet in order to have a chance at being adopted	*BFFs* Hold multiple ideation sessions Practice early-stage prototyping to explore preliminary ideas Evaluate preliminary ideas in terms of their promise to deliver against the essential requirements defined during need screening Select the most promising idea(s) to advance into detailed concept screening	*BFFs* For the lead idea, investigate the IP landscape, regulatory pathway, payment options, and business model Conduct more advance prototyping to evaluate technical feasibility Create a development plan to advance the project beyond the training program Apply for extension funding (if appropriate) Present projects to panel of health tech experts for feedback

Abbreviations: BFFs = Biodesign Faculty Fellows.

The program has been designed explicitly to be workable for surgeons and other busy faculty members. Participants work on their own projects, rather than in pre-assigned groups to provide the most flexibility and applicability for their work schedules. Fellows are expected to devote 8-10 hours per week over eight months as follows:

1. Asynchronous assignments—completed independently.
   (a) Weekly readings and videos that provide didactic instruction and case examples on the fundamentals of each step in the innovation process.
   (b) Project-based work that enables the BFFs to practice what they have learned by applying it to a real-world health technology innovation project of their choosing.
2. Group workshops—held monthly during needs finding and then weekly once the BFFs transition into needs screening (Wednesday evenings from 5:30-7:30 PM after most clinic and/or operating room responsibilities are complete).
   (a) Used to clarify and reinforce key didactic learnings, as well as to coach the BFFs through their innovation projects.

We engage three experienced health technology innovators (all alumni of the Stanford Biodesign Innovation Fellowship) to act as the program directors and primary coaches for the BFFs. However, the BFFs engage with many other mentors during the program (see Table 2). We consider this "high-touch" teaching model to be a top program success factor given the complexities of health technology innovation. In particular, it offers three primary benefits:

1. It enables us to personalize the educational experience for each BFF and the project they are working on and address unique challenges as they arise.
2. It ensures "real-world" perspectives so the program is not simply an academic exercise.
3. It initiates the formation of a rich network in the local health technology innovation ecosystem that the BFFs can tap into for assistance and support beyond the duration of the program.

In addition to the individuals listed in Table 2, other advisors are engaged on an as-needed basis, depending on the specific interests of the BFFs and/or needs of their projects.

Table 2. BFF Program Coaches and Mentors.

Role	Description	Approximate Time Spent With BFFs
Program directors	Three alumni of the Stanford Biodesign Innovation Fellowship who have health tech innovation experience; act as the primary instructors and project coaches for the BFFs	Two hours per week with a cohort of four BFFs during the weekly group workshops, plus asynchronous coaching as needed; engaged for the full eight-month program
Engineering coaches	Six alumni of the Stanford Biodesign Innovation Fellowship with deep engineering expertise; help the BFFs ideate and prototype their solutions; these coaches are especially helpful to physician participants who may not have deep technical skills	Five 1-hour meetings during group workshops, plus asynchronous coaching as needed; each engineering coach mentors two BFFs; meetings take place starting in late Feb once a top need has been selected
Business coaches	Six experienced academic innovators who have translated health tech projects out of the university; provide advice about navigating the university system and preparing to advance new technologies to market	Three to four 1-hour meetings with their assigned BFFs; each business coach mentors two BFFs; meetings take place late Mar through May as the projects become more advanced
Subject matter experts	24 individuals from the local health tech ecosystem who provide 1:1 project coaching to the BFFs in their area of expertise—specifically intellectual property, regulation, reimbursement/payment, and business models	Four topic areas; six experts for each topic; each meets with two BFFs; one 1-hour meeting with their assigned BFF, plus follow-up advice as requested; meetings take place in Apr and May as the projects become more advanced

Abbreviation: BFFs = Biodesign Faculty Fellows.

Beyond the high-touch teaching model, we have identified several other factors that have been critical to making the program successful for faculty trainees (See Table 3).

Methods

In-Person Faculty Fellow Survey Administration

To monitor program performance against its desired outcomes, we conducted a comparative intake and exit survey of three classes of faculty fellows who completed the BFF program. A waiver was issued by Stanford University Institutional Review Board (IRB), indicating the survey of faculty fellows did not meet federal definitions of research nor clinical investigation. Data were collected from identical intake and exit surveys administered via pen/paper at the start of the BFF program and eight months later at the conclusion of the fellowship (See Supplemental Appendix 1: Intake survey). Data were gatherd from Stanford faculty members who completed the Biodesign Faculty Fellowship between October 2017 and June 2020 (n = 36). The participants did not have access to their intake survey answers when completing the exit survey. Answers were de-identified and aggregated into a MS Excel worksheet.

There were three categories of questions asked: demographics, perceived importance of health technology innovation on career trajectory, and perceived change in innovation skill acquisition. Demographics were gathered via multiple-choice questions, while the remaining two categories were assessed on a 5-point Likert scale with 5 representing the "highest" response and 1 being the "lowest." For the perceived importance of health technology innovation on career trajectory, the scale ranged from "very important" (5), "somewhat important" (4), "neutral" (3), "somewhat unimportant" (2), and "very unimportant" (1).

For the perceived change in innovation skill acquisition, the scale ranged from "I consider myself experienced in this"(5), "strong awareness + some practice"(4), "strong awareness but no practice"(3), "some basic awareness"(2), and "no real skill set in this area"(1).

Statistics

Statistical analysis regarding the perceived change in innovation skill acquisition was performed using a 2-tailed paired Student's t-test with a level of significance of 0.05 comparing pre- and post-fellowship responses. Mean values with a 95% confidence interval were computed (See Table 4).

Results

Survey Participants

All 36 individuals completing the Biodesign Faculty Fellowship in the three years surveyed completed the intake and exit surveys. They were required to be Stanford faculty members and represented varying areas of medical and engineering specialties. Those included in this survey (2017-2020) represent 30 MDs, three engineers, and three with both medical and engineering backgrounds.

Table 3. Other Success Factors for the BFF Program.

Factor	Explanation
Seek department chair approval (and funding) in advance	Candidates must get their department chair's signature on their application prior to submitting it, and department chairs must agree to underwrite a nominal fee that compensates Stanford Biodesign, in part, for offering the program. These requirements force an early discussion between the candidate and the department chair, help set shared expectations around the time commitment of the program and increase the accountability of both parties
Allow faculty participants to work individually rather than on teams	While there are many advantages to tackling health tech innovation projects on a multidisciplinary team, we do not require this in the BFF program. Because faculty members are truly experts in their specialty areas, we want to allow them pursue innovation opportunities in their unique domain rather than necessitating that a team of BFFs to agree on a single need area. Some BFFs seek out the benefits of teamwork by enlisting others from their departments to help on their projects. And we also support spontaneous (optional) team formation among the BFFs when they find areas of mutual interest
Allow faculty participants to work on technologies they have already invented	While the Stanford Biodesign innovation process advocates for starting innovation projects with a comprehensive need finding exercise, we recognize that many high-performing faculty members are already working on developing health technologies. We enable them to bring these projects into the program as long as they are willing to set aside their invention for the first five months of the program and spend that time more deeply validating their understanding of the need and the essential requirements that a new solution must meet in order to have a chance at being adopted. Then, they can brainstorm and determine how their original concept holds up to the market analysis and alternative approaches
Require weekly project progress deliverables	Because faculty members have so many other demands competing for their attention, we have found it essential to require the completion of weekly project progress deliverables as "forcing factor" to keep the projects on track and moving forward. Without the expectation of a concrete, weekly deadline it is easy for even the most dedicated, well-intentioned faculty members to start falling behind on their program work
IP assigned to the university	Because the BFF program makes use of significant university resources, any IP resulting from projects initiated in the program is assigned to Stanford University. Keeping the projects in the university during their early stages has many benefits, including the involvement of experts across disciplines and departments in brainstorming and developing solutions. Technologies can be licensed from the university if a BFF wishes to start a company with their IP.
Provide extension funding opportunities to help keep promising projects alive	Without the structure the program provides it can be challenging for faculty members to continue to devote significant time to their projects. By making small extension funding awards available on a competitive basis to the BFFs, along with continued mentoring by the program directors—we have seen a notable increase in the number of projects that have continued beyond the duration of the program
Keep alumni engaged	Once trained, the BFFs who participate in the program become a valuable network in and of themselves. By providing basic mechanisms for our alumni to stay in touch with Stanford Biodesign and with one another, we have developed a robust community of individuals willing to help with other programs and assist one another in their future endeavors

Abbreviations: BFFs = Biodesign Faculty Fellows; IP = intellectual property.

Table 4. Self-Reported Skill Set Evaluation.

Skill Set	Intake Survey Mean (SD)	Exit Survey Mean (SD)	*P*-value
Identifying unmet health-related needs	3.00 (.99)	3.94 (.41)	$P < .001$
Prioritizing unmet needs based on objective factors related to their potential to improve healthcare	2.64 (.96)	3.86 (.54)	$P < .001$
Generate hypotheses	3.36 (1.01)	4.08 (.55)	$P < .001$
Invent a new technology	2.28 (1.16)	3.47 (.77)	$P < .001$
Develop a useful prototype of an idea or invention	2.39 (1.27)	3.17 (.94)	$P < .001$
Understand intellectual property (IP) protection for a new technology	1.91 (1.02)	3.22 (.79)	$P < .001$
Understand the market potential of a new technology	1.92 (.80)	3.22 (.83)	$P < .001$
Understand the regulatory pathway for a new technology	1.56 (.87)	3.25 (.90)	$P < .001$
Understand the payment/reimbursement pathway for a new technology	1.52 (.77)	3.11 (.85)	$P < .001$
Create an implementation plan to advance a new technology toward patient care	1.56 (.69)	2.94 (.92)	$P < .001$

Note. BFFs participating in the surveys self-reported their competence related to multiple innovation-related skills sets before and immediately following the fellowship (n = 36). Ten skill areas were assessed via a 5-point Likert scale ranging from "no real skill set in this area"(1), "some basic awareness"(2), "strong awareness but no practice"(3), "strong awareness + some practice"(4), and "I consider myself experienced in this"(5). Fellows entering the program reported lower awareness and experience in the more technical and business aspects of the fellowship. Following the fellowship, improved awareness was noted across all skill sets with a trend toward increased practice of the skills.

Demographics

During the three classes surveyed, 72% of participants identified as man (n = 26) and 28% identified as women (n = 10). This is a similar ratio of reported gender breakdown as has been previously reported in the flagship Stanford Biodesign Innovation Fellowship.[3] Race was self-reported as white/Caucasian (n = 17, 46%), Asian (n = 14, 38%), Black or African American (n = 3, 8%), Middle Eastern or North African (n = 2, 5%), and Hispanic/Latino (n = 1, 3%).

Of the BFFs surveyed, the majority were from medical or surgical specialties (83%, n = 30), with a minority from engineering alone (8%, n = 3) or combined medical and engineering backgrounds (8%, n = 3).

Surgical specialties represented. A total of 14 surgeons were trained and surveyed, representing the following surgical subspecialties: cardiothoracic surgery (1), general/colorectal surgery (1), general/trauma surgery (2), neurosurgery (1), ophthalmology (1), orthopedic surgery (1), otolaryngology (1), pediatric neurosurgery (1), pediatric otolaryngology (1), pediatric urology (1), plastic surgery (1), and urology (2).

Faculty line. Three different faculty appointment tracks were represented in the survey data: clinical educator (CE), medical center line (MCL), and university tenure line (UTL). Clinical educator staff spend the majority of their time taking care of patients and are promoted based upon their excellence in clinical care and teaching. Medical center line faculty appointees are expected to achieve excellence in clinical care, teaching, and scholarly activity. They are required to have at least 20% FTE support for scholarship. University tenure line faculty are promoted based upon their achievement of true scholarly distinction in a specific field and sustainment of a first-rate teaching program but are not required to engage in clinical care (e.g., engineering faculty). The majority of fellows completing the survey were appointed to the CE line (n = 20, 56%), followed by MCL (n = 12, 33%) and UTL (n = 4, 11%).

Faculty Rank level. As shown in Figure 2, the majority of fellows were early to mid-career, with 39% identifying as assistant professor (n = 14) and 31% as associate professor (n = 11). 8% were instructors (n = 3), and 19% (n = 7) were professors. One participant (3%) was a senior research scientist.

Years at Stanford University. The majority of fellows (75%, n = 27) were relatively new to Stanford University, being on campus only 1-5 years before entering the fellowship. 17% (n = 6) had been at the institution for 6-10 years with 8% (n = 3) 21 years or more. Notably, there were no fellows that had been at Stanford University for 11-20 years.

Perceived Importance of Health Technology Innovation on Career Trajectory

On a 5-point Likert scale, faculty fellows overwhelmingly indicated that developing new advances in health technology was "very or somewhat important" (n = 31, 86%). On their program applications, many of the fellows cited

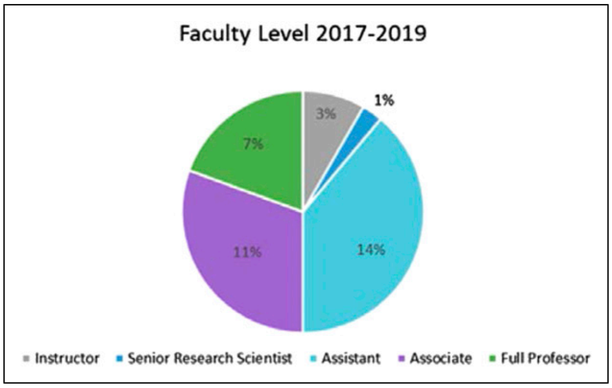

Figure 2. Faculty Rank at Intake. Source: Compiled from three years of intake data.

increased involvement in health technology innovation as a primary reason for pursuing a faculty appointment at Stanford University.

Academic promotion. Following program completion, the majority of fellows (n = 25, 69%) "strongly agree" that academic promotion criteria should include health technology innovation activities (i.e.,, identification of needs, invention of solutions, and the translation of products to the market).

Perceived Change in Innovation Skill Acquisition

Fellows entered the program with variable amounts of health technology innovation experience. In general, they had minimal experience with filing patent applications (total: 10 provisional patents and three non-provisional utility patents) and developing software applications, in particular.

Ten skill areas to enable health technology innovation were assessed via a 5-point Likert scale (See Table 4). These skill areas included: identifying unmet health-related needs, prioritizing unmet needs based on objective factors related to their potential to improve healthcare, generate hypotheses, invent new technology, develop a prototype, intellectual property (IP), regulatory pathways, reimbursement pathways and business models, and create an implementation plan moving a technology toward commercialization.

Biodesign Faculty Fellows largely entered the program with strong awareness and some experience in identifying unmet health-related needs and generating hypotheses, with less experience in the more technical elements of the program (e.g., inventing new technology and prototyping) and minimal to no skill set/awareness in the implementation portion of the fellowship (e.g.,, IP, regulatory and reimbursement pathways, and developing business models) (See Table 4). In comparison, on post-fellowship surveys, the fellows indicated that they gained strong awareness and some experience in all aspects of the program—except implementation planning to advance a new technology toward patient care, which is only expected of those projects that move forward with extension funding but not a requirement for the basic fellowship. Additionally, there was a significantly increased awareness of on-campus innovation resources and grant programs.

Type of clinical need pursued. As part of the program, BFFs are encouraged to perform independent needs finding and generate a list of needs to compete with one another. However, as noted, some faculty members enter the program with a specific project in mind. Based on exit survey results, most of the fellows (n = 23, 59%) started with the needs finding assessment and followed the process to pursue their project, rather than entering with an established need. Other fellows came in with a project and through the process, switched to another need (n = 5, 13%). Some fellows had previously identified a need, but not a solution, and continued to work on that project throughout the program (n = 9, 23%).

Discussion

Case Examples

The following case examples demonstrate how different faculty members, working on various projects, realized the benefits of the BFF program from incorporating learnings into their research, starting new areas of investigation, and building companies with commercially available products.

A more translational approach to research. Alison Marsden, a PhD in mechanical engineering, came to Stanford in 2015 as an associate professor of pediatrics (cardiology) and bioengineering. Her lab focuses on fundamental computational methods for the study of cardiovascular disease progression, surgical methods, treatment planning, and medical devices. When she heard about the BFF program, she was intrigued. "I hadn't done a lot of translation activities out of my lab, so I wanted to learn that process," she explained. "And I was still relatively new to Stanford, so I thought it would be a good way to make new connections, especially with faculty from the school of medicine."

Marsden and her team were working on devices to aid in the prevention of vein graft failure, following coronary bypass surgery. They had some general ideas based on modeling studies that these devices could be helpful in encouraging veins to remodel in a more favorable way. "But we had only looked at it from a purely scientific point of view," she said. Marsden brought this project into the BFF program. Reflecting on the experience, she pointed to several ways the program changed her approach to her research.

First, the early stages of the BFF program required her to temporarily set her solution aside and revalidate the need it was intended to address. "I realized that when conducting research, we often don't step back and formally think about needs. Our research has led us to a certain question, but we don't always think critically about whether that's the most valuable question to answer in the space." She now routinely runs needs exploration activities with members of her lab.

Second, her project took a major turn as a result of the competitive analysis and IP searching that's required as part of the program. "We were surprised to learn how much was already out there in the patent literature," Marsden explained. "A lot of times we have scientific ideas that are new, but they might not be patentable. In our case, our initial ideas turned out not to be protectable so we had to go back to the lab and start looking for other ways to implement a similar concept. It forced us to get more creative and ultimately led to a stronger solution."

Third, the program motivated Marsden to physically prototype her ideas, which significantly accelerated project progress. "Without BFF, we probably would have continued in the modeling direction," she said. "Instead, we're now running an animal study to evaluate at least one instance of the potential device using sheep, which has been an invaluable source of learning. This also helped us initiate a collaboration with Stanford's department of surgery. And we're now in discussions with interested parties from industry about licensing or spinoffs."[4]

Overall, she said, "I wish I had access to the program earlier, as an assistant professor, because it can really change your mindset in deciding what to work on."

Moving beyond an interesting idea. Derek Amanatullah, assistant professor of orthopedic surgery, always had a passion for inventing but was motivated to become a BFF after two unsuccessful attempts to develop medical technologies on his own. "I realized I was inventing things that companies and other people didn't need," he recalled. "I wanted to figure out how to break that cycle."

As part of the BFF program's needs finding experience, he observed healthcare providers being fearful of losing track of items such as sponges or syringes during surgery and that their anxiety caused excess OR time being spent on tracking procedures and recounts. He ended up pursuing a better way to account for surgical items during open operative cases to reduce wasted time.

He imagined a solution that would utilize cameras with computer vision algorithms to visualize these types of objects in the operating room, rather than relying on people. "We would be able to see objects like sponges or syringes move around the operating room. And if one of those objects falls on the ground or gets tucked under a drape, we'd see it go missing so that the team can look for it before the end of the procedure when they usually do the count," he explained. "It's like your keys falling out of your pocket—it's easier to find them right then and there, rather than going back to look for them an hour later."

By the end of the formal BFF program, Dr Amanatullah had designed an early-stage concept. With help from the Stanford Biodesign program, he was awarded a Coulter Translational Research Grant. He filed two provisional patent applications and connected with the Stanford Artificial Intelligence Laboratory, where he found collaborators interested in developing a benchtop prototype of the system.

Over the next several months, he gathered more detailed requirements from important stakeholders (i.e., nurses and technicians), refined the technology, and started testing the system. Ultimately, he said, "We presented our positive findings to the chairs of the surgical departments at Stanford and convinced them to commit discretionary funds to run a pilot." Dr Amanatullah continued, "We've been fortunate in that we've been able to find people who understand the risks but are willing to come along with us to innovate improvements in patient care." In parallel to the Stanford pilot, he and his team are preparing to raise a pre-seed round of funding to help make the technology commercially available.

Reflecting what he had learned since joining the program, Dr Amanatullah said, "It has been an invaluable experience. Biodesign Faculty Fellow taught me the piece that I was missing: There are thousands of inventions you can think of. But unless you take two steps back and really understand the need, you're unlikely to be successful."

Unlikely connections. Eric Sokol, associate professor of obstetrics and gynecology, had a long-standing interest in surgical innovation and medical devices. When he heard about the BFF program, he was eager to join. "I realized that it would be fantastic to learn an end-to-end innovation process. There are many of us who have interesting ideas, but we don't know where to start or who to connect with to point us in the right direction."

He joined the BFF program intending to pursue unmet needs in urogynecology and pelvic reconstructive surgery. However, his plans changed dramatically at the kickoff meeting. In that session, the BFFs were randomly assigned into teams of three fellows each for an exercise designed to expose them to the Biodesign approach. Sokol teamed up with Robert Chang, an assistant professor of aophthalmology, and Jan Liphardt, an associate professor of bioengineering. They were given a vignette that described challenges faced by expats in managing the negative health effects of air pollution when on assignment in countries with poor air quality, and they spent the next several hours investigating the need and coming up with a solution. “We all travel a lot for our jobs, to places across Asia,” Sokol explained. “So we understood the challenge and got pretty excited about the exercise. We ended up coming up with the idea for a small, wearable device that would fit discretely under the nose. We pitched it to the group at the end of the session and they really liked it.”

About a week later, Liphardt contacted Sokol and Chang and proposed that they keep working on the idea. They joined forces and continued to advance their understanding of the need and further developed their solution concept. By the end of the BFF program, they had filed multiple provisional patent applications and had begun seeking funding to keep the project alive. In 2017, they founded Advanced Ventilation Applications, Inc. and raised US$2 million in seed funding.[5] In 2019, the company’s first product——AVA Breathe, which they describe as the world’s smallest, smart, connected, personal air purifier——became commercially available in the United States.[6]

“Our story almost sounds like the set-up for a joke,” Sokol said. “A urogynocologist, an ophthalmologist, and a bioengineer walk into a workshop … and end up starting a company. But that’s the beauty of the program. It brings people together who wouldn’t necessarily have the opportunity to meet and sparks creative connections. And, he added, “It provides you with a framework and resources to help you pursue the interesting opportunities that result.”

Intake and exit survey results from three years of program participants indicate that the fellowship is a valuable hands-on education program to improving awareness and experience with skill sets required for health technology entrepreneurship in surgeons and other medical professionals, especially with the technical and implementation portions of the curriculum. This program has enabled faculty members to start new research, incorporate learnings into already established research programs, and even commercialize medical devices.

While the intent of this article was to describe the Stanford Biodesign Faculty Fellowship in a way that could be replicated by others, there are inherent limitations to pre-/post-survey results. The assessment of skill sets was the opinion of faculty fellows rather than directly reflective of a demonstrated work product. Health technology development takes time; and thus, it takes years to see measurable outcomes of these types of education efforts. The majority of fellows identified as male and Caucasian or Asian. Therefore, there is still much work to do to promote gender, racial, and other forms of diversity within the field of health technology innovation. In the future, programs should report on trainee outcomes overtime by specifically reporting the number of companies started, academic promotion with a health technology innovation focus, research and venture capitalist funding secured, number of employees hired, patients treated, and lives saved.

Conclusion

The Stanford BFF program was established in 2014 to cultivate health technology innovation among Stanford-medical and engineering faculty while also being compatible with the busy clinical schedules of surgical faculty members. The majority of fellows trained to date have been clinically active physicians early in their academic careers, and many of them also have active research programs. This eight-month long, needs-based innovation program covers topics from identifying unmet health-related needs, to inventing new technology, to developing plans for IP, regulatory, reimbursement, and business models to advance the new solution toward patient care. Intake and exit survey results from 3 years of program participants indicate that the fellowship is a valuable hands-on education program to improving awareness and experience with skill sets required for health technology entrepreneurship.

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