Frugal Innovations for Global Health—Perspectives for Students

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Global health opens up a plethora of opportunities, yet it encompasses in itself myriad challenges. Biomedical engineering students should embrace these challenges and make the most out of them through innovative projects aimed at solving real-world problems. An interesting observation when one sees the whole domain of biomedical innovations is that many innovations have been stemming out of emerging economies rather than only from the richly funded laboratories of the developed nations. As it has been said, "necessity is the mother of invention," so the lack of crucial infrastructure and technologies often gives rise to local inventions that solve local problems, and health care has been no exception. Many grassroots innovations are often termed *frugal innovations*, developed by below-the-radar innovators representing low-cost solutions using homegrown or self-created technologies, often born out of dire need [1].

The process of frugal innovation has been hastened by several other factors, and understanding them is vital not only for sustainable development but also to create a healthy ecosystem for entrepreneurship and structured scientific research. During the past few years, when I have been involved in developing technologies for the base of the pyramid (BOP), it has become increasingly clear to me that one of the primary factors fueling the innovative spirit has been the percolation of education and information to the lowest strata of the society [2]. An important vehicle for this change has been the student community, especially the young people in science, technology, engineering, and math (STEM) programs, university students, and young professionals. The pervasiveness of communication technologies, especially the telecom revolution in India, brought the required outlook and encouragement for young people to conceptualize and execute their own dream projects.

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Another important factor has been the constant endeavor of several corporations and universities to enter this space and reshape neighborhoods (often technically termed the *field practice area*). The Manipal BOP Program in the southern India state of Karnataka, in association with corporations such as Philips and Texas Instruments, the Dell Social Innovation Challenge, and the Bill and Melinda Gates Foundation, are all having a significant impact in reshaping global health in niche ecosystems [3]. Moreover, country-specific product development initiatives are being undertaken by multinational companies to tap the vast potential marketplace. The handheld (GE VScan) and portable ultrasound systems, point-of-care screening devices, and low-cost incubators stand testimony to the same.

There is also another side of the spectrum where technoenthusiastic physicians, equipped with an understanding of the ground realities of global health

Curious students look on at a portable ultrasound system being used during a rural health camp in Midnapore, West Bengal, India. The camp was organized by student volunteers from the Engineering in Medicine and Biology (EMB) Student Club of the Indian Institute of Technology (IIT) Kharagpur. (Photo courtesy of the IEEE EMB Student Club of IIT Kharagpur.)

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needs, devise their own equipment in their garages. The story that comes to mind is about the two consultant anesthesiologists at Morriston Hospital in Swansea, United Kingdom, who developed the Shakerscope, a light source for clinical examination of the eye, ear, and throat [4]. It uses the basic principles of electromagnetic induction and generates power in a coil by moving a magnet across it. Shaking the device for 30 s can generate enough electricity to power the light for up to 3 min. This innovation was inspired by the wind-up radio and the innovators' personal experiences in Zambia, where most of the conventional devices failed to work because of the lack of a constant source of power—a problem that echoes around most of the developing world.

The emergence of frugal innovation reduces the need for sophisticated labs and instead relies on clever brainstorming and a better grasp of basic engineering skills.

In the given context of biomedical innovations for global health, it is important to recognize the contributions that students have been making. To emphasize that point, we need go no further than our own IEEE Presidents' Change the World Competition, won by Andrew Brimer, who is studying mechanical engineering, and Abigail Cohen, a bioengineering major, at the University of Washington in St. Louis, Missouri, for developing a low-cost spirometer [5]. The team developed a pocket-size spirometer for the diagnosis and monitoring of asthma, chronic obstructive pulmonary disease, and cystic fibrosis. By integrating the solution with a mobile device, they made a product that empowers the caregivers in rural health care and doubles up as a valuable consumer health care device for the developed nations. The Student Technology Prize for Primary Healthcare, initiated by the Center for Integration of Medicine and Innovative Technologies, provided additional encouragement for United States-based student innovators to explore opportunities in the global health space [6].

The Brazil, Russia, India, and China (BRIC) economies, especially China and India, are the new entrants to the medical technology field, yet they quickly emerged as important drivers of innovation. Many of these designs were presented in the first-ever IEEE Engineering in Medicine and Biology Society (EMBS) Special Topic Conference on Point-of-Care Healthcare Technologies in 2013 hosted by the EMBS of Bangalore, India. Point-of-care technologies are an area of biomedical engineering that I personally feel can highly impact early screening and fortify rural health services in countries such as India and sub-Saharan Africa. During the course of my endeavor to develop a heart sound analysis device for Indian villages, we faced challenges that were more diverse than those encountered in a technology laboratory. The lack of power, unavailability of technically skilled manpower, data connectivity issues, no soundproofing, noisy outpatient departments, and long commutes were only a few of the issues that challenged us. In the end, we were able to devise an ultralow-power cardiac prescreening device that can operate even in these hostile and noisy environments [7]. Such examples of student projects are not rare, but they still lack support.

However, an insight that has dawned upon me is that the emergence of frugal innovation also reduces the need for sophisticated labs and instead relies on clever brainstorming and a better grasp of basic engineering skills. This understanding can indeed stimulate growth of innovativeness and entrepreneurial sprit among the students of universities with not-so-well-equipped facilities and break down the barriers of academic elitism. Things have actually started looking up thanks to excellent IEEE initiatives such as the All IEEE-R10 Young Engineers' Humanitarian Challenge 2013 (AIYEHUM), which provides a platform for students to showcase their solutions to be funded for development [8]. This initiative also helped our group in the EMB Student Club at IIT Kharagpur come up with an image analysis-based solution for malaria detection [9], among other very stimulating projects and success stories. The Web initiative Engineering for Change (E4C) is an efficient tool for collaboration that was used by AIYEHUM participants, and all IEEE Student Members are encouraged to use it to present their innovations to the world and increase their chances of picking up suitable funding opportunities [10].

Finally, touching upon the vibrant career opportunities that the emergent global health care technologies offer is simply exciting. The Stanford Biodesign Program in itself produced several successful ventures and funded student scholarships from several countries, including China, Singapore, and India. The Center for Bioengineering Innovation and Design at Johns Hopkins University and the Consortium for Affordable Medical Technologies (Harvard/Massachusetts Institute of Technology and partners) have been created to teach the next generation of medtech innovators, and they are collaborating with health care device companies to take the designs to emerging economies. In India, Forus Health, the developer of an affordable prescreening tool for glaucoma and retinopathy, and i2i Telesolutions, a technology innovation company in the telemedicine software space, have been an integral part of a larger shift in perspectives and engagements, providing examples of the changing dynamics rather than being the exceptions.

As I look back to recapitulate my experiences as a student and as part of the medtech community and talk with many brilliant innovators in a quest to navigate my way among the biomedical engineering academia and innovation networks, only one statement comes to my mind, that of EMBS President Bruce Wheeler: "There is no better time to be a biomedical engineer!"; and I quip—"especially if you are a student and you have an open world of opportunities lying ahead." Best wishes to all of my student friends, and happy innovating as we enter 2014.

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PRESIDENT'S MESSAGE *(continued from page 6)*

2012, EMBS lead, shared; now *IEEE Journal of Biomedical and Health Informatics)*

- 2001: *IEEE Transactions on Neural Systems and Rehabilitation Engineering* (formerly *IEEE Transactions on Rehabilitation Engineering*)
- 2002: *IEEE Transactions on Nanobio-Science* (EMBS lead, shared)
- 2004: *IEEE/ACM Transactions on Computational Biology and Bioinformatics* (IEEE Computer Society lead)
- 2007: *IEEE Transactions on Biomedical Circuits and Systems* (IEEE Circuits and Systems Society lead)
- 2008: *IEEE Reviews in Biomedical Engineering* (EMBS lead, shared)
- 2010: *IEEE Pulse* (redesigned magazine)
- 2013: *IEEE Journal on Biomedical and Health Informatics* (EMBS lead, shared)
- 2013: *IEEE Journal on Translational Engineering in Health and Medicine* (one of the first three IEEE all open-access journals).

EMBS International Summer Schools

Unusual for a professional society, EMBS sponsors a growing number of week-long immersion summer schools. With superb faculty and an excellent reputation, admission has become highly competitive, attracting the world's best students. Through these efforts, we are laying the foundation for the next generation of leaders in the world of BME. Recent schools included:

- Biomedical Imaging (France)
- Biomedical Signal Processing (Italy)
- Biocomplexity and Biodesign (Turkey)
- Medical Devices and Biosensors (Hong Kong)
- Neural Engineering (Shanghai; new in 2013)
- Telemedicine (Slovakia; new in 2013).

IEEE's Expanding Involvement in the Life Sciences and BME

We are not the only ones to have noted the spectacular expansion of biomedical engineering around the world, which has led the United States to quadruple the number of BME departments in the last 20 years. In academia, this interest and demand quickly exceeded the resources of any single department, leading to the beginning of a wave of coordination of BME activity across colleges of engineering, entire campuses, and medical schools.

The same explosion of interest has spread rapidly across the IEEE, far exceeding the scope and resources of EMBS. The IEEE Nuclear and Plasma Sciences Society and IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society have very substantial biomedical engineering activity, principally in imaging, with perhaps 25% of their journals' content related to biomedical engineering. The IEEE Computer and Signal Processing Societies are also quite active, and both share conference and/or publication activity with EMBS. But the interest is present and growing in many other Societies, too. For example, the IEEE Microwave Theory and Techniques Society and IEEE Communications Society are both considering shared journals that have significant BME content. Many other Societies sponsor conferences with biomedical tracks that give focus to their members working in these areas.

More generally, it is clear that there is much intellectual property developed across the entire IEEE that is not specifically aimed at biomedical problems but is foundational to biomedical technology, including areas such as improved laser technology, improved scintillation detectors, faster data mining algorithms and hardware, more secure data transfer procedures, and a myriad of wireless communication technologies.

The IEEE has initiated the Life Science Community (LSC) to help address the coordination of the tremendous breadth of activity and opportunity within the IEEE, and to attract new people to the IEEE. The LSC has held two Grand Challenge Conferences and has a Web site and newsletter that aggregates IEEE life science activity for distribution worldwide. This effort has great potential to complement, augment, and synergize activity by the EMBS and the other IEEE Societies. As we approach our next half-century, EMBS looks forward to working with the LSC to further expand the impact of BME.