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What If the Patient Dies?

Educating the Human Engineer

By Kristina M. Ropella

Why would a student elect to pursue a graduate engineering degree at a Jesuit university where the emphasis has typically been on excellent undergraduate education, and the resources for graduate training are relatively limited compared to the larger research-focused universities? Is there something special about graduate education at a Jesuit university?

As at most universities, the core of graduate education at the Jesuit university is research, discovery and advancement of knowledge. But, at the Jesuit university, the ethical, moral and social responsibility of the engineer as scientist and creator is weaved through the curriculum, the one-on-one interaction between faculty and student, and the collaborative community of faculty scholars. There is an ongoing dialogue of how one's work affects humanity and ultimately serves the greater glory of God. There is a sense that there is a greater purpose to one's research than simply writing a paper or book or securing government funding. The graduate degree is not merely another set of credentials or test of self-worth.

For example, at Marquette University, a significant number of faculty and graduate students are engaged in rehabilitative engineering — restoring basic movement that will allow a person to be independent in daily living. Engineers, scientists, physical therapists and physicians work together to study neurological disorders that impair locomotion. Faculty have a calling to serve those who are not fully participating in society because of a disability. After listening to the personal stories of the subjects participating in the research and enlisting their help in better understanding the disability, the faculty and graduate students strive to develop assistive technologies or therapies to give the subjects the opportunity to live a fulfilling life.

Mentoring as a calling

The graduate students routinely interact with subjects who have suffered stroke, spinal cord injury and other neurological disorders. The faculty and graduate students typically begin their research study by escorting the subjects from the parking lot to the laboratory, taking time to learn about the individual's personal story and how the disability weighs on daily activities. The graduate student, in turn, often shares his or her own personal story and motivation for an engineering career. The faculty and students take time to educate the subject about the latest developments in new technologies and the aims of the research. The students and faculty then work as a team to perform a series of experiments with the hope of testing a hypothesis or validating a new technology.

In the smaller research institution, the faculty mentor works side-by-side with the student to perform the experiments and interpret data. The student need not rely on a post-doctoral fellow or more senior graduate students to debate and reflect. But rather, the student interacts daily with the faculty member who directs the laboratory and research program. The faculty member, besides his accomplishments, has experienced his or her share of failed experiments or manuscript rejections, and can offer the student strategies for dealing with the disappointment and can encourage him or her to move forward.

When our graduate students are asked about their primary reason for selecting our graduate program, mentoring by faculty is at the top on the list. The faculty understand that they are investing in a person who will also carry the research forward. The graduate students are not just cheap labor, not

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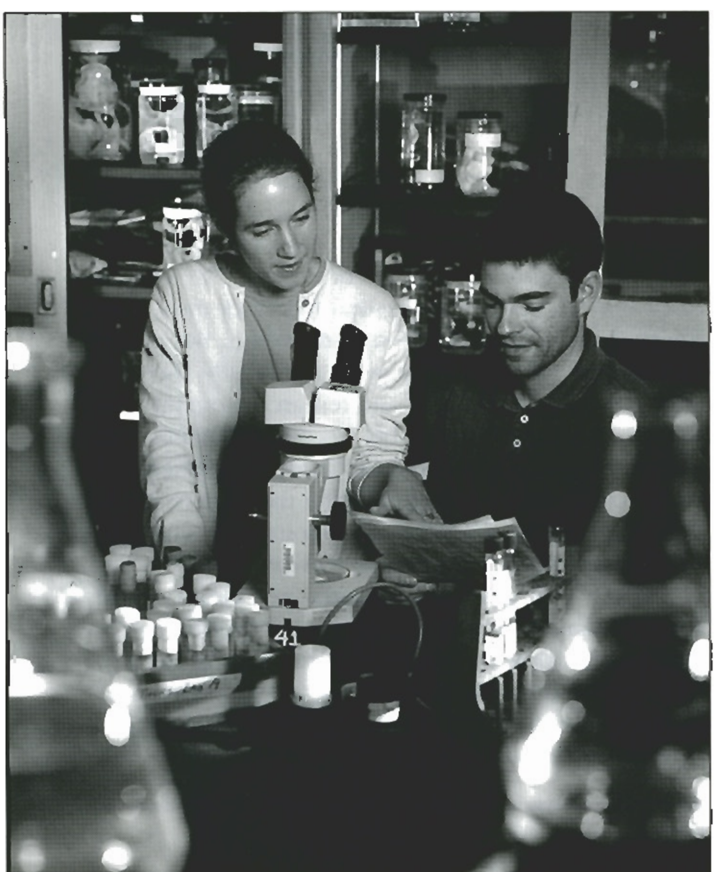
just a teaching or research assistant. But rather, the graduate student is someone who has the potential be a leader in his or her community and alter the course of discovery. Most faculty have personally spoken with the majority of our graduate students and serve on their dissertation or thesis committees. Every committee member feels the responsibility to mentor the student in some way.

The advice might concern the mechanics of a blood flow model or the physics behind a medical imaging technology. Or making effective conference presentations or writing a convincing conference abstract. Or, when to start a family in light of an academic career. We teach the graduate students to ponder their research in light of a very complex world, to question, critique, hypothesize, and accept failure as redirection for new ideas.

The mentoring is not only with regard to the science and engineering, but also in the context of "how do I fit this profession into my personal life?" How do I see my role as an engineer with a graduate degree fitting with my need to serve God, my family and my neighbor? In a Jesuit university, the faculty tend to make more time to get to know the students' personal stories, and offer genuine guidance as they struggle through the ups and downs of graduate education and ultimately find success as they mature into independent thinkers and researchers. As the students progress through graduate education, the faculty help them discern how to best put their talents and passions to use.

The faculty tend to serve as good role-models for a balanced life. The vast majority of faculty are married, have several children and regularly practice some religious faith. At our university, graduate students are mentored by faculty who manage to balance their academic life with a personal life that involves care for a child, parent or spouse, coaching a child's sport team, serving as a lay minister or serving meals at the local soup kitchen. Yes, these additional activities mean time away from the research lab and the faculty often sacrifice some research achievement to serve their other commitments. But, the fact that the faculty are using their god-given talents to serve a number of different communities is evident to the graduate students.


Students conduct research at Holy Cross.

On the brink of death

In biomedical engineering research, we typically submit the students to the clinical environment so that they gain an appreciation for the precious life for which they are developing innovative technologies. I recall taking three of my doctoral students out to the hospital early on in their studies. Because of our collaborations with a number of physicians at the local medical school, we often have the opportunity to have our graduate students observe surgical procedures that incorporate the technologies resulting from our research. My students witnessed the implant of a defibrillator into an elderly gentleman. We donned surgical gowns and facemasks and entered the surgical suite after the patient had been prepped and the chest was open. We watched as the surgeon implanted the device and sewed several leads to the patient's heart.

It was clear from the x-ray of the patient's chest that the patient had a history of surgical interventions, including bypass procedures, to improve heart function. In addition, the electrocardiogram showed many abnormal heart beats, even as the patient was at rest. The heart was clearly very sick and unstable. This patient's only hope of leaving the hospital with a functioning heart was to have an implantable defibrillator. The graduate students, who had been developing computerized rhythm detection algorithms for these implantable devices

In the operating room.

in the laboratory, were excited to see an actual implantable defibrillator in action. What they were not prepared for were the unexpected problems that often arise when dealing with human life.

To test the performance of the device, the surgeon intentionally induced a lethal, abnormal rhythm in the man's heart. It was necessary to actually put the patient's heart into the life-threatening rhythm in order to test the proper function of the device before closing up the patient. During the first induction, the device did detect the abnormal rhythm about 8 seconds into the rhythm and attempted to shock the heart.

However, the shock failed to restore a normal heart rhythm. As is typical of implant protocol, the surgical team nervously waited for another 8-10 seconds for another shock. The second shock also failed. At this point, the surgical team began to scramble about the table. The anesthesiologist began pumping fluids into the patient and the surgeon grabbed some external defibrillation paddles. The surgeon administered a third shock. Still no normal rhythm. The surgical staff was intense knowing that time was of the essence and the patient was clearly in trouble.

Trouble

The various technologies designed to fix the heart problem were not working. My students were stunned and I was praying that they not witness a loss of life in during their first clinical visit. Finally, upon a fifth shock with the external paddles, the heart assumed a normal rhythm. A long sigh of relief filled the room. As I turned to my graduate students, I noted that one was lying back in a chair feeling faint and the other two were pale and silent. They had never expected to witness a loss of life as the doctors were attempting to implement a routine, life-saving technology.

Suddenly the questions arose. Why did the device fail? What does the surgeon do now? Do the doctors need to induce a life-threatening rhythm in order to test device function? Was the device really necessary to sustain life? How can device performance be improved? How expensive is the device and the surgical procedure? How long will the device prolong the patient's life? When will such a device be turned off if heart continues to decline in health? Suddenly, the graduate students made an important connection between the fancy computing and data processing that they leisurely explored in the research lab and the real life that they would touch with the fruits of their engineering research. Their research was no longer just about getting a degree or producing a conference abstract. It was about using their gifts to give the gift of life to a fellow human being.

Just because it will work...

Engineers are taught to problem-solve given real-world constraints and opportunities. We help build the foundation of science, math, engineering, communication and ethics to allow our graduates to evaluate their solutions. But, what about constraints that exist because of our love of God and our respect for human life? Is it all right to destroy a fertilized embryo so that another living being might continue to live? Is it all right to enhance our athletic performance with drugs or prosthetic devices? Should we develop technology to prolong life for a person who faces a terminal illness? Should we continue to save the heart when the brain is deteriorating? Whether developing a new water treatment system or an implantable medical device, our students are given the message that just because it will work does not mean it should be implemented. There are social, cultural, ethical and economical aspects to every solution created. And, solving one problem often means creating another problem. For example, exposing a patient to high levels of radiation to detect a possible cancer can eventually lead to the development of cancer. All technologies pose some risks, and no solution is fool-proof.

The Jesuit aspect of education encourages students to reflect on the risks, manage the risks and maximize the effectiveness of the solution in light of serving humanity and God. Engineering education seeks to produce people who will go out and make the world a better place by serving the needs of society through invention, innovation and entrepreneurship. And, to do this work while serving God and respecting all God's creation is an added responsibility to the researcher to consider when working in a Jesuit institution. ■