How to Grow Researchers: A Fresh Perspective on Graduate Student Collaboration

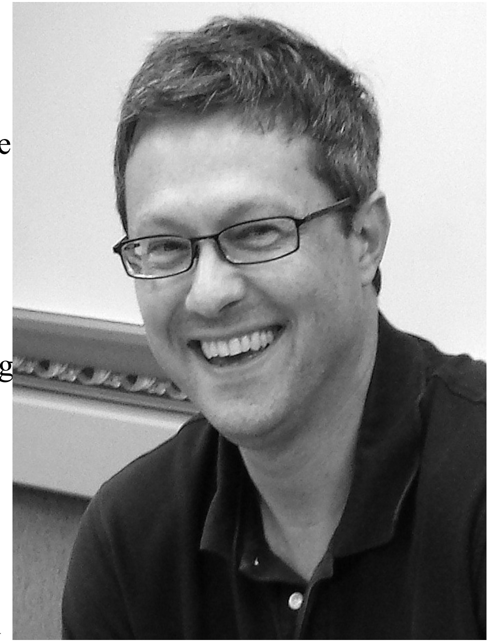
by Luke Redington

Brent Ladd is the Director of Education for the Center for Science of Information (CSoI), an NSF Science and Technology Center. From its headquarters at Purdue University, CSoI brings together researchers from all over the world to understand how people and machines process information. Brent has worked with CSoI since its inception. His job there revolves around a fascinating riddle: How do you take the science of information—a new academic discipline familiar to just a sliver of the scientific community—and make it a topic that is well taught to students everywhere? If Brent's response to this riddle can be summed up in one word: Growth. Brent knows how to make things grow. An ecologist by nature and training, he is deeply invested in mapping out the intricate series of interactions that must take place in order to get an entire system where everything flourishes. He loves to dig into the complexities of the growth process. He loves to talk to others about how things grow. Before coming to CSoI, Brent traveled around Indiana as an extension agent and talked to Hoosiers about the state of their air and water. (They're in rough shape, which makes Brent truly sad.) Brent's office bookshelves abound with volumes about things that grow. Crammed among the books is a dazzling array of healthy snacks. Just walking by his door lowered my blood pressure.

Brent knows that when organisms are under prolonged, tremendous strain, they don't grow. They survive, at best. Having been a graduate student himself, Brent knows what that particular type of strain can do to human beings. He kept that knowledge in mind as he addressed the following riddle: How do you design an environment in which graduate students can make fast yet lasting progress in their research on the science of information? Framing this riddle around graduate students is a key strategic move on Brent's part. Most of the researchers at CSoI are distinguished scientists—tenured professors who began advancing the Center's research agenda the moment they joined. Fair enough. But Brent is always thinking about the future, and how to make things grow now to improve that future. The answer: Graduate students. Where to find them? That's easy. The professors who drive the Center's research agenda have graduate students, most of whom have followed their professor's lead in working on projects within the science of information. How to give them a unique experience that will boost their research? That's a little trickier. Brent believes in face-to-face communication as a cure for the haze of the digital age. But, these grad students are scattered all over the U.S. and beyond. And then there is that scarcest of resources: Time. Paradoxically, the acute scarcity of time made it the easiest constraint to plan around. Brent quickly realized there was only one season in which to hold an event like the one he envisioned: Summer. How long could the event be before the law of diminishing returns kicked in? A week. Once those decisions had been made, Brent made the rest by prioritizing the concept of balance: The graduate students he wanted to attend were already up to their elbows in research that required specific outcomes; Brent left the outcomes of his event open-ended. Graduate research is often closely supervised; Brent wanted attendees of his workshop to operate with plenty of elbow room. Traditional research is tightly bound to the norms and traditions of the academic discipline in which it operates; Brent wanted to create a space for young researchers to play jazz.

In fact, Brent had already noticed a trend in the work these grad students were doing that let him correctly anticipate what their jazz might sound like. A few years after the Center's inception, some of the researchers began applying their theories about how information is stored and transmitted to biology. Brent was particularly fascinated by CSoI researchers who began applying principles of computational statistics to help biologists with a tantalizing problem: Today's microscopes are too powerful. Today's microscopes are actually staggeringly powerful digital cameras. The images they produce are of such high resolution they become hard to process, interpret, and transport. Indeed, the hallmark of graduate students in biology is that everywhere they go, they carry a portable hard drive with a capacity of several terabytes. This hard drive stores the super hi-res images generated by their lab's microscopes. Biology students guard their hard drives as if each one were the Hope Diamond.

So, in the summer of 2014, Brent shaped the workshop around putting graduate students with a statistical background in contact with biology students whose hard drives were weighing them down. He arranged free food and lodging. He made sure everyone knew where they could work out and where they could relax. Then, he watched things grow.


Brent at the summer workshop. Photo credit: Mike Aatwell.

On a hot Monday in June, the workshop began. The attendees—about 20 graduate students in all—packed themselves sardine style around a conference room table in Lawson Hall, the building that houses Purdue's computer science department. The students introduced themselves and their work in the interest of discovering shared interests. By the time we had gone around the table, teams were forming organically.

One of those teams consisted of two graduate students named Maurina and Frank. Maurina's work in cellular biology had taken a turn toward the production of new cancer treatments. Frank's journey as a chemical engineering student took a sharp turn toward the science of information. He had been studying a riddle: As cells consume energy, how it is that they seem to know the optimal rate at which to to burn certain chemicals? To solve this riddle, or least quantify it, he needed more powerful statistical methods than the ones he had been using. His advisor, professor Doraiswami Ramkirshna, gave him a boost. As a CSoI researcher, Dr. Ramkrishna had successfully applied information theory to biology in a number of ways by the time Frank became his student. With Dr. Ramkrishna's help, Frank quantified his riddle. Ever since then, Frank has been doing the same for others.


Students explaining their research on the first day of the workshop. Photo credit: Brent Ladd

Maurina's riddle was this: How you do effectively study and treat bladder cancer given that the tumors are three dimensional, but the tools we use to study them can only view them in two dimensions? In other words, even the best microscope could only provide a two dimensional image of a round tumor. Plus, as she explained, bladder cancer tumors have this nasty habit of beginning the inner lining and then burrowing deeper into tissue as they grow. Before the workshop, Maurina had been utilizing two common techniques in cellular biology: In vivo testing and in vitro testing. In vivo (Latin for “in the living") usually involves mice, pigs, or some other mammal whose similarities to our physiology allow for experiments that yield results useful for human health. In vitro (Latin for "in glass") is the phrase used to describe growing or gathering small samples of things and then viewing them under a microscope. Maurina was running up against the limits of both approaches. Mostly, she needed more time. She was on a quest to build a better toxin that would burrow as deep as the tumors without killing healthy cells. Setting up the in vivo and in vitro tests took a long time. Compiling, interpreting and using the the results of those tests took forever. She needed to find a way to speed up the feedback loop in which results from one experiment were used to produce a subsequent round of tests that produced better results. (If the undergraduate experience is about waiting in line, the graduate student experience is about waiting for results.)

So Frank played a trick on time. I was there watching while he did it. The trick went like this: Using an open source statistical analysis program called "R," Frank wrote an algorithm that significantly closed the time required to transform the raw data from Maurina's experiments into usable results. How significant was the time reduction? Maurina is even keeled, but she was so overcome with joy at Frank's gift of time that she almost lost it. At the end of the week, she described the breakthrough like this: "Due to my interaction with [Frank] using R software, we programmed a code to automate a large portion of what previously I had to painstakingly do manually. I estimate this new code will save me as much as 40 hours per week of data gathering time, and I think the results are going to be more accurate!"[1]

Brent snapped a photo at the moment Frank explained to Maurina and rest of us how he played a trick on time.

Maurina and Frank's collaboration became one of those instances in which the story behind the research belongs at the center of the research. Realizing this, Brent shares their story every chance he gets. Maurina and Frank were not the only team to experience rapid growth during the workshop. Several teams had their research branch out into new directions; other teams had their research develop so quickly that it seemed like a different animal by the end of the week. Many teams have continued collaborating, adding new team members as their projects grow in scope in complexity.

Luke Redington was a staff writer and technical writer with the Center for Science of Information. He is currently an Assistant Professor of English at the University of Maine. Photo Credit: Adam Kuykendall.

1 Center for Science of Information. Annual Report 2014, page 142.