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Learning How to Ask Research Questions

SUSAN MUSANTE

Collaborative research is a demanding endeavor, and for a group of undergraduate students tasked with identifying their own interdisciplinary research problem, the challenges are even greater. “It was scary—we didn’t know what to ask the professors, and we couldn’t decide on a research question,” says Miran Park, a student at the University of California, Davis (UC Davis), about her first quarter there in the Collaborative Learning at the Interface of Mathematics and Biology (CLIMB) program. The yearlong program, sponsored by the National Science Foundation’s Undergraduate Biology and Mathematics program, is modeled on UC Davis’s Biological Invasions IGERT (Intergrative Graduate Education and Research Traineeship) program (www.aibs.org/eye-on-education/eye_on_education_2004_10.html).

The CLIMB program abandons the traditional apprentice model for research experiences, says Rick Grosberg, its principal investigator and an evolutionary ecologist. Unlike many undergraduate research experiences, CLIMB does not assign a project or enlist students in current faculty research. Each year a cohort of biology and math majors in their junior or senior year becomes part of an interdisciplinary collaborative team that uses “mathematics and computation to answer state-of-the-art questions in biology” (<http://climb.ucdavis.edu>). Says Grosberg: “The notion of how you formulate a question out of all possible questions, and how you turn it into research objectives that are implementable, is something that most programs don’t teach students.”

Julia Svoboda is a graduate student researcher who, since the program’s inception in 2006, has studied how CLIMB students develop their understanding of science and modeling. “The most important thing the students do

is articulate a research question, but this takes a very long time,” Svoboda says. Over the years she has developed a series of structured activities to provide students with a more systematic approach. “At first they just need help talking with one another,” she explains. As they become comfortable sharing ideas, they move on to more reflective reading and writing assignments, which they discuss. Then come the brainstorming sessions, which Svoboda facilitates. Park says her seven-member team benefited from these meetings as they worked to define their biological research question and the mathematical or computational tools they would use to address it. “By the end, they are comfortable approaching professors and much more integrated into the scientific community,” Svoboda says.

As part of the community, the students witness the dynamics between the CLIMB faculty. “Initially, the students wonder why we are arguing,” Grosberg said, referring to the frequent debates he has had about the cohort’s research questions with Sebastian Schreiber, a theoretical ecologist and mathematician. But the students soon recognize that the faculty are exploring the pros and cons of their research approach. “A lot of students view our process of doing science as formulaic,” says Grosberg. “They think faculty know the approach and how to make it all just happen, so to watch us go back and forth, the students realized that even formulating a question is challenging.”

Schreiber agrees: “The students learn that some of the hardest work in science is coming up with the questions.” Schreiber admits he was astounded when he first learned that CLIMB requires students to develop their own research questions. After three years with the program, however, he is now clearly in favor of the model. “The students are forced to mature in many ways as potential researchers,” he says,

“because they have to identify what is important, what’s not, and agree with each other on a topic.” He adds that CLIMB gives the undergraduates multiple opportunities for intellectual, social, and technical growth, and that when the year ends they know the research process from start to end.

Park’s group eventually decided to embark on two projects: one to explore whether the use of *Wolbachia* in mosquito populations is a viable way to control dengue fever, and another to investigate voluntary vaccine use on measles dynamics. They completed their research and organized a workshop, held on campus last fall, to share their results; attendees included internationally recognized scholars and medical professionals. They also presented their results at an undergraduate research conference at the National Institute for Mathematical and Biological Synthesis (www.nimbios.org). “It was a fun experience, and very educational, because I saw how other math-bio programs worked and learned about the range of topics that you can apply models to,” Park says. She thinks all undergraduates would benefit from experiencing the same process she and her colleagues went through.

“There is nothing constraining faculty from inverting the process even in an introductory course,” suggests Schreiber. Instead of asking the students questions to find out how well they know the subject matter, Schreiber recommends asking them to take the knowledge they have and develop questions about what else they might want to know, and how they might achieve that knowledge. Says Park, “Learning how to ask a question is an incredibly good skill.”

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