Using BioQUEST Simulations to Bring Evolution into the Lab

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Using BioQUEST Simulations to Bring Evolution into the Lab

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Why use technology?
For me, turning to technology when I did was the right thing at the right time – in fact, it was perfect. I teach evolution, which isn’t naturally a laboratory-based course. Setting up evolution labs is difficult, if not impossible, especially given our resources. But I wanted to find a way to really get my students involved in studying the process of evolution, to bring evolution alive by engaging them in solving problems in a laboratory-like setting. The computer simulations available through Project BioQUEST provided the answer, allowing the students to visually track changes in population demographics over time.

The strategy
I first heard about Project BioQUEST from Mary Swift, a colleague in the Biochemistry Department here at Howard University. Mary had been on a sabbatical at the University of Maryland-College Park at the time they were handling the distribution of the BioQUEST Curriculum – she had actually worked on the development and beta-testing of one of the modules. She said, “This is really cool. We ought to think about how we can get it to Howard.” In 1993, Mary and I went to one of the summer workshops offered by BioQUEST at Beloit College, BioQUEST’s birthplace and home, and that summer the workshop just happened to focus on the evolution module of the BioQUEST curriculum.

The dilemma I faced – and continue to face – is the dilemma of many historically Black higher education institutions: finding the funds for technology, tech support, and especially for updating the technology. Howard University, a Black research university and the home to the largest community of African-American scholars in the United States, is challenged by dealing with financial infrastructure issues for funding computers and Internet access in the classroom. Some students have computers in their residence hall rooms; some students access computers and the Internet from computer labs only. However, funding for computers in the classroom and for connections to the Internet is lagging.

Immediately after that summer workshop, Mary and I submitted a grant to the National Science Foundation, to use the BioQUEST Curriculum in our respective units. Mary was a biochemist teaching in the undergraduate pharmacy program; she wanted to give her undergraduates an adequate laboratory experience, asking questions and solving problems, using a computer simulation package. And I wanted to create a laboratory experience in my evolution course. In 1994, we received an NSF grant to fund the hardware and purchase a site license for BioQUEST.

Currently my evolution course is the primary user of the BioQUEST curriculum in the Biology Department, although other faculty have used other modules in the past. Increasing the number
of modules used is important in justifying the site license and upgrading the material for my department.

The course
My course, “Evolution,” is for sophomore and junior biology majors and enrolls about 25 students; they have already had basic biology and genetics. I give them their first introduction to population genetics and to the basic parameters of the Hardy-Weinberg Equilibrium, the concept that gene and genotype frequencies will stay the same in a population free of evolutionary forces and with random mating. We use the “Evolve” BioQUEST module to look at changes in population and in the genotypes of populations over time, under various evolutionary parameters.

The Evolution course is one that I alternate with another faculty member who does not choose to use BioQUEST; in part this is due to a bias against technology. But it’s also because he doesn’t do much population genetics in his course, whereas I do have students study population genetics, and for this we use BioQUEST.

The learning technology
Evolve (BioQUEST Library V Collection): Evolve is one of seven simulation/tool computer modules developed through Project BioQUEST for its Library V Collection. All 11 items in the Collection (seven computer modules and four text modules) are extensively peer reviewed and tested in the classroom.

The Evolve computer program is Macintosh-based and allows us to model evolution experimentally, something that could not be done without computer simulations. Within Evolve, my students can control the parameters of the evolutionary process in a hypothetical population, such as population size, natural selection effects, and inheritance and migration patterns.

In the classroom, we have 12 computers (no Internet access). My students, working in pairs, access the data within Evolve and create graphs that chart the changes in the genetic constitution of the population over successive generations. In this way, they really get to see the effects of, for example, small population size and differences in survivorship or reproductive rate; then they look at what happens over many generations. I ask them to think about a problem they would like to pose, using the models available in this module and setting the particular parameters; further, they must define their question in a real-world context. They must put these results and analyses in the form of a laboratory write-up. The students also do their homework assignments in computer labs that have Internet access, to find research similar to what they are doing and to support the ways they are manipulating the data from Evolve.

As an example, for the model of “selection for the recessive allele,” some students looked at sickle cell traits – what allelic form is evident over time if we allowed for certain differences in selection to occur. They had to do some independent research to define how the sickle cell trait is really characterized, what the outcomes are and what the impacts are. Thus, they are able to pose the question and use this module to analyze some results. In their lab write-up, they synthesize that data and come to some conclusion that hopefully will sound reasonable to their colleagues.

There are applications in Evolve that are much more sophisticated than this example. But all of the applications take evolution out of the very dry, “talking head” format of lecturing and give
students an opportunity to engage and do inquiry at the bench level. They have to explain when they don't get their predicted results. They have to dig deeper: “What happened? Where does this lead us? What would be the next question here?” This actually engages them even more. And doing this is pairs gives them the experience and deeper learning benefits of the collaborative learning process.

You can find out more about Evolve and other BioQUEST modules at the BioQUEST Website: http://www.bioquest.org.

The project support
To fund the purchase of hardware and a BioQUEST site license, Mary Swift and I applied for and received a grant from the National Science Foundation's Division of Undergraduate Education, under its “Course, Curriculum, and Laboratory Improvement (CCLI)” program, as an “Adaptation and Implementation” project. You can find out more about the CCLI program at: http://www.ehr.nsf.gov/EHR/DUE/programs/ccli/.

I have since applied to the University for additional funding to update these classroom computers and get them on line, and to buy the latest version of BioQUEST for this year, but I didn’t get the funding. It’s frustrating and difficult to argue for departmental support of a resource base that not all faculty are using or have decided to use. But that’s an institutional constraint – where institutions choose to put their resources – that you have to face. Unfortunately, we’re still using the original hardware and software that we last purchased in 1997.

The results
BioQUEST is fundamentally important to the success of this class. This approach is more work for the students, and they grump about it. But in the long run they actually do value it, because they ask for more technology and more experiences like this in some of their other classes. Although I may not get the validation in my faculty evaluation, I do get validation when they ask another faculty member in their next course, “Why don’t we have more technology applications in this laboratory?”

One of our genetics faculty, who teaches an advanced population genetics course, has said to me on more than one occasion that my students have a much better framework and conceptual understanding of the fundamental principles of population genetics than students who come to his class straight from the basic genetics class. He doesn’t use Evolve in his class, but he has benefited from the fact that my students have had to do more inquiry-based learning in that area of biology, and he feels that they are better prepared.

Doing this project was a catalyst for bringing technology in – we had absolutely no learning technology before this project. By accessing and implementing BioQUEST, we were able to open up a computer laboratory in our department. If I hadn’t been inspired by Mary to actually go to the workshop and then come back and write the grant with her, we wouldn't have had the money to buy the hardware. It was our first computer lab and it’s one of only two that we have in our department. That computer lab and BioQUEST are not just used by my students in evolution, but by other students as well. In the ecology class, they use the computer simulation modules “Biota,” “Environmental Decision Making (EDM),” and other BioQUEST simulations for population growth. A faculty member who teaches molecular biology also uses some of the modules.
BioQUEST provides a wonderful way to extend the students’ learning experience in a class that doesn’t have a traditional laboratory, and it can do many of the things that a modern laboratory experience can do. And it provides an opportunity for collaborative learning, for inquiry-based learning, and for problem solving.

Would I recommend BioQUEST to other biology faculty? Absolutely – I recommend it to everybody.

If you have any questions, please contact me at: mposton@fac.howard.edu.

| LINKS                                      |
|------------------|----------------------------------|
| BioQUEST:        | http://www.bioquest.org/        |
| BioQuest Library:| http://www.bioquest.org/BQLibrary/index2.html |
| Evolve:          | http://www.bioquest.org/BQLibrary/library/evolve.html |
| NSF’s CCLI program: | http://www.ehr.nsf.gov/EHR/DUE/programs/ccli/ |
| BioQuest ordering information: | http://www.apnet.com/bioquest/order.htm |