BLEND: A Biomathematical Learning Enhancement Network for Diversity

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Abstract

Minorities are significantly under-represented advanced degree holders in bioscience and mathematics. A small, cross-departmental alliance at our university has developed a learning community among students and faculty to enable students and instructors to access greater contemporary biomathematical learning and teaching. This alliance significantly expanded our existing efforts to promote collaborative biomathematics research, training, and shared discovery with students interested in pursuing graduate studies. This alliance has served as a forum for students and faculty to express their creativity and ultimately succeed in careers at the intersection of math and biology. This paper describes how we bound together a critical mass of interdisciplinary research collaborations and partnerships, which fostered increased numbers of knowledgeable and motivated under-represented individuals who are pursuing professions at the interface of math and biology. We believe our alliance will lead to the future reshaping of our math and biology undergraduate training infrastructure to harness more meaningful integration at the interface of these disciplines.

Background Concepts

Introduction

The current century has been predicted to be "the century of biology," where researchers must use quantitative methods to visualize and interpret high-throughput biological measurements. Mathematical and computational components are vital to many areas of contemporary biological research, such as genomics and molecular modeling. However, for the nation as a whole, overcoming minority under-representation in the bioscience and mathematics career fields represents a major challenge.[1] Paradoxically, this challenge exists despite expanding career opportunities in industry, academia, and government for those skilled at the intersection of biology and mathematics.[2,3] We have the same challenge at North Carolina Agricultural and Technical State University (NCATSU), a historically minority-serving land-grant institution located in Greensboro, N.C. In the late 1990's, motivated by the fervor associated with the emergence of high-throughput genomics, a small number of mathematics and biology faculty formed an alliance at NCATSU. Early cross-departmental meetings served as brainstorming forums to connect undergraduates and faculty with interactions between biology and mathematics. From these small meetings, an alliance emerged of like-minded faculty. This new synergistic alliance, which consisted of a network of biology and mathematics faculty members, became known as the **B**iomathematics **L**earning **E**nhancement **N**etwork for **D**iversity (BLEND). Formation of the BLEND alliance was due to effective coordination between all faculty. A

key to our success is that faculty recognized the complementary expertise of our alliance members. A key vehicle was needed to serve as a natural bridge between imaginative learning, research, and technology. For BLEND, MATLAB (The Mathworks, Inc., Natick, MA), short for Matrix Laboratory, satisfied this role as a simple and flexible programming environment for a wide range of problems, such as optimization and linear programming. With MATAB, students pull data from various national databases covering the spectrum from genomic sequence analysis to protein structure prediction, to health disparities and epidemiology, to systems biology, to global warming issues. With these data, students use MATLAB to better understand biology and computing problems on multiple scales **(Figure 1**). Our goal is to provide math and biology majors with quality research and training experiences that provide core concepts that bridge cutting-edge research activities and regular academic courses.

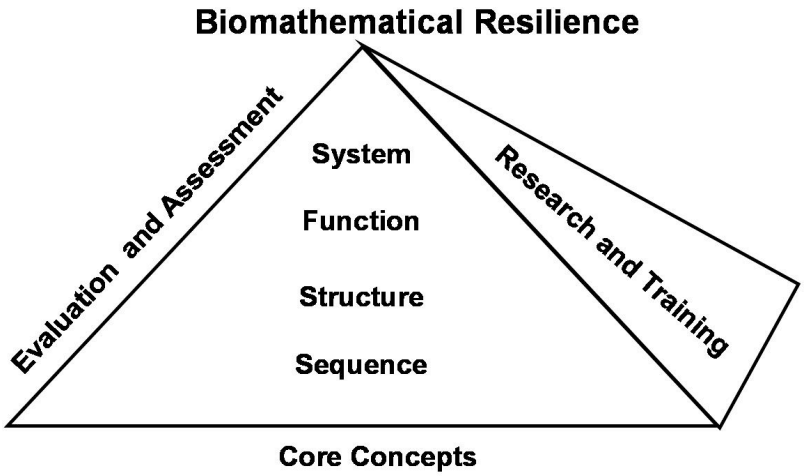

Figure 1. The basic strategy for using MATLAB to help students better understand biology and computing at multiple scales.

Methods

The basic MATLAB software package can be extended by using add-on toolboxes, such as the computational biology toolbox. Investigative cases draw from realistic situations in which scientific reasoning can be applied. Although a case defines a general area of science under investigation, students generate specific questions to guide their study. Using mainly the various algorithms in the MATLAB computational biology toolbox, students investigate scientific problems that they find meaningful. In the process, they also learn to locate and manage information, develop reasonable answers to the questions, use scientific inquiry strategies and methods, provide support for their conclusions, and work on decision-making abilities. We have found that investigative cases are useful for lifelong learning because they are open-ended and draw from a broad range of situations in which scientific reasoning can be applied. We believe that active engagement with biological and mathematical relationships must transit the research laboratory into the biology and mathematics classrooms. To help engage all students in a deeper learning experience inside the classroom, the BLEND faculty mentors have adopted MATLAB, but in a problem-based, case-based learning approach to help clarify

complex biological and mathematical concepts. The implementation of case-based activities, combined with learning modules in our curriculum, represent a mechanism by which instructors can maintain student interest through the use of current topic narratives.

The Biology department has already made in-roads to aid "virtual" learning spaces that are used for teaching and learning, such as ongoing National Science Foundation (NSF) Course Curriculum and Laboratory Improvement Project (NSF- DUE 0511479). The online modules have interactive feedback and assessment tracking features in the database, which enable instructors to remediate problem areas and identify individual students who need extra help. Moreover, we will soon employ the use of two bio-math intensive, interactive Web-based tools, Excel Simulations and Tools for Exploratory Mathematics (ESTEEM) (http://www.bioquest.org/esteem/) and the NSF-CCLI sponsored Case-It! project (http://caseit.uwrf.edu/caseit.html), which allow students to pose scientific questions based on actual data sets, design, and perform experiments *in silico* to explore the data, and gain valuable experience with data analysis. By expanding the biomathematics case modules to the students with MATLAB, we have been able to create a culture of biomathematical problem-solving and thinking based on informed decision-making through collaborative communication. For our students to maximize learning outcomes, it is very important that the MATLAB applications and cases stay context-driven and purposed to formulate a posture of biomathematical resilience through integrated student focus on concepts and techniques that bridge mathematical methods with biological systems.

Findings

The BLEND program has provided a cross-disciplinary forum for catalyzing mathematical research relevant to the life sciences. BLEND has helped to facilitate rapid diffusion of new mathematical and computational methods in the life sciences on our campus. The BLEND faculty at NCATSU have been successful implementing MATLAB with investigative cases drawn from realistic situations in which scientific reasoning can be applied. Although a case defines a general area of science under investigation, students generate specific questions to guide their study. Students investigate scientific problems that they find meaningful. In the process, they also learn to locate and manage information, develop reasonable answers to the questions, use scientific inquiry strategies and methods, provide support for their conclusions, and work on decision-making abilities. Ultimately, we feel this work has added to our students' skill sets in problem-solving in a laboratory setting.

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