THE OFFICE FOR
UNDERGRADUATE RESEARCH

Graduate Research Consultant (GRC) Program Course Example

Natural Sciences: Mathematics

Faculty name: Dr. Peter Mucha and Dr. Greg Forest

Department: Mathematics

Course: Math 231, 2 team taught sections: *Calculus I Special Section with Biological Connections (BioCalculus)*

GRCs: Eric Choate and Wanda Strychalski, Mathematics

Number of students: 35 students divided into two sections

Date: Fall 2006

Course overview:
We team teach 2 sections of "BioCalculus". This course is an alternative to the standard Calculus first semester course and is driven by applications to biology to provide a different focus that is more appropriate than the standard Calculus sequence for undergraduates majoring in Biology and the health sciences. We use a different textbook, and run a separate computer lab component of the course where the students learn and apply MATLAB (a sophisticated software package that we install on their laptop computers). The lab component involves modules for exploration of biological applications, where each student chooses one module as a point of departure for their personal research project.

We view this course as a critical component of the "Quantitative Biology" initiative that is promoted by the Dean's office among Biology, Chemistry, Computer Science, Mathematics, and Physics. We think Psychology majors likewise will benefit from this Calculus sequence since they will learn how to connect the principles to biological and medical applications.

Course research methodology: Quantitative analysis in Biology

Examples of specific student group research projects:

1. Population Modeling

   Overview and purpose: A repeating theme of the BioCalculus course sequence is population modeling, with examples from the recent scientific literature (last 10 years) on various models tracking the AIDS epidemic in populations and HIV viral loads in individuals. By merging the basic materials from the analysis and modeling arms of the course with powerful computational tools, the students can rapidly implement discrete-time and differential equations models of such populations, thereby generating and exploring solutions and comparing with actual population data and qualitative behaviors also observed in the literature. A number of materials from last year's sequence can be used as the foundation for further development this year.

   Research skills used: data analysis; computational modeling

2. Biological Modeling

   Overview and purpose: We have identified and explored approximately 10 modules, ranging from risk factors for breast cancer, to coupled species and population dynamics, to discrete models of signaling pathways. The students learn how to develop models for the biological problem, and then how to use software to implement the model and solve it on the computer. They then take the numerical data and see how well they can fit the experimental data, and use experimental data to fit parameters in the model.

   Research skills used: data analysis; computational modeling

3. Other Computational Projects

   Overview and purpose: More detailed and advanced course projects are also explored by a smaller number of students who sign up for an optional hour of independent study. The GRCs help build and guide the computational projects for both the modules in the regular course and for these projects in the additional hour.

   Students can furthermore use this experience to continue with research experiences by getting involved with our research training grants that have support for undergraduates (one from NSF in the applied math group, which supports any level undergrad; and another NIH T90 award that supports 10 junior/senior level undergrads), or with individual faculty grants that have support for undergraduates (such as Mucha's NSF CAREER award).

Communicating research findings:

In one course section, the primary mechanism for the students to communicate their project results are through the recently-started BioCalculus@UNC wiki, http://biocalculus.amath.unc.edu, which includes links to the Analysis, Computation, and Modeling elements of the course, as well as Projects (and with a number of placeholders for additional materials to be developed in the future). These project results then continue to be used and built upon by some of the same students in the second semester of the sequence and by students in future years as this offering continues to expand.

In the other course section, each student has weekly projects based on the lab and one project that is a semester long project of their own. They write up the project in a document, and then they present their project to the class in a 20 minute PowerPoint presentation.

GRC role in the research:

Peter Mucha: The GRC interaction with the students is critical to the successes of various projects available to the students. Specifically, the audience for this course typically has had zero or extremely limited interaction with such computational tools prior to the course. Therefore, the GRCs, who are well versed in the use of MATLAB from their own courses and research, are instrumental in helping the students through the nuances of its use (it is, after all, a commercial-grade computational tool, as opposed to educational software). Most of the first half of the semester is spent simply introducing the tools to the students, and then working through example projects on the interplay of models and comparison with real data. The GRC picks up a feeling for the level of the students and that is then instrumental in guiding the scope of the larger closer-to-research projects in the 2nd half of the semester. The GRC and I then target reasonable projects with highest priorities being in the balance of pushing the boundaries of student knowledge while selecting tasks with high probability of success.

Greg Forest: We work with the GRCs in designing the framework of the student projects. We tend to give guidance at first, but then allow the students to explore with latitude to follow their interests and instincts with feedback from us. The undergrads require a lot of time and patience at the outset, on the order of a month, to get used to the mathematical software and its nuances, but then they need time for a deeper skill: to learn how to use the computer as an investigative tool, to run virtual experiments, to build models of experimental or observational data, etc. In general, students have never used a computer in this way before. So, the GRC plays a critical role by working with students on an individual basis so they do not get bogged down or frustrated with the math or the software.

GRC: Eric Choate and Wanda Strychalski were both graduate students in Applied Mathematics. Both students used the mathematical environment called MATLAB everyday in their research lives so they were great in helping with this computer technology element of the class.

Faculty comments on their course and incorporating research:
GRCs provide an essential bridge between the faculty and the students in the course. Such vertical integration of teams is a highly common element of a number of research groups, particularly those that lead to successful undergraduate research.

Having a GRC provides enrichment to this class, without question. Part of the lesson we want to convey is that modern research is dominated by teams, and while I allow students to work in teams, the concept is more realistic if the team is "vertically integrated". That is, I am the top level team member, the GRC is the next most senior and experienced, and then they are the creative ones doing most of the discovery but with guidance! The difference is that we upper management types will let the real creative drivers have the credit for success!

<u>Sources for this GRC course summary</u>: Edited text from Dr. Peter Mucha's and Dr. Greg Forest's GRC Proposals.