Constructing an Undergraduate Biomath Curriculum at a Large University: Developing First Year Biomath Courses at The Ohio State University

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Name of Institution	The Ohio State University
Size	about 38,000 undergraduate students
Institution Type	large state university with graduate program
Student Demographic	recent high school graduate with interests in mathematics, statistics or biology
Department and Program Structures	six departments (Mathematics, Statistics, and four Biology), plus the biology major, administered by the Center for Life Sciences Education, all in the College of Arts and Sciences

Abstract

All curriculum development shares standard decisions and processes, and all curriculum development also has wrinkles particular to the courses and institution. In this article, we describe both as they pertain to developing first-year courses in calculus and statistics in the Mathematics and Statistics Departments that are aimed at biology students.

Course Structure

• Weeks per term: 10 weeks (will convert to semesters in 2012)

• Classes per week/type/length: three 48-minute lectures, two 48-minute recitations

• Average class size: Calculus I = up to 120; Calculus II = up to 60; Statistics = up to 40

• Enrollment requirements: standard for 1st-year Calculus; Statistics = Integral Calculus prerequisite

• Faculty per class, TAs: 1 faculty; 2 TAs for Calculus I; 1 TA for Calculus II; 1 TA for Statistics

Introduction

Development and revision of a curriculum to meet the educational needs of students is one of the most important and most difficult jobs of faculty and administrators at the nation's colleges and universities. This especially applies when the topics of interest overlap distinct disciplines, which is becoming increasingly common. When we set out to develop a curriculum in BioMathematics at The Ohio State University (OSU), we were faced with the considerable challenge of navigating these difficulties at one of the nation's largest universities; OSU hosts more than 50,000 students on the main campus in Columbus, Ohio, approximately 38,000 of whom are

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undergraduates. Development of the curriculum we envisioned involved the participation of several departments belonging to two of OSU's eighteen Colleges. The curriculum developed thus far has resulted from a collaboration of faculty within the College of Mathematical and Physical Sciences (MAPS), including faculty from the Departments of Mathematics and of Statistics, and within the College of Biological Sciences (CBS).

While our task seemed daunting, several factors were working in our favor. Motivation for the course development came from the growing interaction between MAPS and CBS (after the development of the first year courses mentioned here, the two colleges merged), and was boosted by efforts within CBS to make their curriculum more quantitative and by the NSF's establishment of the Mathematical Biosciences Institute (MBI) at OSU. While the two colleges have historically worked well with each other, interactions between them tended to be driven by specific projects. However, the establishment of the MBI required two levels of interaction, one administrative, largely at the level of the Deans, and one oriented toward specific research, largely at the level of the faculty. The result has been a strengthened partnership and frequent conversation between the colleges, and has also created a group of people who are experienced and at ease with working in the middle.

The relevance here is that we took advantage of this network when investigating what to do and whom to talk to. We have now developed a sequence of four first-year courses in BioMathematics, three of which have been taught regularly since the 2006-07 academic year. (The fourth will be piloted in Spring 2013, its delay caused by OSU's switch to semesters in Summer 2012.) In this article, we describe the process of developing these courses, focusing specifically on the challenges we faced due to the size of our university. We discuss what aspects of the process worked well, what we could have done better, and we make suggestions for others who may be considering development of such courses in a similar setting.

Description

The three courses that have run regularly include a two-quarter sequence in Calculus for the Life Sciences and a one-quarter course in Statistics for the Life Sciences (see Kubatko et al 2012). Other courses were later created or modified to complete an undergraduate major in mathematical biology, as well as a Masters program, in the Mathematics Department. Following the semester conversion, we will resume work on cross-departmental minor and major programs, and on a PhD program.

The four courses were designed to serve freshmen who place into differential calculus and express an interest in the life sciences (including pre-medicine). We have learned, however, that the third-quarter courses will also enroll sophomore biology majors, as many freshman biology majors are unable to fit these courses into their schedule.

The courses were first offered during the 2006-2007 academic year, but planning began much earlier. A first step, facilitated by the MBI, was to verify the desire, demand, and audience for them. After receiving some informal positive feedback from faculty and administrators in CBS, conversations began within the Departments of Mathematics and Statistics concerning the viability of such courses. One issue within Mathematics was that biology-themed math courses had been attempted in the past, with less than stellar success; in particular, a less rigorous Calculus for Life Sciences sequence had been abandoned only recently. Thus, initial conversations for the new courses had to consider how the newly proposed courses would differ from the prior ones, in rigor and scope.

Within the Department of Statistics, there was enthusiasm for developing a course for students majoring in biology. An existing (and popular) 200-level statistics course served several populations

of students, ranging from students getting degrees in computer science to those in the life sciences. There was agreement that dividing the group into life science and non-life science students would be useful, provided that the audience from life sciences was large enough.

With the support of our departments, we worked with the Deans of both MAPS and CBS to develop the courses. We were happy to receive enthusiastic support from both colleges. The problem of scheduling the courses at a large institution is non-trivial. We talked with the set of academic advisors for students majoring in the eight majors offered by CBS to obtain an idea of what courses freshmen majoring in the biological sciences would be taking; then we scheduled our courses at times that didn't conflict with required courses.

Of course, content is important and we took several approaches to selecting material to include. We looked to learn from other people's experiences. The BIO 2010 report (NRC 2003) and subsequent Math & Bio 2010 (MAA 2005) gave us a picture of efforts around the country and starting points to access the existing community. We also talked with several of the MBI's long term visitors. While the vast majority of them are in residence for research, nearly all of them are involved with interdisciplinary curricular efforts at their home institutions. From them we received valuable advice and learned from their experiences. We talked with the people who run the introductory biology program within CBS, looking for places we could reinforce each other in the classroom, referring to specific labs or tailoring specific problems for example. The instructors for the calculus sequence (T.N. and others) met throughout the academic year with the instructor (L.K.) for the statistics course, both to ensure that the students would be prepared for the statistics course (which assumes calculus) and so that the Statistics course could build on the material covered in calculus (thereby increasing the students' opinion of their "relevance").

The next step was to recruit students. To make sure the target audience was aware of the courses, we worked with student counselors from both colleges. The summer freshmen orientation advisors were extremely helpful in recruiting students into the first-quarter calculus sequence. However, recruiting students into the third quarter statistics course was much more difficult. We attempted to recruit by making the academic advisors aware of the course and by distributing information in the calculus courses. However, the response was much lower than we had hoped during the first offering of the Statistics course in Spring 2007 (of 160 students enrolled in two sections of calculus II, only a handful continued in the statistics course; however, the course enrolled 38 students total, and thus there was significant interest from other life science students). The subsequent offerings have been similarly populated. In the Discussion, we describe how have worked to improve recruitment into the third quarter courses.

Both the calculus and statistics courses were taught in a lecture-recitation format, in which students met with a faculty member for three hours of lecture per week and with a graduate teaching assistant (GTA) for two recitation session per week (see Kubatko et al 2012)). Considerable thought was given to the use of GTAs, because the courses had not been offered before and were interdisciplinary, thus we asking a bit more of a GTA than the usual assignment. It proved beneficial to have early conversations with the GTA Coordinators in the Department of Mathematics and of Statistics. Pilot courses often succeed because the designers have a passion for the course and the GTAs are hand-chosen for their experience and high teaching ability. While that can be important, we felt it imperative to have GTAs who were at ease with the biology. If they happened to be excellent teachers, that would be a bonus. Our GTAs were good, but it was their knowledge of biology that secured their selection for this position and helped make them effective with the students.

We received important feedback from teaching the pilot versions of the calculus and statistics courses during the 2006-2007 academic year, and we used it to improve the courses in their second offering during the 2007-2008 academic year. With the support of our departments and administration, we have made the courses permanent offerings, with their own distinct courses

numbers.

A next step is the development of a third quarter course in mathematics, to provide an option for students wishing to continue their quantitative training following the calculus sequence. This course has been developed by one of us (T.N.) and is designed to complete a (second) semester course in the upcoming conversion. The first offering of this course is in Spring Semester 2013.

Discussion

While it took a great deal of time and effort, the process of developing these courses went very smoothly. We feel that this was largely due to how much communication there was throughout the process. Initial conversations were critical due to their content and they firmly established relationships and lines of communication that we used to foster a sense of active participation and teamwork. We were conscious of the need to keep all parties informed of progress on the development of the courses, even while keeping a core group of faculty involved in the day-to-day efforts of course development.

Also crucial has been our willingness to keep an open mind about how these courses should be set up and to solicit and consider the suggestions of students and faculty. We feel that maintaining openness will be vital as the courses continue to develop, so that we can meet the needs of students.

Our primary difficulty was recruiting students for the third quarter statistics course. The course size has been large (approximately 40 students), but only a small percentage were students who continued on from the calculus courses. We have worked to improve our recruiting, including visiting the calculus II courses and meeting with the bioscience academic advisors closer to the start of the course, so that students will be aware of the optional third quarter courses. We are also talking with the undergraduate committees for majors within CBS that require a statistics course in the hope that this will be considered a desirable option to satisfy this requirement. The course requires two quarters of calculus, so that it will likely be listed as a choice of several courses for B.A. degrees; most B.S. degrees require calculus, and so it may be the favored course for B.S. degrees.

Suggestions

Our experience suggests that keeping all groups informed at all stages in the development is crucial. It is equally important to listen carefully to the advice of colleagues and students. Ask faculty in the biological sciences what topics from mathematics and statistics they feel are valuable for their students. Ask for specific examples of where mathematics and statistics are used in the laboratory experiments the students perform. Ask about what students would be expected to know for graduate work in the biological sciences.

Communication will lead to the development of a community of faculty, staff, and administrators who care about the success of this curricular venture. While we were fortunate to have the MBI to help us build this initial community at OSU, we feel that a few networked and enthusiastic professionals who can draw others in can be enormously successful in creating such a community.

The process requires work: selecting the textbook, deciding on topics to cover, and figuring out what approach will work best are difficult and time-consuming tasks. It is important to be flexible and willing to learn by trial and error. We also recommend taking advantage of the ever-growing set of resources available in this area (this volume being one example!).

Finally, we suggest advertising courses extensively and enthusiastically. This is particularly important at a large institution like OSU, where students have many options in course

scheduling. Advertising should be aimed at students and the faculty and staff who advise them.

We have learned a great deal from developing and teaching the courses. While difficult at times, we have enjoyed our work in developing courses to meet the needs of students in the biological sciences, and hope to continue to adapt our courses to provide the best experience possible for them.

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