

# Transforming Undergraduate Mathematics at NC State

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# Goals

- Modernize Mathematics Curriculum, both for majors and non-majors
- Improve both success rate and retention of material
- Deliver content more cost effective

# Challenges

- Problems: Shrinking state budgets leading to fewer faculty and larger class sizes.
- Number of students has grown by 50%. Currently about 10,000 students take math classes each semester.
- Many disciplines are changing rapidly and need different mathematics focussed on their discipline. For example Biology, Engineering, Business, (Elementary) Education, etc.
- Changing demographics (more engineering students have AP credit, more biology majors taking math, general education quantitative requirements).

# Methods

- Different ways of delivering classes: Scale-up, flipped, online classes and hybrid classes
- Develop interactive electronic text books focussed at the client discipline.
- Work with client departments to not only modernize service courses, but also create new courses.

## Hybrid Classes - Large Course redesign

- Class size increase of 30 average to 100 to 250.
- Provide lots of interactive online materials, videos of topics, online homework, electronic textbook, etc
- Provide tutorial sessions (some online).
- Course becomes a hybrid course: Some lectures (fewer), supported by online materials and tutorials as well as problem sessions where students work in small groups.
- Assessment shows that student success in these courses has improved significantly compared to our traditional classes of 30 students. Also in followup courses. Better retention of material.

## New Course Materials

- Work with service departments to develop text books customized for their needs.
- Not only examples specific to their discipline, but choice and timing of topics.
- For example our Calculus 2 course contains a large section on modeling and differential equations.
- Students are more engaged in the course because they see more examples relevant to material in their major.
- Added Benefit: Students get much cheaper textbooks and it creates a new revenue stream for the department, independent from state budget.

## Examples of New Service Courses

### Differential Equations for the Life Sciences

- This course seeks to provide students with an understanding of how mathematics and life sciences can stimulate and enrich each other. In particular, all methods discussed (either analytical or graphical or computational) are motivated with examples from the biological sciences (such as growth models, kinetics and compartmental models, SIR and other epidemic models, mixing models, cell proliferation, biological switches and clocks, predator-prey) and include first order equations, separable equations, second order systems, vector and matrix systems, linear algebra, eigenvectors, eigenvalues, graphical and qualitative (phase-plane) methods, inverse problems techniques in biology, and numerical techniques. Computational modeling is carried out using SimBiology, a MATLAB toolbox based graphical user interface, which automates and simplifies the process of modeling biological systems.

## Examples of New Service Courses (continued)

### Calculus for Elementary Education

- This 2 semester course was developed and is taught jointly between faculty of Mathematics and Education.
- The aim of this course was to address the enduring problem of preparing elementary teachers with STEM knowledge.
- Focus is on concepts rather than methods.
- A 2014 study measuring the math performance of Elementary Education graduates from NC colleges shows that the NCSU graduates have a deeper mathematical understanding than new Elementary teachers from other schools.
- Topics related to teaching elementary mathematics are included as well.



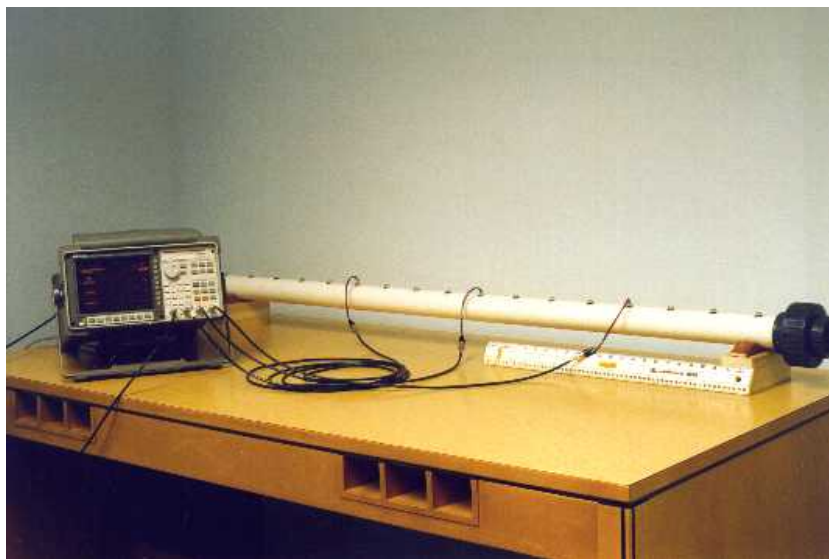
# Mathematics Program Data

- 11 years ago two majors: MA and AMA with about 40 graduates each year.
- Modernized the requirements+curriculum and started new concentrations that align with professional masters degrees:
- Financial Mathematics (not actuarial sciences), Bio-Mathematics (under development), Data sciences (under development), Interdisciplinary Mathematics (under development).
- 5 year BS/MS programs aligned with these.
- Number of yearly graduates in last 7 years: 80 - 100 and still growing.
- Build in more research opportunities.
- This has resulted in 1/2 of our graduates in the last 5 years going to graduate school.

## Examples of New Major Courses

### Mathematical Modeling of Physical and Biological Processes I & II

- These modeling courses exposure students to specific laboratory experiments, data collection, and analysis. They start with first principles in a physical, chemical, or biological process and deriving quantitative models in the context of a specific applications such as thermal nondestructive damage detection in structures, smart material (piezoceramic sensing and actuation) structures vibration suppression, mosquitofish and daphnia population dynamics, and blood pressure regulation. The students then use the models (with appropriate computational software) to carry out simulations and analyze experimental data. The students are exposed to actual hands-on experience through experimental design and data collection in the Instructional Laboratory. Currently, the laboratory provides capabilities for several distinct physical and biological experiments and demonstrations including heat conduction, acoustic wave propagation, soliton, beam vibration control, inverted pendulum stabilization, blood pressure regulation, and Daphnia biology (web-lab experiment).





## Examples of New Major Courses

### Mathematics of Scientific Computing

- This course provides students with an overview of methods to solve quantitative problems and analyze data. The tools to be introduced are mathematical in nature and have links to Algebra, Analysis, Geometry, Graph Theory, Probability and Topology. At the end of the semester, they have an appreciation of (i) the fundamental role played by mathematics in countless applications and (ii) the exciting challenges in mathematical research that lie ahead in the analysis of large data and uncertainties. Each section lasts about two weeks and is paired with a project, that could turn into a research experience.

# Examples of New Major Courses

## Methods of Applied Mathematics I & II

- Topics include: dimensional analysis, asymptotics, continuum modeling, traffic flow analysis, physical continuum processes such as fluid flow and the deformation of solid elastic materials. Techniques include the modeling and formulation of equations of motion, the use of Lagrangian and Eulerian variables; further topics are: examples of incompressible fluid flow, calculus of variations and applications to optimal control problems.