

TRANSFORMING THE GATEWAY: Redesigning large introductory-level courses

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Background:

- Michigan State University (MSU) is a large public university located in East Lansing, Michigan.
- Michigan State has 50,000 students (39,000 undergraduate, 11,000 graduate).
- The MSU Mathematics department teaches 22,000 students per year.
- 54 tenure stream Math faculty, plus 11 joint appointments.



Gateway Courses in Mathematics:

Intermediate
Algebra
1825

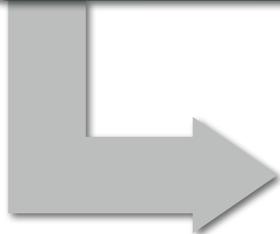
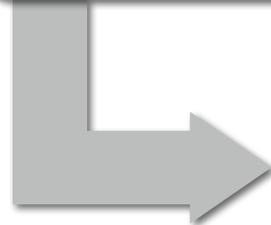
Intermediate
Algebra
1825

College
Algebra
103

Pre-Calculus
116 (or 103 +
114)

Survey of
Calculus
124

Calculus I
132



Calculus I Courses at MSU

- Math 152H – Honors Calculus
 - ❖ Enrollment around 20 students per year
- Math 132 – Calculus I
 - ❖ Enrollment around 2000 students per year
 - ❖ Required for majors including: physics, chemistry, geological sciences, computer science, engineering, etc.
- Math 124 – Survey of Calculus I
 - ❖ Enrollment around 3600 per year
 - ❖ Satisfies calculus requirement for majors including: human biology, neuroscience, plant biology, physiology, finance, economics (BA)

Survey of Calculus – Math 124

- Three credit “applied calculus” course.
- Enrollment around 3600 students per year
~2400 Fall, ~1200 Spring
- Primarily majors from life sciences or business/economics.
- Terminal math course for many students.
- Historically taught in small sections (30-35 students), mostly by graduate students.
- Applications were primarily focused on economics, with some from life sciences.

Motivation:

- A university-wide interest in improving gateway STEM education.
- Interest from the College of Natural Sciences in better serving the needs of the Life Sciences majors.
- Interest at the department level in demonstrating a commitment to lower-level courses. Get tenure-stream faculty involved in courses below regular Calculus I (Math 132).

Goals of Course Redesign:

- Create separate streams of the course for students in the life sciences versus students in business/economics.
- Highlight the relevance of calculus to the academic interest areas of the students.
- Incorporate research-based teaching strategies.
- Course development team:
 - ❖ Teena Gerhardt – Associate Professor
 - ❖ Benjamin Schmidt – Associate Professor
 - ❖ David Bramer - Instructor

Major Course Changes:

- Two separate tracks: one for students in life sciences and one for business/economics
- Two lectures plus one “lab” per week
- Lecture size options:
 - Large section (~270-300 students): Led by experienced faculty
 - Small section (~32 students): Mostly led by graduate students
- Textbook, WeBWork, Syllabus, etc...

Application Labs

- Team-based active learning “labs” focused on applications of calculus to life sciences or economics.
- Students work in assigned groups of 3-4. The groups change twice throughout the semester.
- Students spend one course period (50 minutes) per week working on a lab activity with their group.
- Labs are graded on participation and correctness.
- Labs tie to lecture material from that week.

❖ Lab 1: Functions and Models

- Bio: Modeling Cancer Incidence
- Business: Cost, Revenue, Profit, Supply and Demand

❖ Lab 2: Exponential Functions

- Bio: Bacteria Growth
- Business: Interest-Bearing Investments

❖ Lab 3: Average Rate of Change

- Bio: Modeling 2014 Ebola Epidemic
- Business: Modeling Housing Costs

❖ Lab 4: Average and Instantaneous Rate of Change

- Bio: Modeling Climate Change
- Business: Trends in Oil Prices

❖ Lab 5: Introduction to the Derivative

- Bio: Zoology -- Mass of Bighorn Sheep
- Business: Marginal Cost

❖ Lab 6: Basic Derivative Rules

- Bio: Enzyme Kinetics
- Business: Marginal Analysis and Profit Maximization

❖ Lab 7: More Derivative Rules

- Bio: Epidemiology – Modeling Rotavirus
- Business: Elasticity of Demand

❖ Lab 8: Optimization

- Bio: Cellular Biology – Shapes of Cells
- Business: Determining Concert Ticket Prices

❖ Lab 9: Second Derivative and Concavity

- Bio: Population Ecology and Sustainable Farming
- Business: Law of Diminishing Returns

❖ Lab 10: Definite Integrals and Riemann Sums

- Bio: Position, Velocity, and Acceleration
- Business: Marginal Cost and Total Cost

❖ Lab 11: Integration

- Bio: Zoology – Oxygen Consumption by Birds
- Business: Social Networking Membership

❖ Lab 12: Area Between Curves

- Bio: Environmental Science – Pollution Leak
- Business: Consumer and Producer Surplus

Sample Application Lab:

❖ Life Sciences [Lab 6](#): Enzyme Kinetics

❖ Business/Economics [Lab 9](#): Law of Diminishing Returns

Student Impressions:

“[The class] really drove home the application problems and allowed us to work together to solve these detailed, yet conceptual problems, and helped build a solid foundation of knowledge as I move further on in my education.”



Student Success:

DFW (Grades of 0.0, 1.0, 1.5, and withdrawals)

FW (Grades of 0.0 and withdrawals)

National numbers: From MAA Calculus Survey 2009-2015.

294 calculus courses at 197 institutions.

Calculus I: 22% DFW. Calculus I for Biology: 25% DFW.

❖ Fall 2013: 25.8% DFW, 17.4% FW

❖ Fall 2014: 21.4% DFW, 13.4% FW

❖ Fall 2015: 13.5% DFW, 9.3% FW

❖ Fall 2016: 17.8% DFW, 10.4% FW

Involvement of Research Faculty:

- Math 124 was pilot project for reforming gateway courses within the Math department.
- Department looking for sustained commitment from a faculty member to a particular course (3+ years).
- Department and university willing to incentivize faculty participation: course releases, summer salary, post-doc hires.
- Clear Memorandum of Understanding with faculty members.
- Part of a larger university vision for transforming the Gateway.

Transforming the Gateway:

- The President's Council of Advisors on Science and Technology (PCAST) in 2012 reported a need for 1 million more college graduates in STEM fields than expected over the following ten years.
- The PCAST report noted:
 - “The first two years of college are the most critical to the retention and recruitment of STEM majors.”*
- Michigan State University has focused recent STEM education reforms on improving the gateway courses.

AAU STEM Education Initiative

- In September 2011 the Association of American Universities (AAU) announced the Undergraduate STEM Education Initiative, aimed at increasing the quality and effectiveness of undergraduate STEM education at its 62 member universities.
- Michigan State University was one of eight project sites initially funded by the AAU STEM Education Initiative.

AAU STEM Education Initiative



<https://stemedhub.org/groups/aaup>



AAU STEM Education Initiative

The overall objective is to:

“... influence the culture of STEM departments at AAU universities so that faculty members are encouraged to use teaching practices proven by research to be effective in engaging students in STEM education and in helping students learn, particularly at the first year and sophomore levels”



Transforming the Gateway:

Creating a Coherent Gateway for Teaching and Learning at MSU

MSU's AAU STEM Initiative Project:

- Gateway course reform focused on three-dimensional learning:
 - Core ideas, scientific practices, and crosscutting concepts
- Institutional engagement
 - e.g. STEM Gateway Fellowship

STEM Gateway Fellowship Goals:

- Identify disciplinary core ideas, crosscutting concepts, and science practices that form the basis of the gateway curriculum.
- Develop, implement, and assess evidence-based curricular materials that address teaching and learning challenges in gateway courses.
- Develop a community of faculty committed to improving the STEM Gateway curriculum.

STEM Gateway Fellowship

- Open to faculty who teach gateway courses in Biology, Chemistry, Mathematics, Physics, and Statistics.
- Open to tenure stream faculty, fixed term faculty, and academic specialists.
- A two year program with monthly fellowship meetings as well as small group meetings.
- \$8,000 stipend to support participation.
- Read discipline based education research literature, share teaching approaches, peer review curriculum pieces and assessment materials, etc.

Current STEM Gateway Fellows

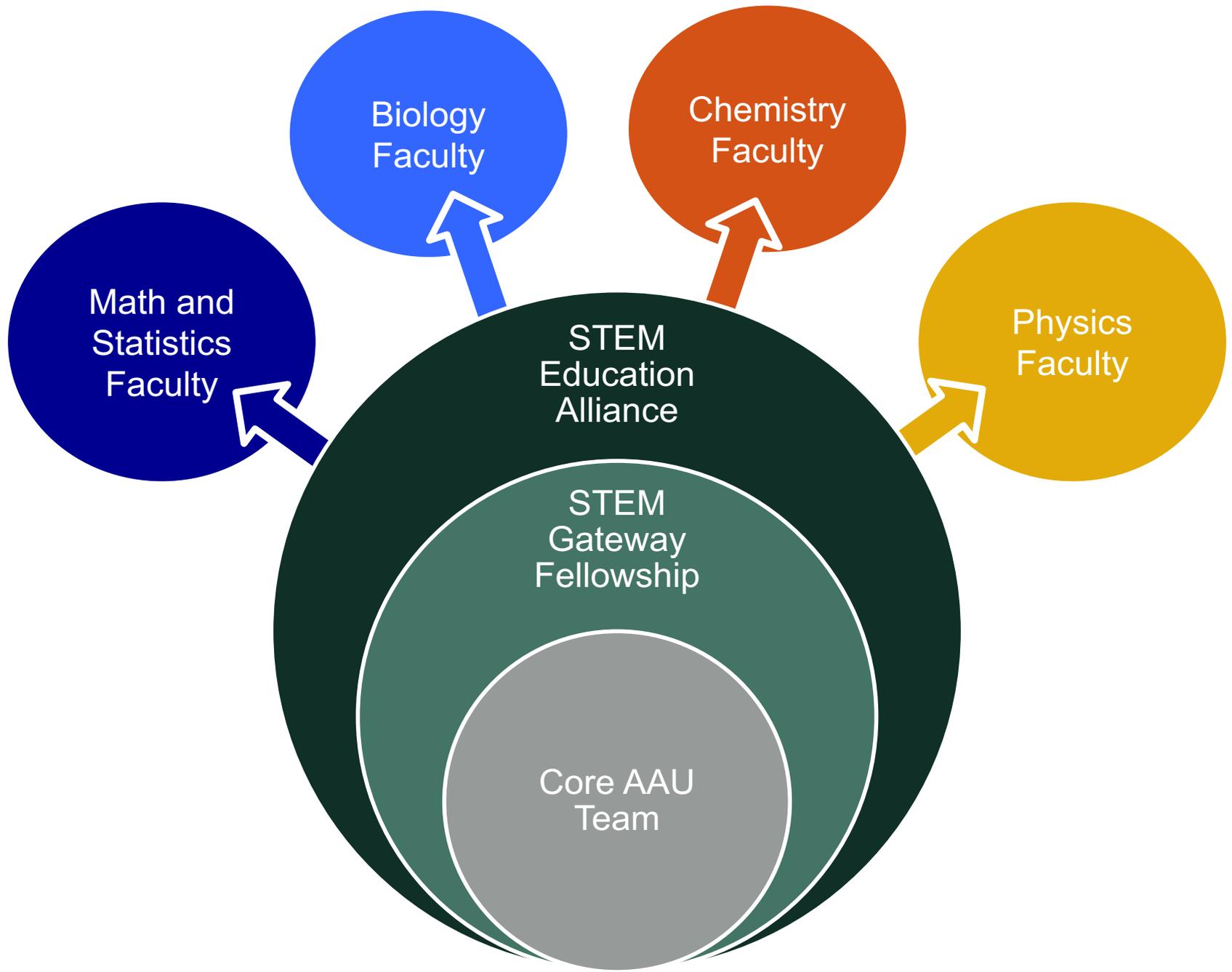
18 STEM Gateway Fellows (2016-2018):

- 8 Chemistry
- 3 Biology
- 2 Math
- 2 Physics
- 3 Computational Mathematics, Statistics, and Engineering (CMSE)

This is the second cohort of fellows. First cohort had 9 fellows.

STEM Education Alliance

- The Alliance is a cross-college effort that connects faculty, academic staff, and advisors committed to persistence and success of students in STEM. Around 210 members.
- The goals are to:
 - Create a faculty and academic staff learning community in the area of college-level STEM education.
 - Connect those doing research on Discipline-Based Education Research (DBER), those interested in the scholarship of teaching and learning, and with those interested in continuing faculty development in teaching and learning in MSU STEM colleges.
- 3 meetings per year, each focusing on a different theme in STEM Education



Further Initiatives in Math

- Continued development of Quantitative Literacy courses.
- Transformation of the College Algebra course to:
 - Align more closely with Calculus courses.
 - Eliminate the need for Intermediate Algebra.

Thank you!

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