Improving Quantitative Skills of Life Science Majors at CSULA

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Biomathematics and Ecology:
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BIO 2012 - Call to Action

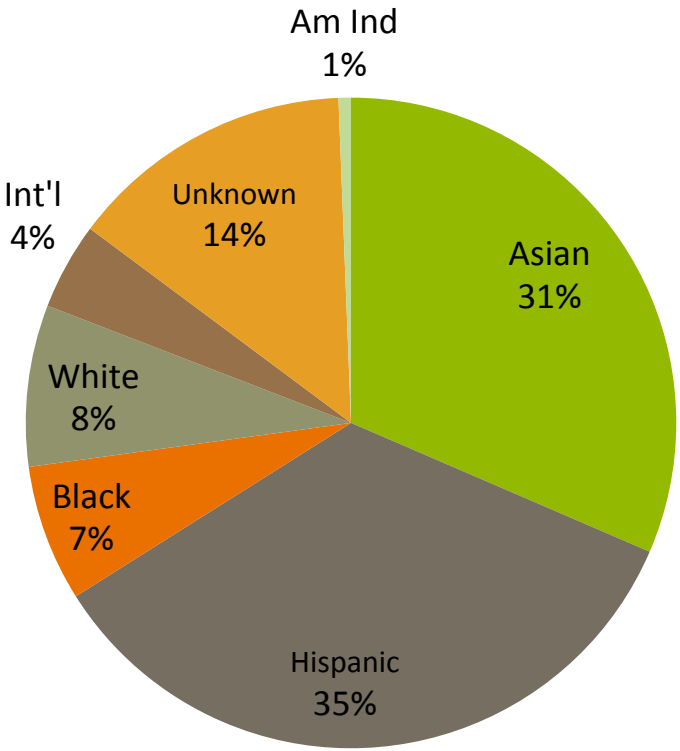
- In response to BIO 2012, faculty from biology, mathematics, physics, biochemistry and computer science applied for a special NIH T36 training grant
- Goal: Improve quantitative skills of life science students
- Phase II Grant awarded for 2008-2013 (NIH 5T36 GM078013), 1.57 Million
- Nine Institutions received this type of grant

Background of Students

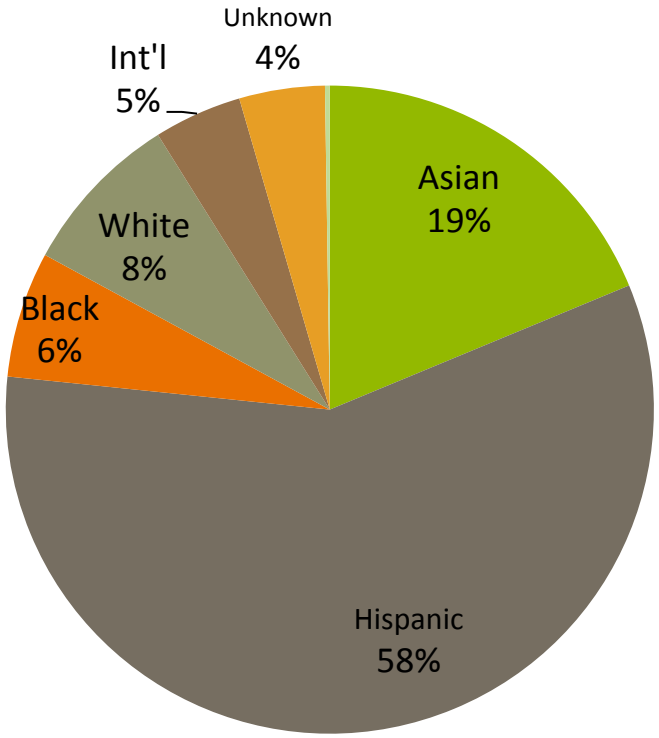
- Many are the first in their family to go to college
- 55% Hispanic, average age (UG) 24 years
- Many students work one or more jobs, most live at home or have their own family already
- Weak academic background (~ 2/3 of the students need math and/or English remediation)
- Mostly transfer students (Fall 2004: 65% transfer; 35% FF), but percentage of FF is increasing

Student Ethnicity Biology Majors

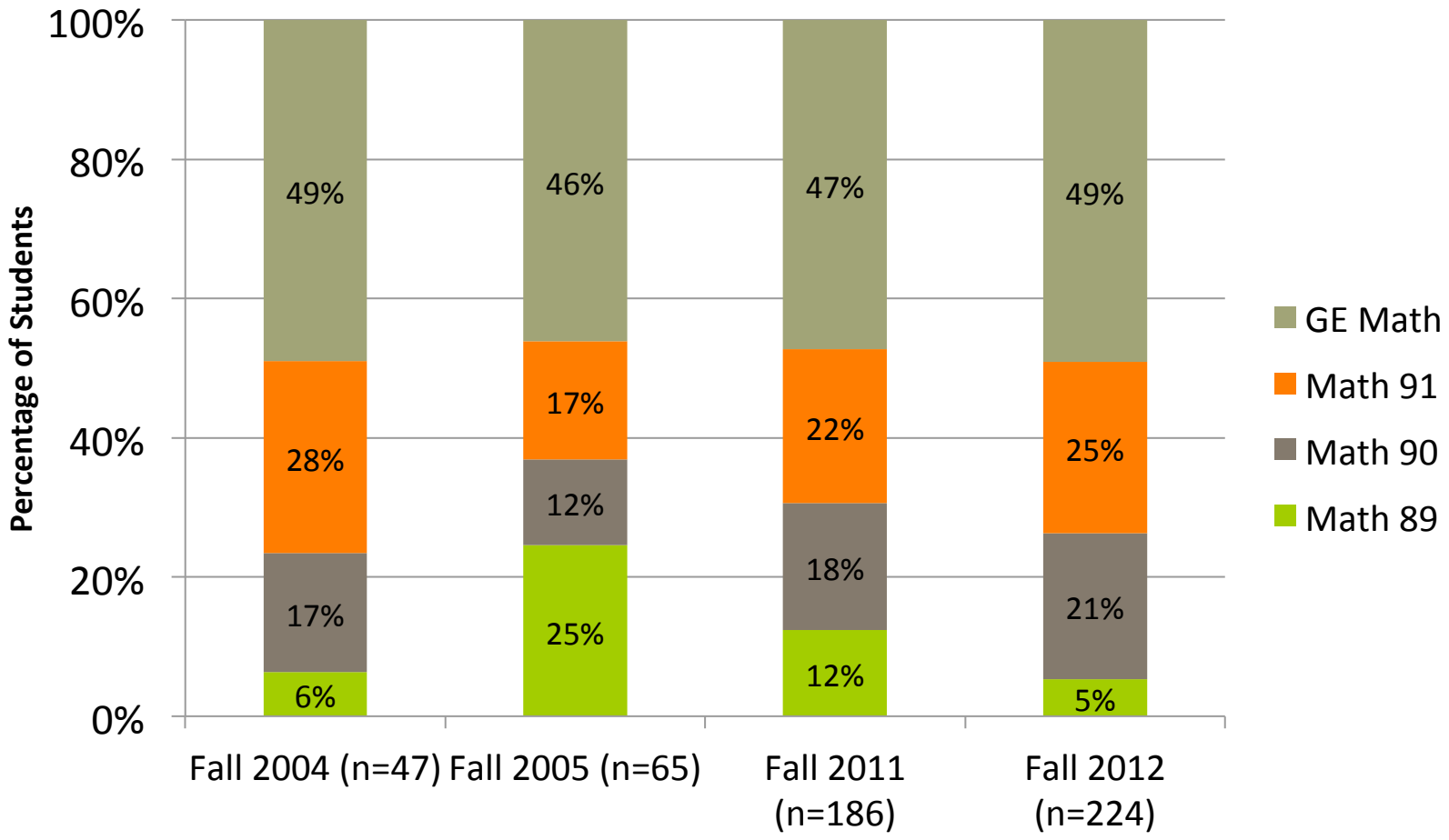
Fall 2004 (n = 486)



Fall 2011 (n = 843)



Math Placement of Biology majors



NOTE: Biology and microbiology majors only.

Curricular Project Components

- **Curricular Revisions in required courses for Life Sciences Majors**
  - Introductory biology course series
  - **Mathematics sequence**
  - Introductory physics sequence
- **New Cross-listed UD modeling course (elective)**
- **Creation of Bioinformatics Minor**

Comparison of Courses

Old Course	New Course
Math 102, College Algebra	Math 104A: PreCalculus – College Algebra
Math 103 Trigonometry	Math 105 – Introduction to Mathematical Models in Biology
Math 206, Calculus I (Differentiation)	Math 204, Applied Calculus I
Math 207, Calculus II (Integration)	Math 205, Applied Calculus II

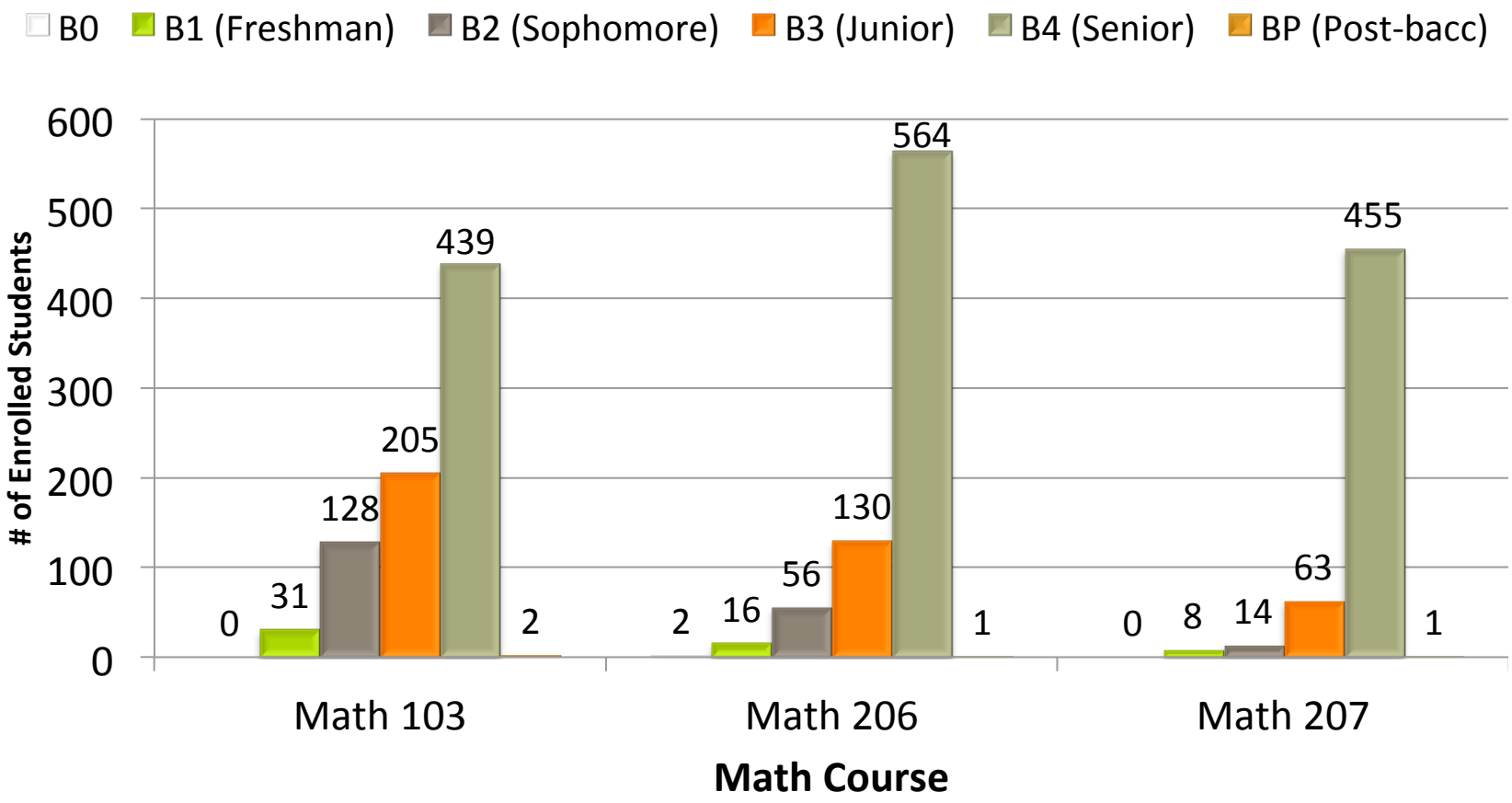
Previous Curriculum

- **Required for biology majors:**
  - Calculus I (Math 206 - Differentiation)
  - Calculus II (Math 207- Integration)
  - Prerequisites: College Algebra and Trigonometry (Math 103)
- **Required for microbiology majors**
  - College Algebra and Trigonometry

Previous Curriculum

- Connections between mathematics courses and biology courses **almost non-existent**
- Trigonometry prerequisite for UD biostatistics course
- Students take Calculus courses late in their major and struggle with it

Biology and Micro Majors Math Course Enrollment by Academic Status: 2004-05



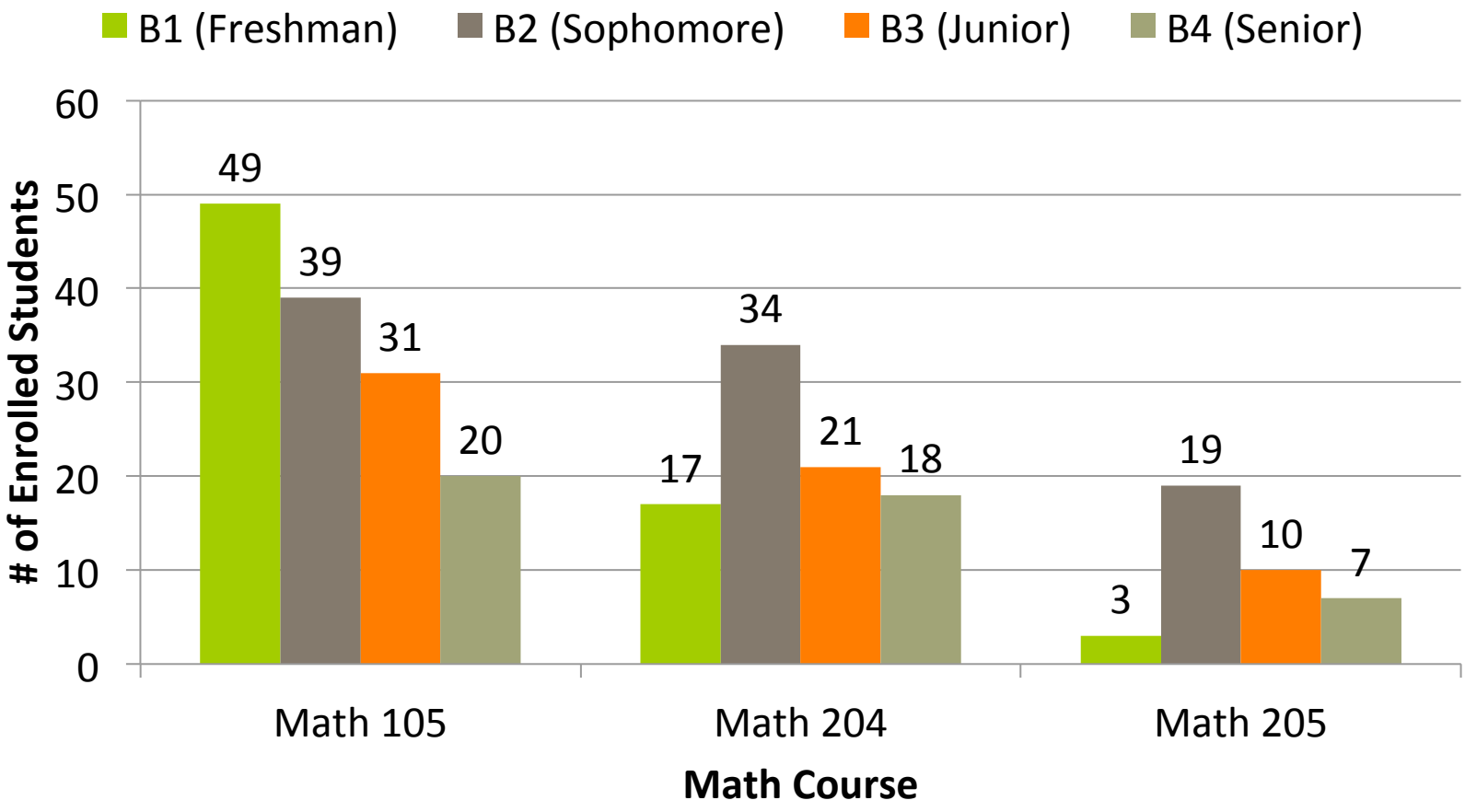
New Curriculum

- **Required for biology majors:**
  - **Applied Calculus I (Math 204-Differentiation)**
  - **Applied Calculus II (Math 205- Integration & Intro Differential Equations)**
  - Prerequisites: College Algebra & **Introduction to Mathematical Models in Biology (Math 105)**
- **Required for microbiology majors**
  - **Introduction to Mathematical Models in Biology**
  - **Applied Calculus I (Differentiation)**
  - Prerequisite: College Algebra

New Curriculum

- Mathematics courses **focus on biological applications**
- Introductory Biology sequence now has **math co-requisites** (College Algebra co-requisite for first course, Intro to Modeling recommended for 2nd course)
- Students in the new sequence **complete their mathematics much earlier**

Biology and Micro Majors Math Course Enrollment by Academic Status: 2011-12



Math 105 – Introduction to Mathematical Models in Biology

- **New course that focuses on**
  - Discrete dynamical systems
  - Exponential and sine/cosine functions
  - Basic probability
  - Markov chains
- **Excel activities and assignments**
  - Graphs with Excel
  - Cobwebbing
  - Fitting data to sine function by estimating relevant parameters

Math 204 – Applied Calculus I

- **New course that focuses on**
  - Differentiation as rate of change
  - Stability of equilibria
  - Long-term behavior of the system
  - Introduction to Differential Equations
- **Excel activities and assignments**
  - Connections between graph of function and derivative
  - Limits of functions
  - Newton's Method
  - Stability of equilibria

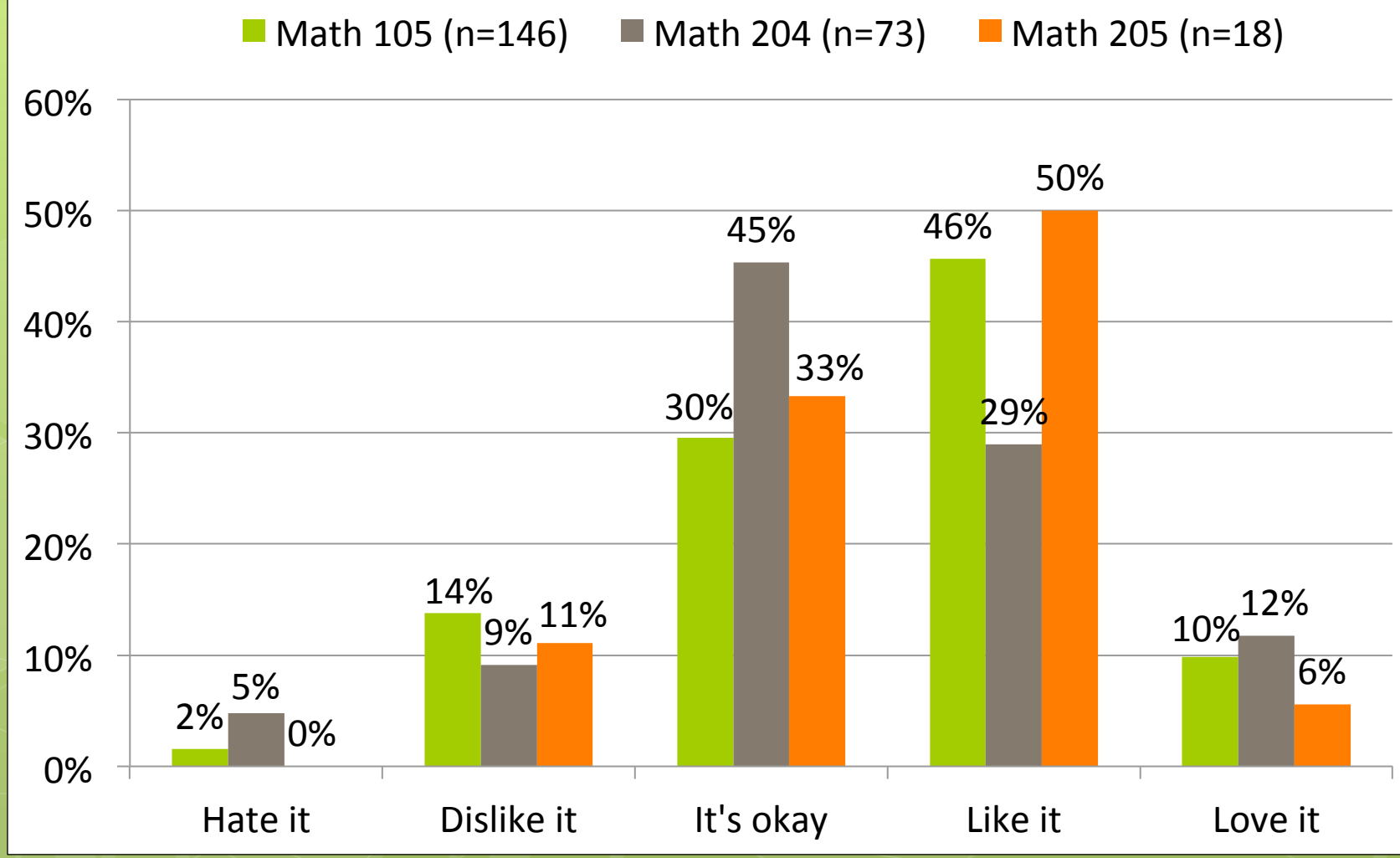
Math 205 – Applied Calculus II

- **New course that focuses on**
  - Methods of integration, including integration by parts and u-substitution
  - Solving pure-time and autonomous DEs of one variable
  - Qualitative analysis of systems of 2 variables (e.g. predator-prey)
- **Excel and Mathematica activities and assignments**
  - Euler's method for solving DEs (pure-time, autonomous and systems)
  - Vector fields for dynamics of systems

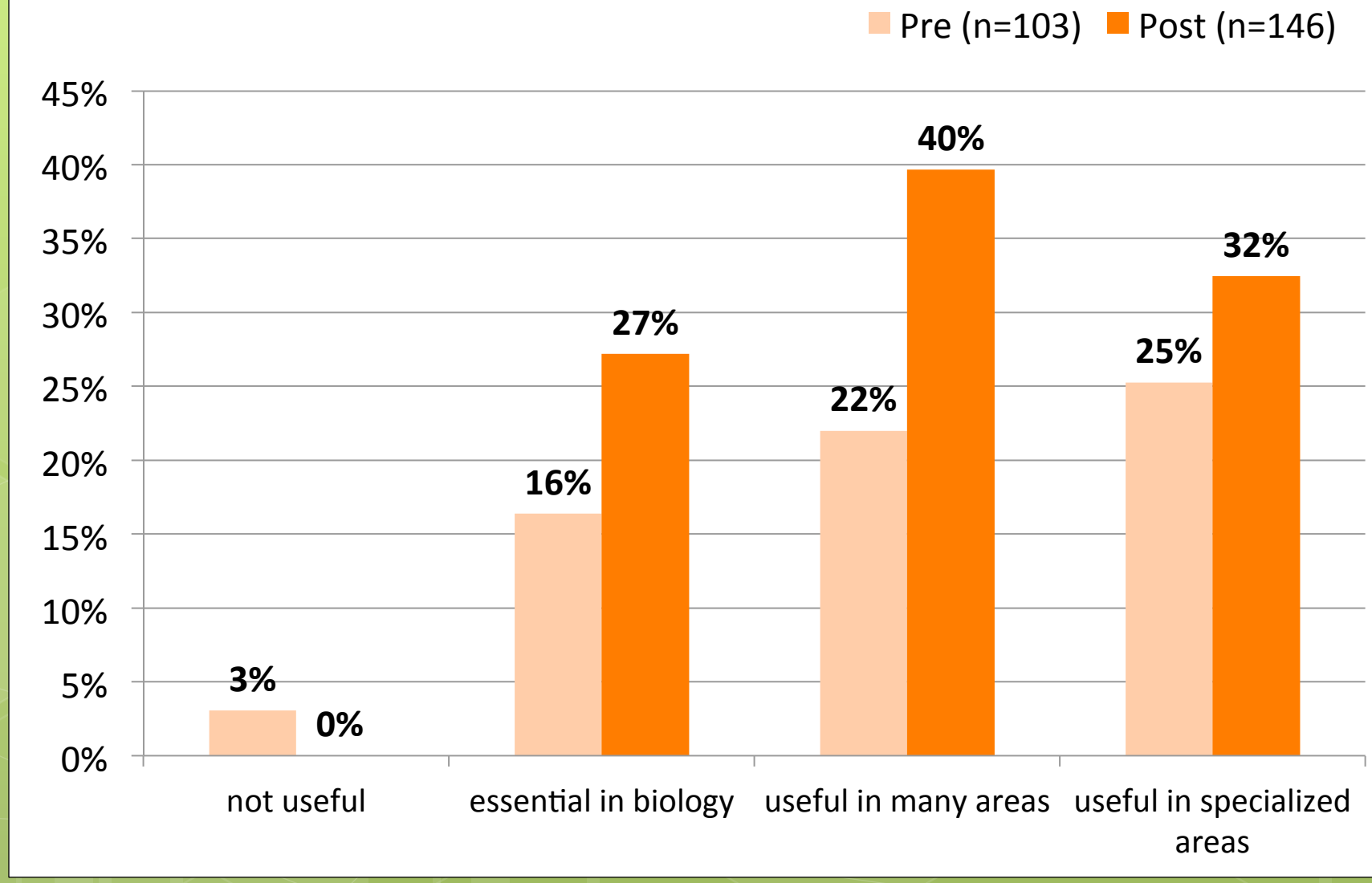
Assessment

- Pre- and post tests on
  - Attitudes towards mathematics
  - Usefulness of mathematics in biology career
  - Understanding graphs, charts, tables
  - Understanding math behind biological concepts
  - Ability to use Excel to explore biological concepts

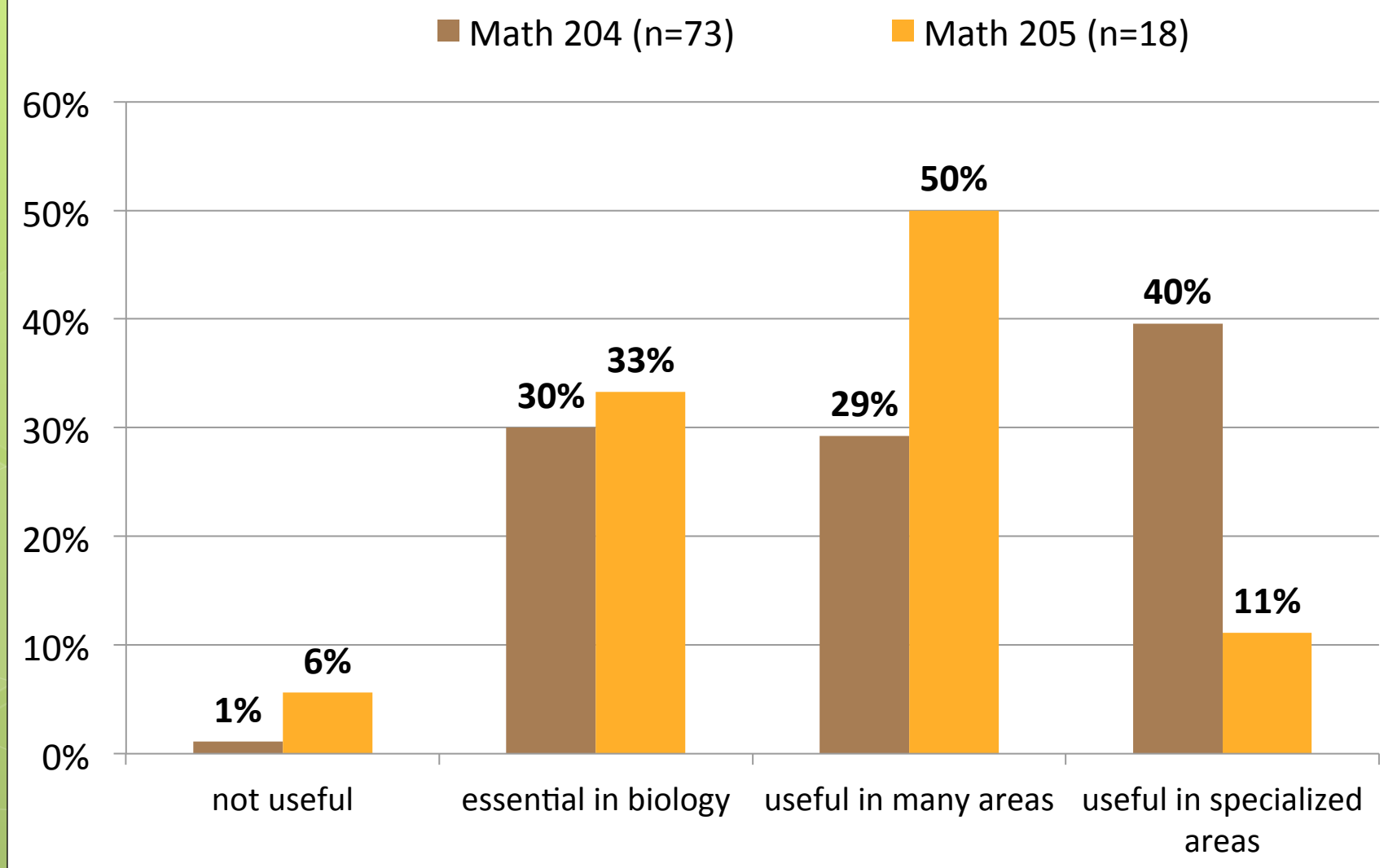
Students' Attitudes Toward Mathematics by Course (Fall 2011 – Spring 2012)



Usefulness of Math in Biology Career
Math 105 (Fall 2011-Spring 2012)

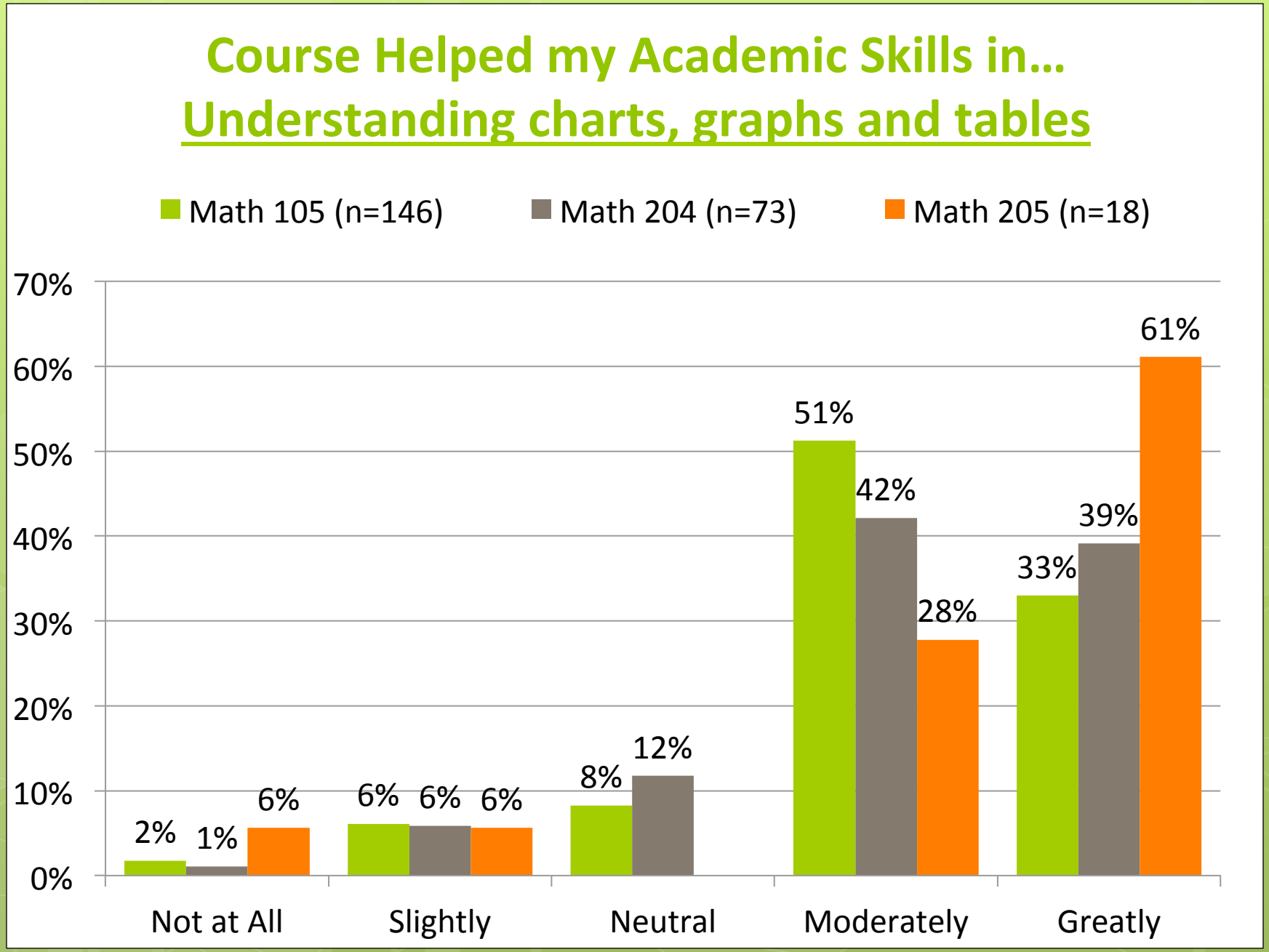


Usefulness of Math in Biology Career
Math 204 & 205 (Fall 2011-Spring 2012)



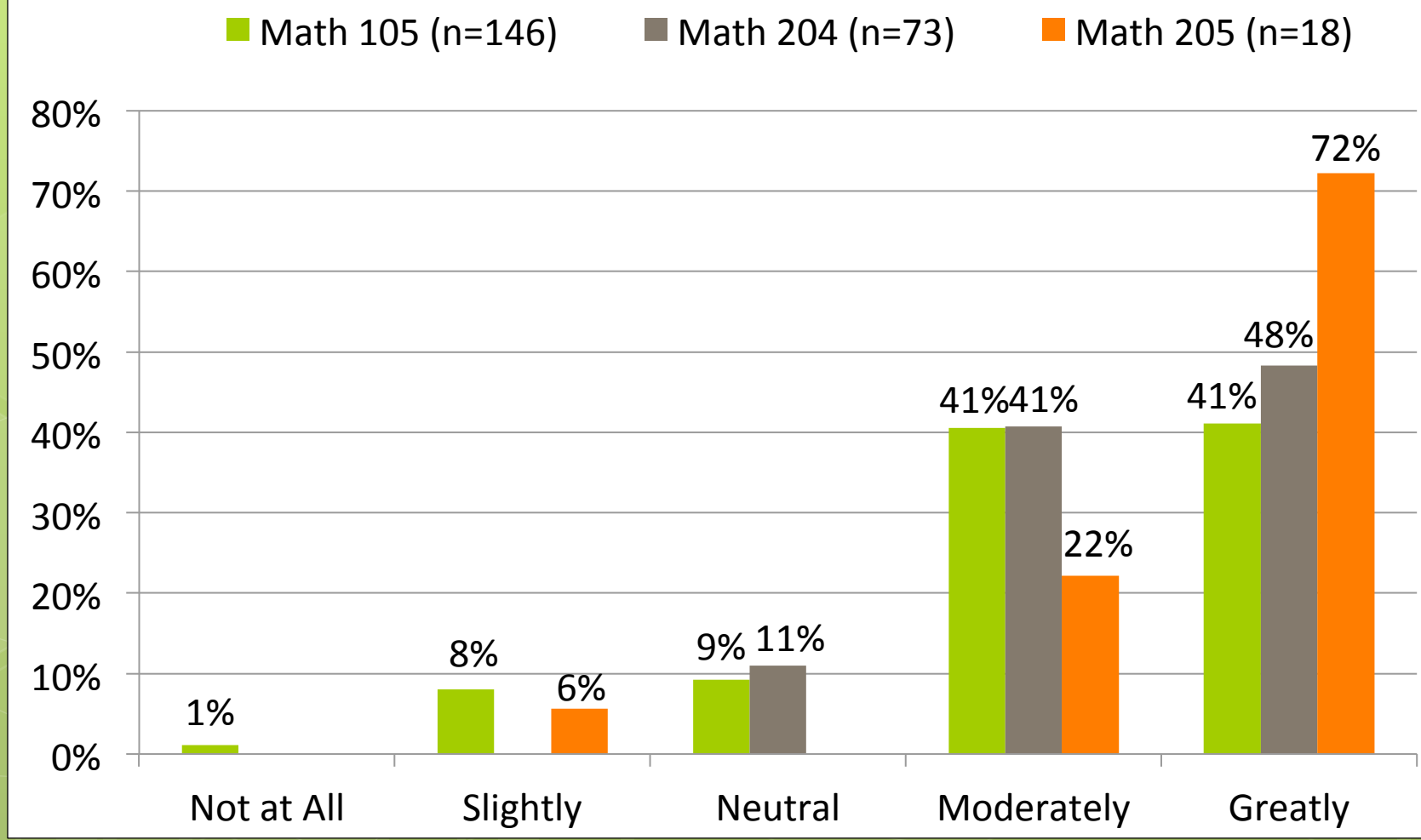
NOTE: Only post-data available for Math 204 and Math 205.

Course Helped my Academic Skills in…
Understanding charts, graphs and tables



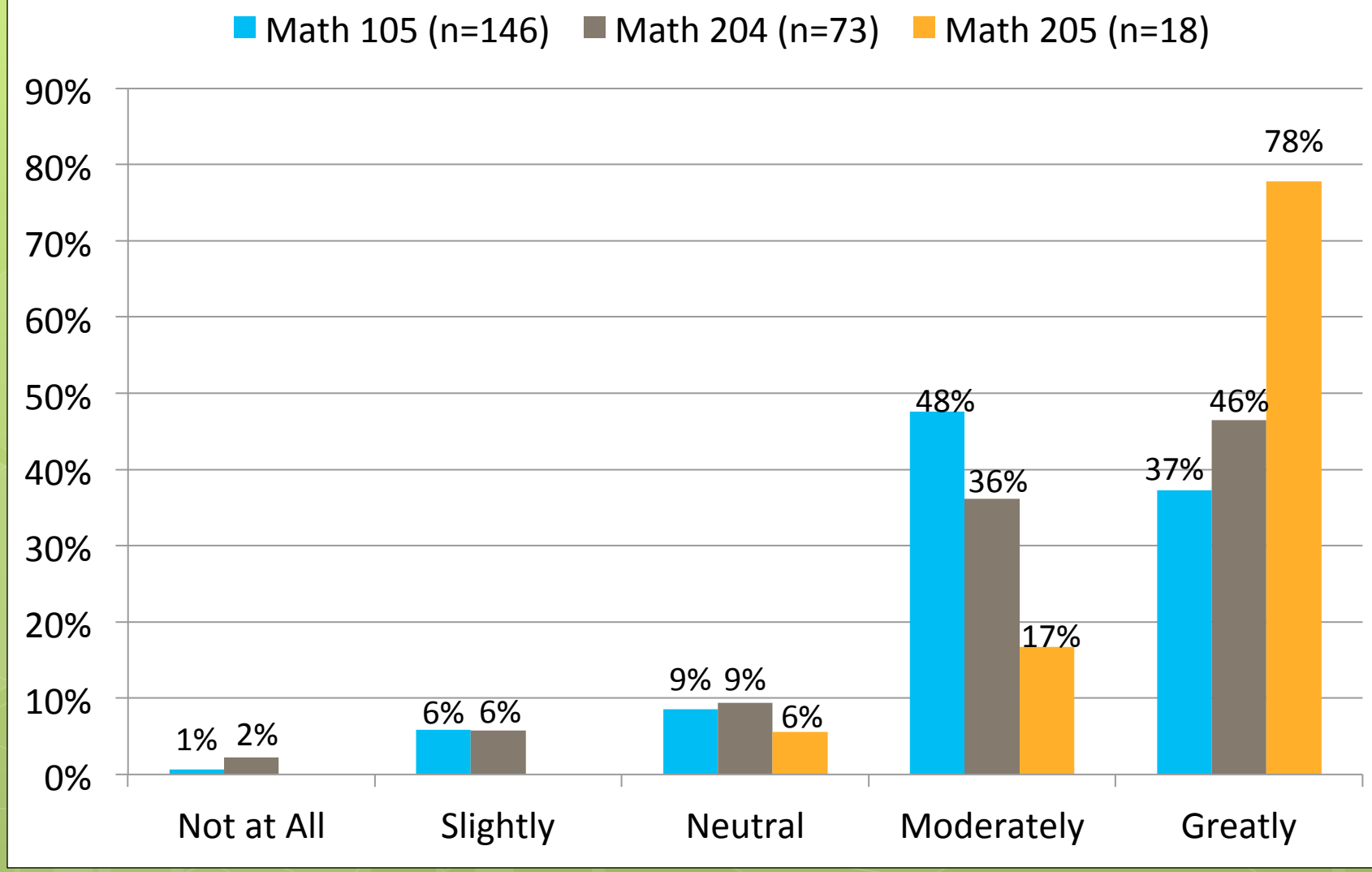
Course Helped my Academic Skills in…

Understanding the Math behind Biological Concepts



Course Helped my Academic Skills in…

The ability to use Excel to explore Biological Models



Student comments (Math 105)

Elaborate on why (or why not) you think mathematics is important to your biology degree and career goal.

- Math is essential to biology for figuring out probability of alleles and genetics. **Probability of having a rare disease**. Graphing your data. Until this class I didn't know exactly how essential math was to biology.
- I have taken **biology 100B** and I had hard time with the part when it came to genetics and alleles. **This class actually helped me understand how to compute the percentages of an offspring with certain phenotype qualities.**
- **It is extremely important, unfortunately**. I have a hard time understanding math so while I know it is important it doesn't necessarily mean I enjoy it. **But when applied to specific situations that are interesting it is less abstract and easier to understand.**

Student comments (Math 105)

What did you like best about Math 105?

- **I liked that I was able to learn how exactly math concepts were used in biology**.
- Made me to look deeper into the concepts of math and when these concepts would be useful.
- Some interesting concepts that regard my career goal. **Focuses on many other careers that involve biology besides the medical field**.
- I liked how it really related to biology and the mix of the content.

Student comments (Math 105)

What is the most interesting thing you learned in Math 105?

- The most interesting thing I learned in Math 105 was **how useful math is in the biological world & how it goes hand in hand.**
- How to figure out the probability of really having a disease. How to figure out the population after a given time and the allele probability.
- What was interesting was the majority of the material I learned **applied to real life situations** that I may run into in the workplace.
- Overall, how biology used in math is interesting and as a biology major. **I liked seeing how math is useful for once.**

Student comments (Math 204)

Elaborate on why (or why not) you think mathematics is important to your biology degree and career goal.

- **It activates the brain** and forces us to think outside the box.
- Mathematics is important to my biology and my career goal because I am interested in research and I believe that **the more math I know, the more credible and valuable my future experiments can be**.
- When it comes to substance concentration and population size, I can see finding stable and unstable equilibria as a useful tool. It can **make trends easier to predict in different environments**.

Student comments (Math 204)

What is the most interesting thing you learned in Math 204?

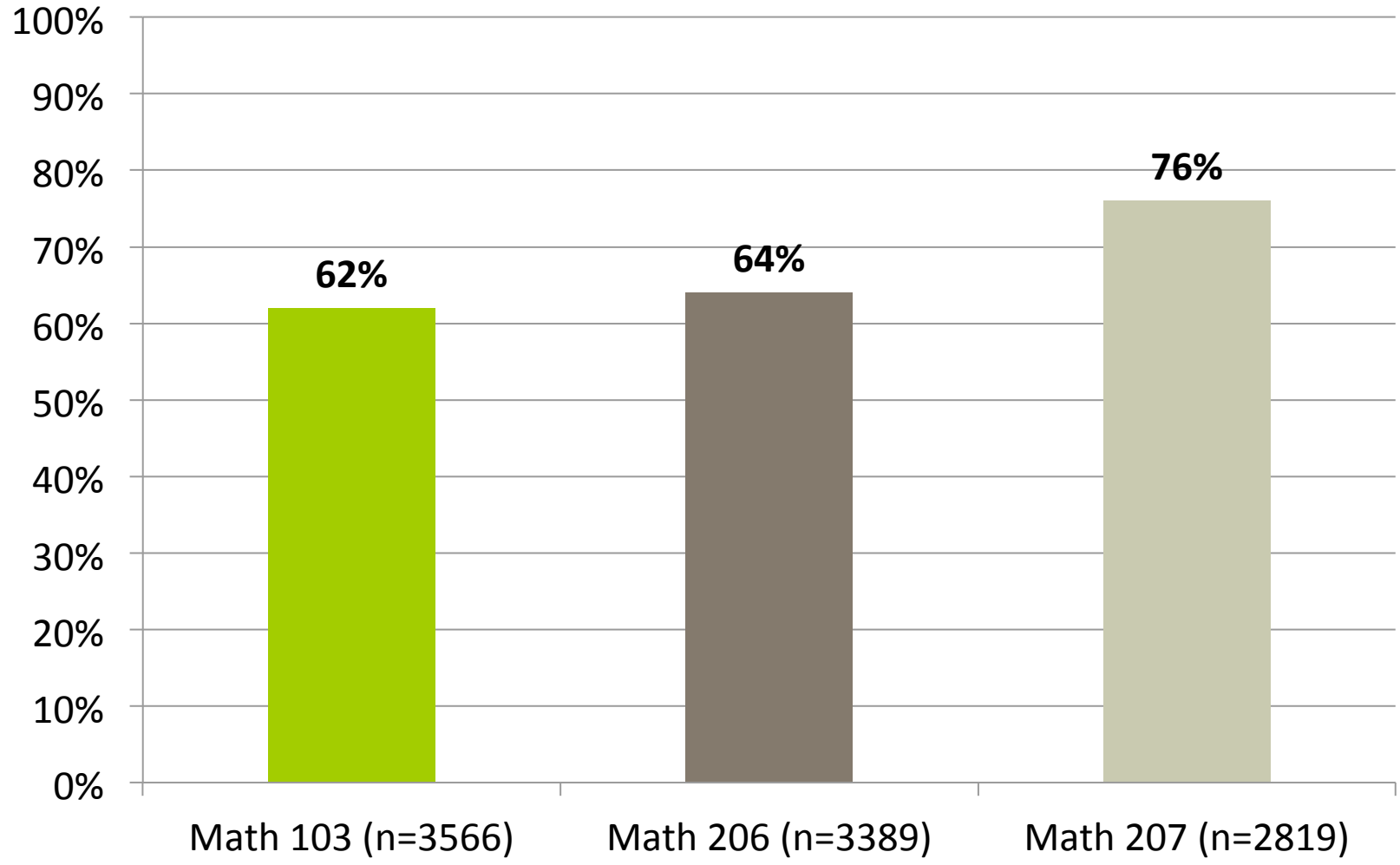
- The most interest thing about Math 204 is **that it is different than other regular Math courses.** I was able to apply math to biological concepts.
- That derivatives can be used to calculate **real-life situations**
- Is the fact that I learned the relationship between different types of functions and their derivative. Also how **taking derivatives gives us lots of information** on different functions.
- What was most interesting about Math 204 is how it's applied to biology, **I never thought it would be connected the way it is**.

Student comments (205)

What did you like best about the Math 105, 204, 205 sequence?

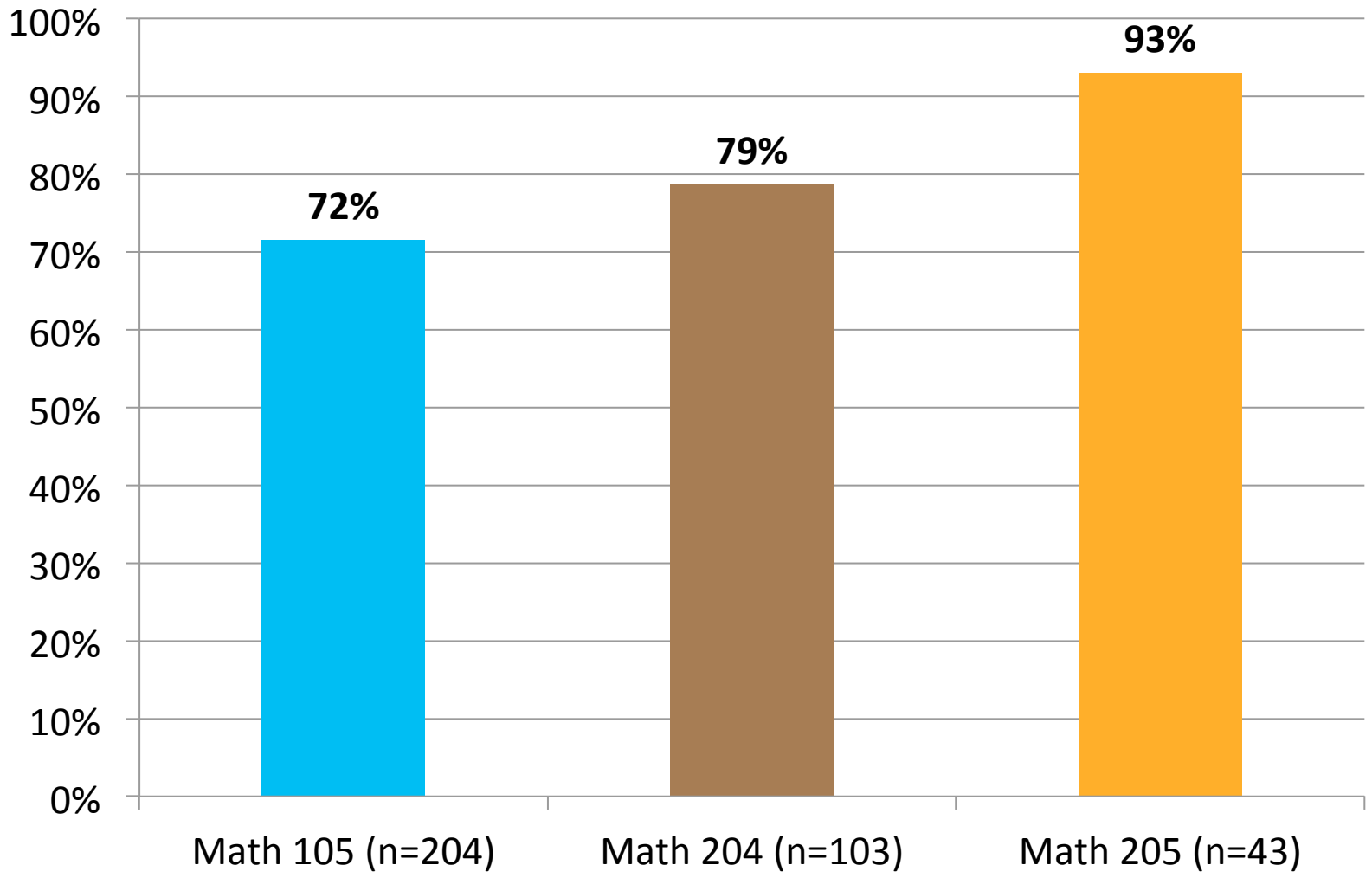
- The transition of mathematical concept **to real life situations.**
- Being able **to integrate math and biology** together.
- I like how it applied math to biology.
- The relationship of the different models depending on the organism.
- I liked the combination as math and biology, makes it more understandable.
- **That it all related to my major**.

Math Course Pass Rates: 2003-2008



NOTE: Math 103 and 206 require a "C" or better and Math 207 require a "D" or better to pass the course.

Math Course Pass Rates: 2011-2012



NOTE: Math 105 and 204 require a "C" or better and Math 205 require a "D" or better to pass the course.

Challenges

- Curriculum change takes time
- Different culture of departments (unit structure, lab courses, etc)
  - Biology: Unit limitations (Math 105 prerequisite, no intro stats course)
  - Mathematics: Concern about major-specific calculus sequence
- Finding enough instructors willing to teach applied materials and using computers
- Finding a good text

Challenges

- Higher levels of review also had concerns
- Getting biology faculty comfortable with teaching using a more quantitative approach
- Transfer student advisement (no course equivalent to Math 105 exists)
- Integrating transfer students who come with pre-calculus into the Applied Calculus sequence w/o the Math 105 course

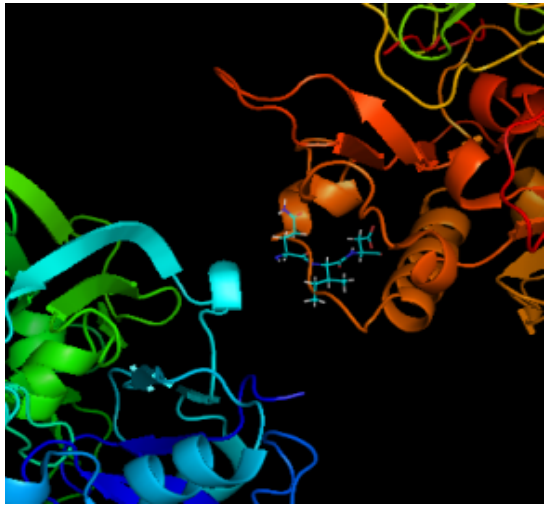
Benefits

- Students get better integrated curriculum
- Closer working relationships between the departments
- Co-directors attended each other's classes
- Workshops for biology faculty (probability)
- Grant has purchased equipment (laptops carts) that will remain

New Upper Division Elective

- Developed a cross-listed math biology modeling course **Math/Biol 480**
- Math majors prerequisite will be Calculus I&II, Linear Algebra and Differential Equations
- Biology majors will have Math 105, 204 and 205 as prerequisite.
- Course taught by both math and biology faculty (alternating)
- First offered in Spring 2012
- Also potentially useful course for graduate biology majors





BINF Minor

- Target Audience = Biology and CS majors
- LD requirements:
  - 2 Programming courses
  - 2 biology courses
  - 1 stats/probability course
- Half of these required by respective majors

Upper division requirements

- **BINF 400** - **Bioinformatics and Computational Biology** (Fall 2012)
- **BINF 401** -**Machine Learning Applications in Molecular Life Sciences** (Winter 2013)
- **BINF 402** – **Phylogenomics** (Winter 2013)
- **BINF 403** - **Process Estimation and Detection in Cellular Biology** (Spring 2013)
- **BINF 450** - **Advanced Topics in Bioinformatics and Computational Biology** (Spring 2013)