Curriculum and Program Integration

- UF MARC GatorSTAR Program
- SF2UF Bridge to the Baccalaureate Program
- UF Bioscience Scholars Program
- CLAS Pre-Health Post-Baccalaureate Program
- All UF STEM BS degree programs
  - Summer Boot Camp
Why Do We Have Lab Courses?

• Reinforce lectures, or vice versa?
• Classic experiments or modern research skills and techniques?
• Highly structured labs, inquiry-based, or authentic research?
SCIENCE EDUCATION

Increasing Persistence of College Students in STEM

Mark J. Graham, Jennifer Frederick, Angela Byars-Winston, Anne-Barrie Hunter, Jo Handelsman

A 2012 report by the President’s Council of Advisors on Science and Technology (PCAST) predicts that the U.S. workforce will suffer a deficit of one million college graduates in science, technology, engineering, and mathematics (STEM) over the next decade (1). The report calls for addressing the shortfall by increasing retention of college students in STEM. But many academic leaders have not responded aggressively to workforce needs by implementing strategies as white students (4). Such stark statistics invite a hard look at research and practice that bear on retention.

The concept of persistence originates in social and cognitive psychology as one manifestation of motivation (6). In education, motivation is viewed as a driver of student engagement. Among the important constructs underlying motivation is the powerful influence of confidence (i.e., self-efficacy), which is a requirement for persistence (9).
STEM Persistence

Increasing Persistence of Students in STEM

Mark J. Graham, Jennifer Frederick, Angela McFadden, Jo Handelsman

A 2012 report by the President’s Council of Advisors on Science and Technology (PCAST) predicts that the U.S. workforce will suffer a deficit of one million college graduates in science, technology, engineering, and mathematics (STEM) over the next decade (1). The report calls for addressing the shortfall by increasing retention of college students in STEM. But many academic leaders have not responded aggressively to workforce needs by implementing evidence-based strategies that can both increase student retention and improve their preparation for work. A science education model, in which success in the classroom is followed by exposure to real-world research, is one simple but effective way to help motivate and inspire students and to enhance their confidence in their abilities.

Graham et al. Science 2013; 341, 1455-1456
Increasing Retention and Graduation

• Increase active learning.
• Increase confidence and motivation to excel in foundational biology, chemistry, physics, and mathematics coursework.
• Increase *early* participation in authentic scientific research.
### Physics Outcomes

**Students will be able to:**
- design an experiment
- analyze data
- communicate results graphically and verbally

**Students will have skills in:**
- circuits
- spectroscopy
- optical design
- transducers
- polarization
- modeling
- [more...]

### Chemistry Outcomes

**Students will be able to:**
- design an experiment
- analyze data
- search literature
- keep a lab notebook

**Students will have skills in:**
- weighing
- extraction
- chromatography
- calibration curves
- making solutions
- spectroscopy
- measuring pH
- measuring chirality

### Biology Outcomes

**Students will be able to:**
- design an experiment
- read and interpret data
- think critically

**Students will have skills in:**
- microscopy
- molecular techniques
- cell culture
- spectroscopy
- field sampling
- cladistics
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X-Lab

• Two-semester, six credit undergraduate laboratory course (two 3-h sessions/week).

• Replaces traditional laboratory courses in general biology, chemistry and physics.
Cross-Disciplinary

• 56 laboratory sessions that roughly parallel topics in traditional biology, chemistry and physics courses.

• Instructors from multiple STEM departments.
Acceptance and Integration

• Statewide course numbering system
• Five colleges with undergraduate STEM majors, nine colleges with graduate degrees.
• Professional programs in Medicine, Dentistry, Pharmacy, Veterinary Medicine, and Nursing
Sustainable Funding Model

• Revenue-neutral with regard to student credit hours and faculty effort.
• Supplies (consumables) costs met by student laboratory fees ($140/sem.).
• High initial investment in equipment, but may provide long-term cost-savings.

cutting-edge lab instrumentation
Outcomes

• Qualitative Assessment (focus groups)
• Quantitative Assessment
  • Research on the Integrated Science Curriculum Survey from David Lopatto (Grinnell College)
  • Compares learning benefits between interdisciplinary course experiences and other experiences, particularly in science education.
  • Parallels questions in other surveys (SURE, CURE).
RISC Survey: Learning Gains

- Clarification of a career path
- Skill in the interpretation of results
- Tolerance for obstacles faced in the research process
- Readiness for more demanding research
- Understanding how knowledge is constructed
- Understanding the research process in your field
- Ability to integrate theory and practice
- Understanding of how scientists work on real problems
- Understanding that scientific assertions require supporting evidence
- Ability to analyze data and other information
- Understanding science
- Learning ethical conduct in your field
- Learning laboratory techniques
- Ability to read and understand primary literature
- Skill in how to give an effective oral presentation
- Skill in science writing
- Self-confidence
- Understanding of how scientists think
- Learning to work independently
- Becoming part of a learning community
- Confidence in my potential as a teacher of science
RISC Survey: Mastery

Student reports of mastery of 48 research-related elements.

• Significantly higher on 34 elements than the average of other highly interdisciplinary courses.
• Significantly lower on two elements: taking tests in class, and listening to lectures.
• NSD on remaining 12 elements.
Skills and Techniques

- Adjustable pipettes
- Arduino programming
- Aseptic technique
- Bacterial culture
- Bacterial transformation
- Building a colorimeter
- Building electrical circuits
- Calculating molarities
- Calorimetry
- cDNA synthesis
- Circuit diagrams
- Current measurement
- Design of experiments
- DNA standards
- Electrolytic cells
- Electronic balances
- Electronic sensors
- Error analysis

- Eukaryotic cell culture
- Excel
- Fluorescence spectrometry
- Force measurement
- Gel electrophoresis
- Genetic transformation
- Graphical analysis
- ImageJ
- Instrument calibration
- Laboratory notebooks
- LabVIEW programming
- Live cell imaging
- Making molar solutions
- Mapping electric field lines
- Measuring liquid volumes
- Measuring solution pH
- Microscopy
- Molecular models

- Nematode culture
- Lenses and Optics
- Paper chromatography
- PCR
- Pigment extraction
- Plotting data
- Polarimetry
- Propagating error
- Absorption spectrometry
- R statistical software
- Ray tracing
- Residuals analysis
- RNA isolation
- Serial dilutions
- Solution conductivity
- Titration
- Vernier scale caliper
- Voltage measurement