QUBES – A virtual synthesis center catalyzing change in undergraduate quantitative biology education

Sam Donovan
University of Pittsburgh

HHMI Constellation Meeting: Advancing science students mastery of quantiative skills
March 8-10, 2017

constellation
HHMI Studios for Science Education

March 8-10, 2017
HHMI Headquarters | Chevy Chase, MD

Advancing Science Students Mastery of Quantitative Skills:
A FACULTY DEVELOPMENT PERSPECTIVE

Co-Chairs:
Paul Overvoorde (Macalester College) | **Muhammad Zaman** (Boston University)

STUDIO OBJECTIVES:

- Provide participants with information about tools or approaches to assessing the **quantitative skills of life science students**.
- **Expand faculty capacity** to advance student mastery of quantitative skills through expert testimony and **peer-engaged discussion** on developing or adapting assessment tools that help gauge student’s quantitative skills.
- **Create action plans** that either makes use of **existing resources** or that lead to a **networked improvement community**, white paper, or grant proposal.

Overview

Brief overview of QUBES with an emphasis on faculty mentoring networks

Project brainstorming activity

If we have time:
discussion of additional lessons learned.

QUBES: A virtual synthesis center

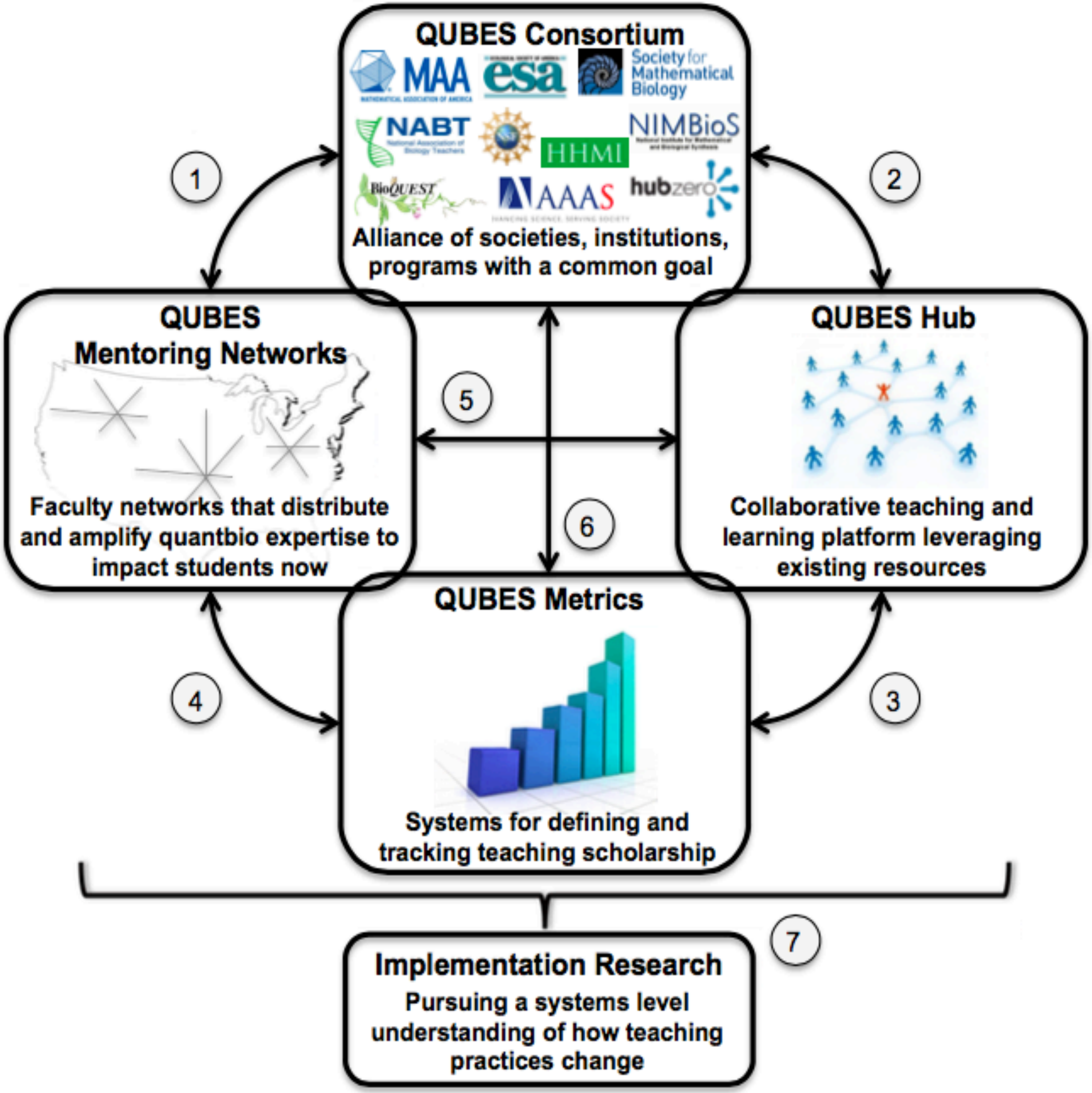
Quantitative
Undergraduate
Biology
Education and
Synthesis

Synthesis Centers:

- Focus on big challenging problems
- Mobilze a community
  - Coordinate activities
  - Support collaboration
  - Provide key resources

QUBES
The Power of Biology × Math × Community

qubeshub.org



QUBES Consortium

Alliance of societies, institutions, programs with a common goal

QUBES Mentoring Networks

Faculty networks that distribute and amplify quantbio expertise to impact students now

QUBES Hub

Collaborative teaching and learning platform leveraging existing resources

QUBES Metrics

Systems for defining and tracking teaching scholarship

Implementation Research

Pursuing a systems level understanding of how teaching practices change

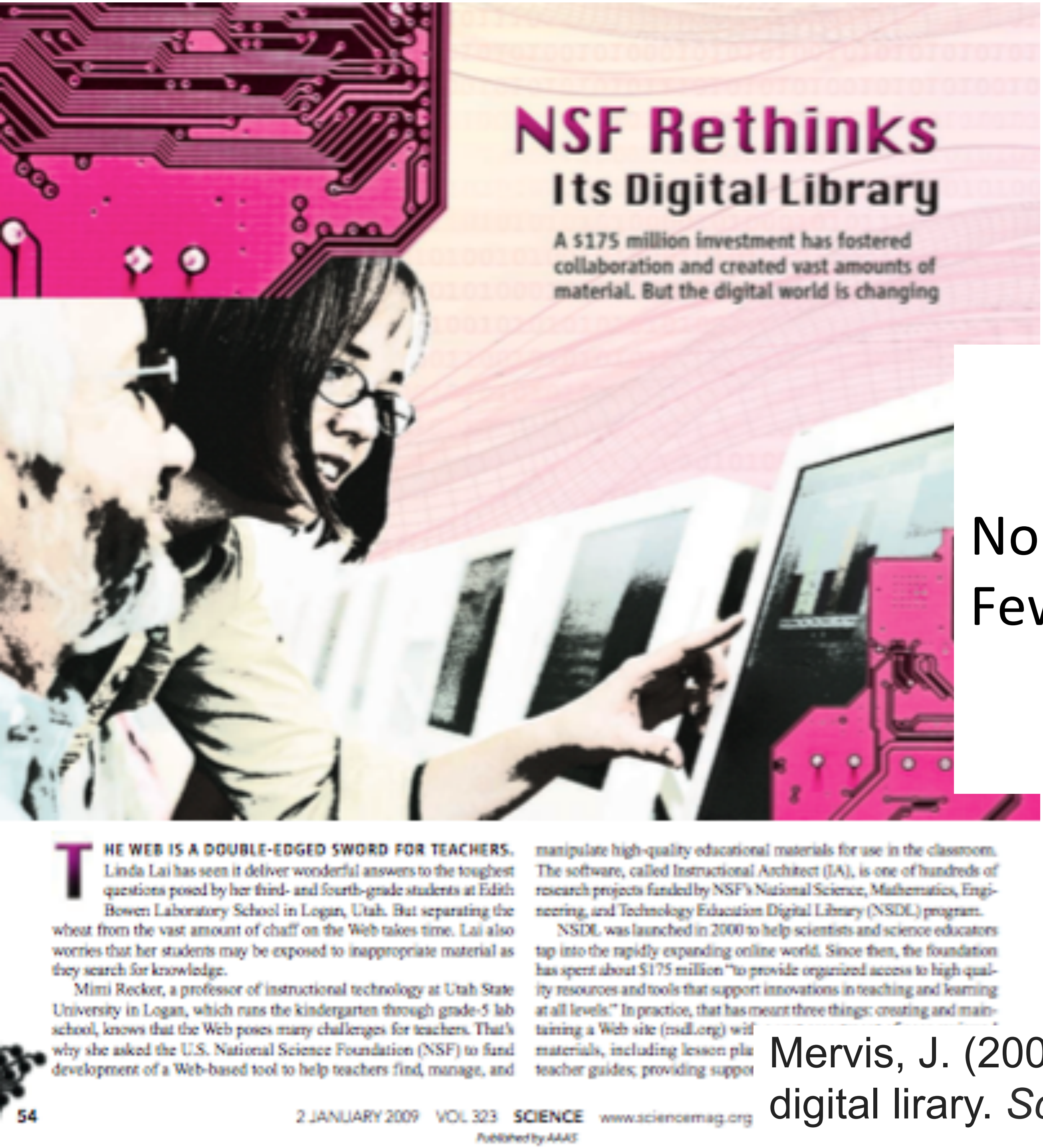
Perceived barrier to getting more quantiative reasoning into biology

Access to high quality learning resources

- NSF has funded a diverse and robust collection of projects
- The barrier is not around finding them

NSDL

THE NATIONAL SCIENCE DIGITAL LIBRARY



NSF Rethinks
Its Digital Library

A $175 million investment has fostered collaboration and created vast amounts of material. But the digital world is changing

THE WEB IS A DOUBLE-EDGED SWORD FOR TEACHERS. Linda Lai has seen it deliver wonderful answers to the toughest questions posed by her third- and fourth-grade students at Edith Bowen Laboratory School in Logan, Utah. But separating the wheat from the vast amount of chaff on the Web takes time. Lai also worries that her students may be exposed to inappropriate material as they search for knowledge.

Mimi Recker, a professor of instructional technology at Utah State University in Logan, which runs the kindergarten through grade-5 lab school, knows that the Web poses many challenges for teachers. That's why she asked the U.S. National Science Foundation (NSF) to fund development of a Web-based tool to help teachers find, manage, and manipulate high-quality educational materials for use in the classroom. The software, called Instructional Architect (IA), is one of hundreds of research projects funded by NSF's National Science, Mathematics, Engineering, and Technology Education Digital Library (NSDL) program.

NSDL was launched in 2000 to help scientists and science educators tap into the rapidly expanding online world. Since then, the foundation has spent about $175 million "to provide organized access to high-quality resources and tools that support innovations in teaching and learning at all levels." In practice, that has meant three things: creating and maintaining a Web site (nsdl.org) wit

materials, including lesson pla

teacher guides; providing suppo

54

2 JANUARY 2009 VOL 323 SCIENCE www.sciencemag.org

Published by AAAS

Problems

No one was using it.
Few had heard of it.

Thanks Google!

Mervis, J. (2009). NSF rethinks its digital lirary. *Science*, *323*(5910), 54-58.

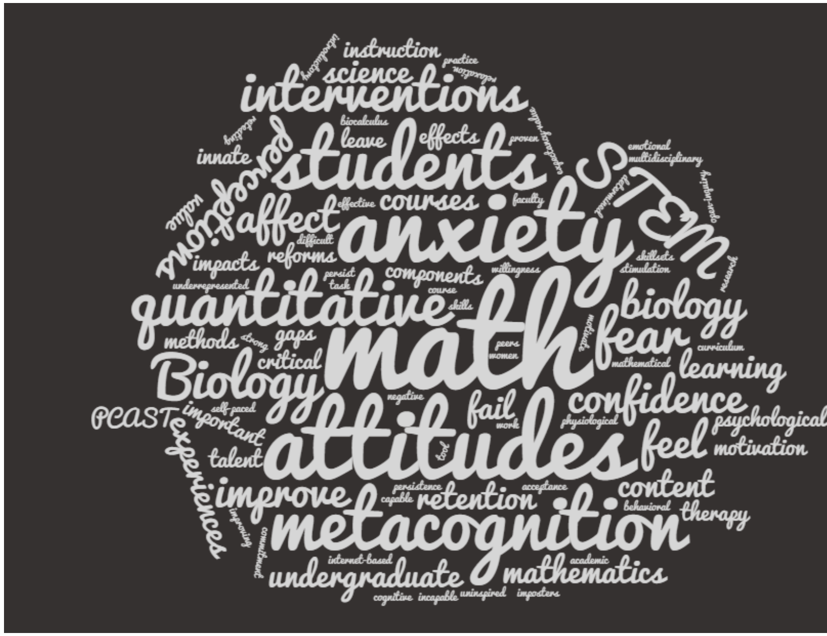
Real barrier to getting more quantiative reasoning into biology

Faculty need support to:

- Develop their own skills and confidence, particularly around pedagogical content knowledge.
- Customize resources for use in their own speicalized teaching setting, with their particular student audience.

Supporting professional development around quantitative biology is particularly tricky

- Faculty barriers
  - Feel unprepared to teach quantitative reasoning
  - Overwhelmed by initial effort to learn new quantitative skills
- Student barriers
  - Math anxiety
- Evolving Science
  - Big data, new tools, …
- Understanding workforce needs



QUBES is not …

a static repository of teaching and learning resources.

QUBES is…

a collaborative workspace that supports teaching scholarship.

FACULTY MENTORING NETWORKS

Want to use real data in your classroom?

DRYAD LAB

Join us at the Ecological Society of America annual meeting to kick-off an online network featuring hands-on, data-driven teaching modules!

Motivating quantitative biology with open-inquiry image analysis

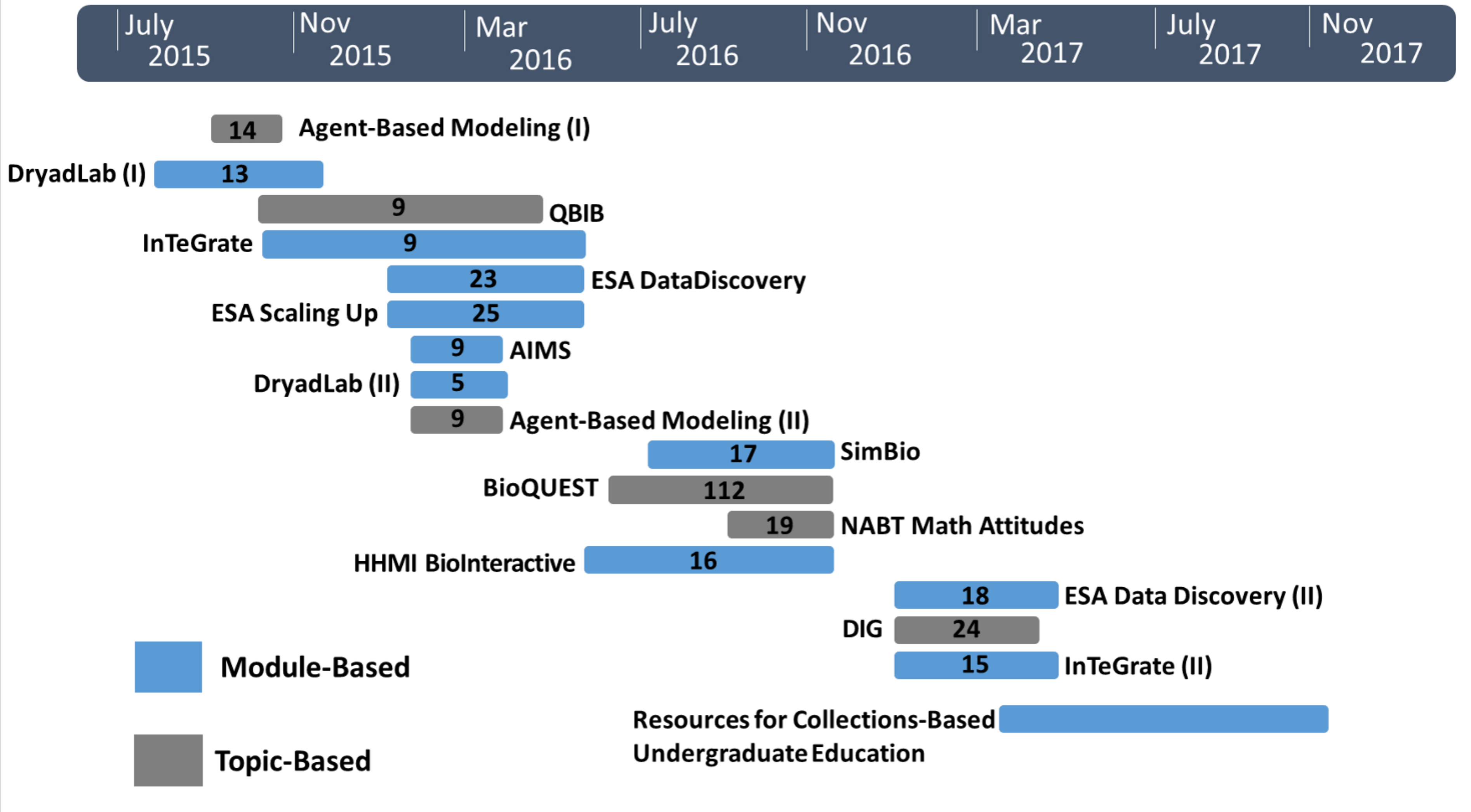
ImageJ
Image Processing & Analysis in Java

Learn the basics of image analysis, teach fascinating biology research stories, and get students motivated to do math and stats!

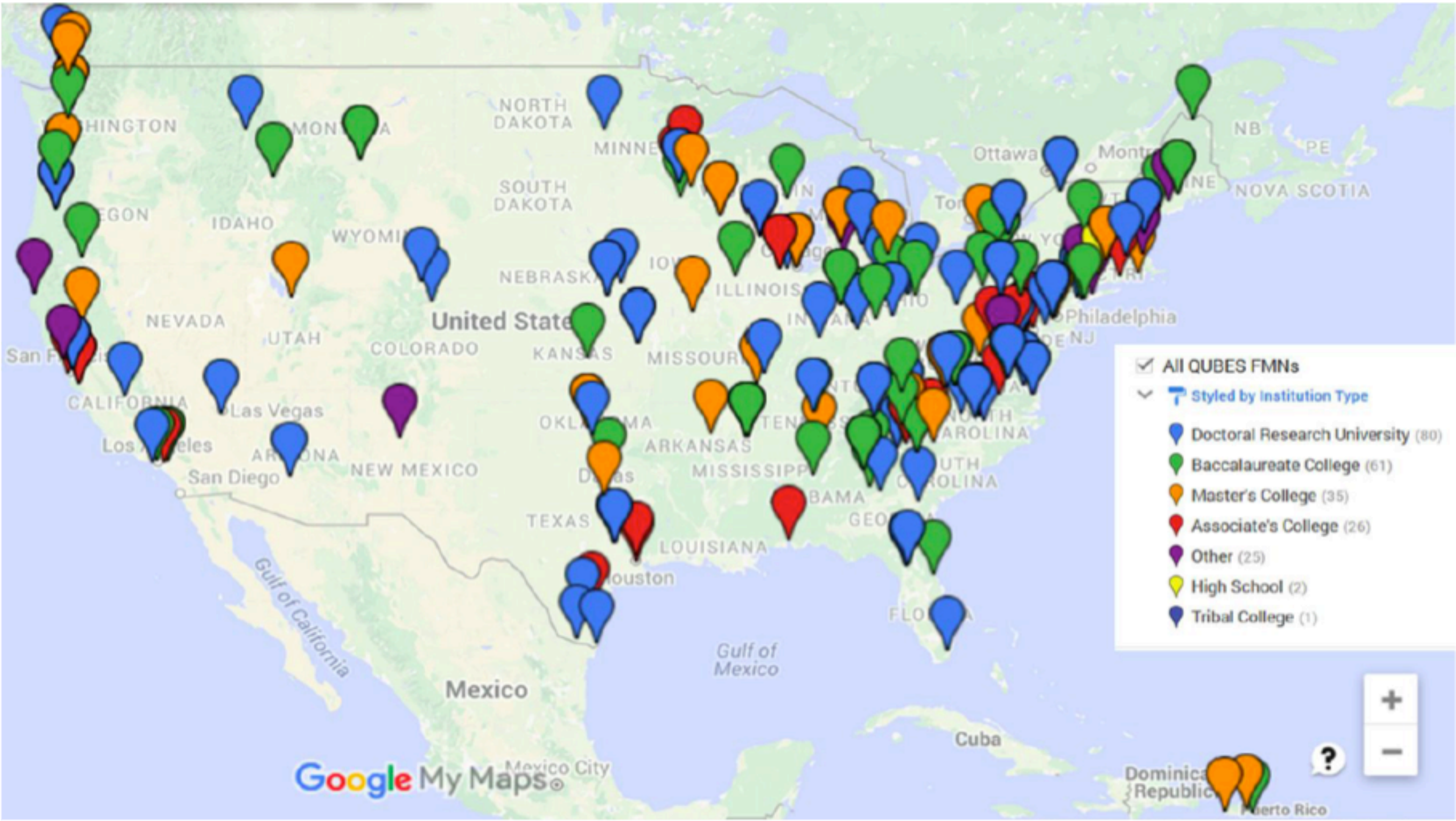
Teaching quantitative biology with agent-based models and NetLogo

Learn the basics of agent/individual-based modeling, Netlogo programming, and how to get your students using models!

Past FMN Summary



FMN Participation



Reimagining Professional Development

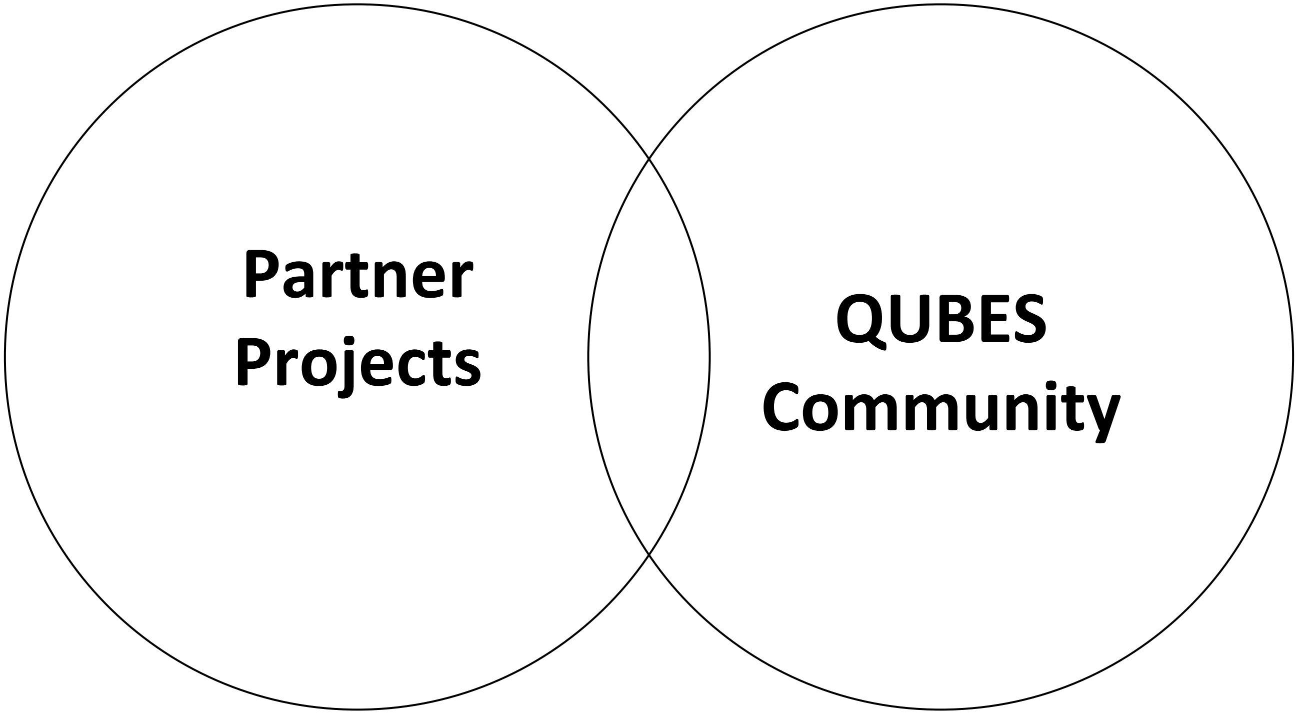
Move toward a model that promotes faculty engaging in teaching scholarship.

Move much of the activity online.

Emphasize faculty learning communities with access to disciplinary expertise.

Partner with existing projects that have resources and needs.

Mutalistic Relationships



Partner Projects

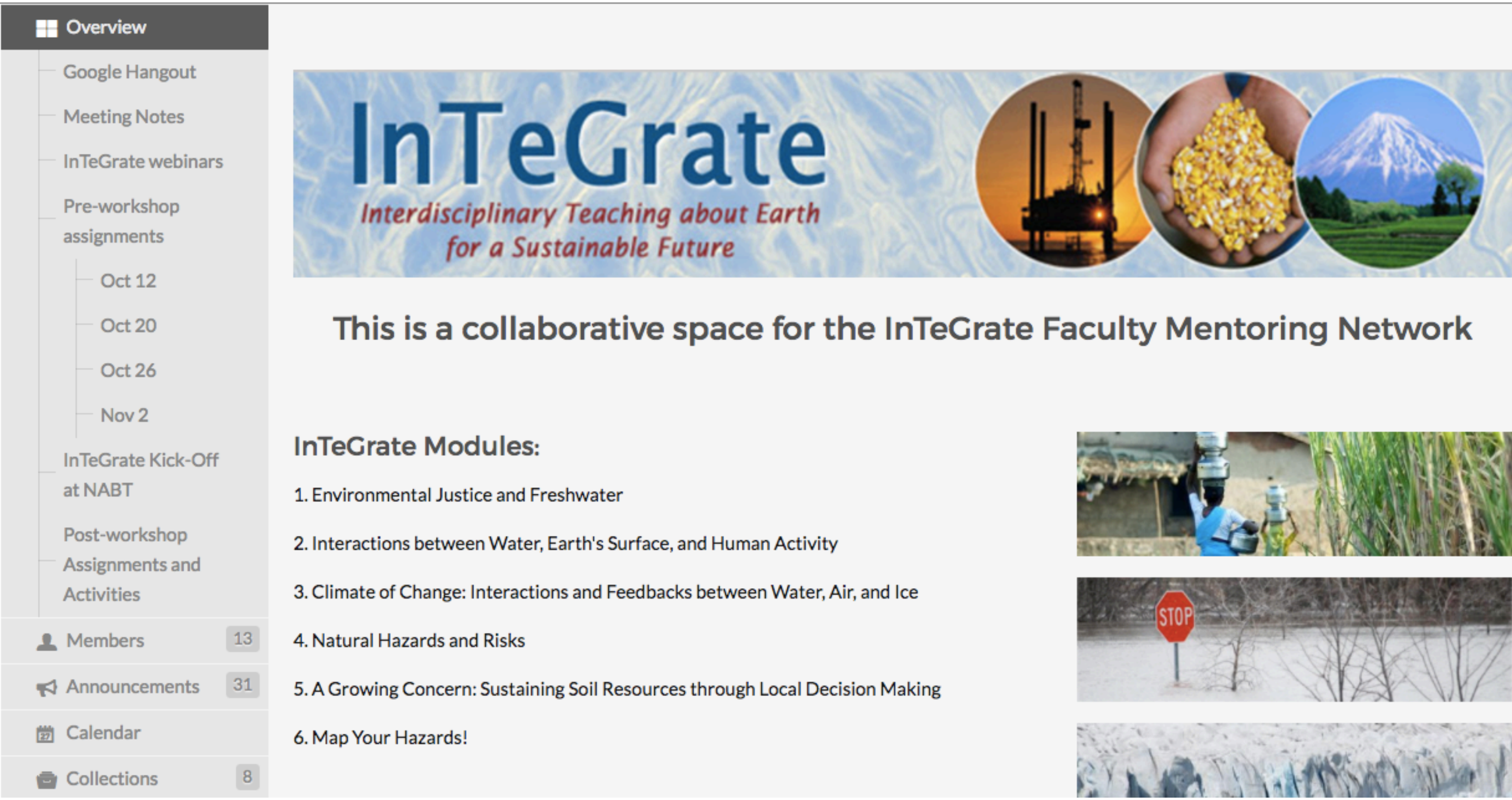
QUBES Community

FMN Design

The focus is on supporting faculty participation in a scholarly teaching project

- identifying a need or qustion to address
- reviewing a variety of existing resources
- learning new tools and techniques
- adopting and adapting materials for your teaching setting
- classroom implementation
- reflection, review and write-up

Social engineering in an online collaborative environment

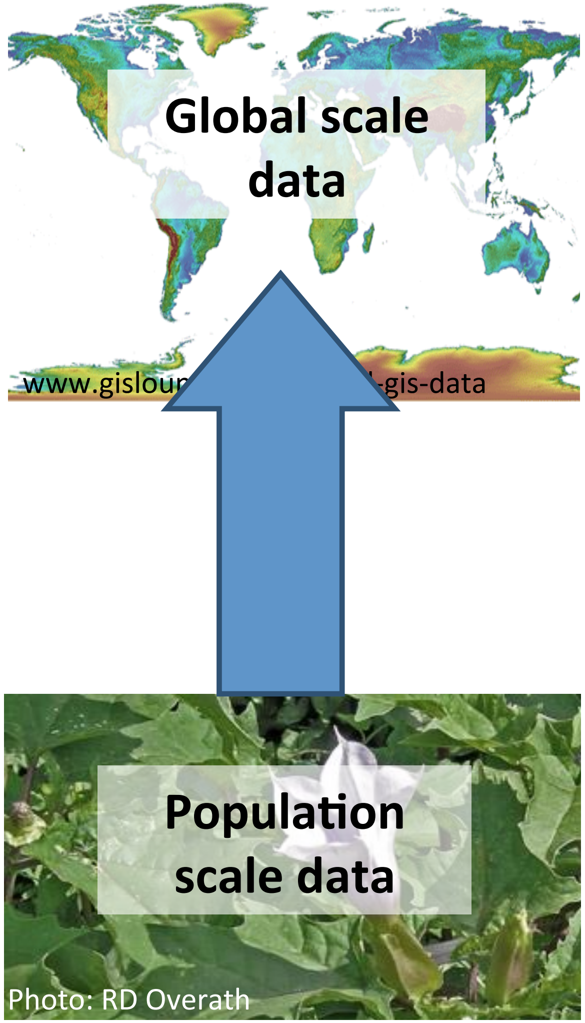


This is a collaborative space for the InTeGrate Faculty Mentoring Network

InTeGrate Modules:

1. Environmental Justice and Freshwater
2. Interactions between Water, Earth's Surface, and Human Activity
3. Climate of Change: Interactions and Feedbacks between Water, Air, and Ice
4. Natural Hazards and Risks
5. A Growing Concern: Sustaining Soil Resources through Local Decision Making
6. Map Your Hazards!

ESA Faculty Mentoring Networks



Global scale data

www.gislour -gis-data

Population scale data

Photo: RD Overath

Global temperature change
(Taub & Graham 2011)

Lake ice and global change
(Bohanan et al. 2005)

Avian local species richness
(Langen 2012)

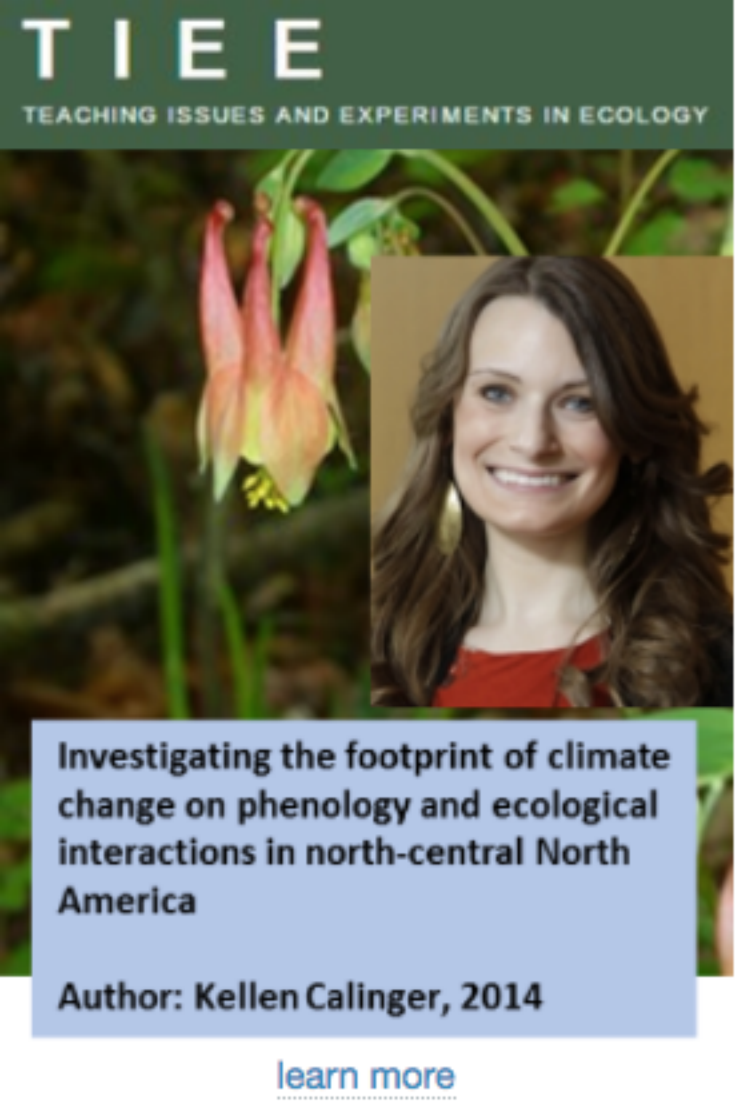
Climate change effects on phenology
(Calinger 2014)

Population dynamics of bald eagles
(Beckstead et al. 2011)

Cemetery demography
(Lanza 2012)

PVA of a local plant population
(Charney & Record 2013)

Modules available at: http://tiee.esa.org



T I E E

TEACHING ISSUES AND EXPERIMENTS IN ECOLOGY

Investigating the footprint of climate change on phenology and ecological interactions in north-central North America

Author: Kellen Calinger, 2014

learn more

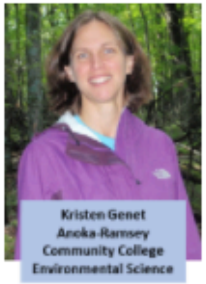
Original published TIEE Module

12 derivative versions shared by FMN participants

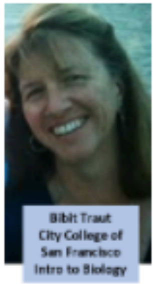
Implemented in Lecture

Marja Bakermans
Worcester Polytechnic Institute
Intro to Biology

Meg Steinweg
Roanoke College
Intro to Biology


Kristen Genet
Anoka-Ramsey Community College
Environmental Science

Implemented in Lab & Lecture


Bibit Traut
City College of San Francisco
Intro to Biology

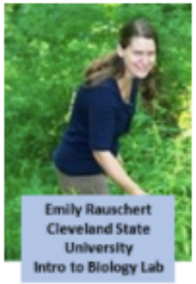
Deb Overath
Del Mar College
Intro to Biology II

Patricia Saunders
Ashland University
Non-majors Biology

James Vance
University of Virginia's College at Wise
Biological Diversity Lab

Implemented in Lab

Josephine Rodriguez
University of Virginia's College at Wise
Intro to Biology Lab


Emily Rauschert
Cleveland State University
Intro to Biology Lab

Kerry Byrne
Oregon Institute of Technology
Intro to Biology Lab II

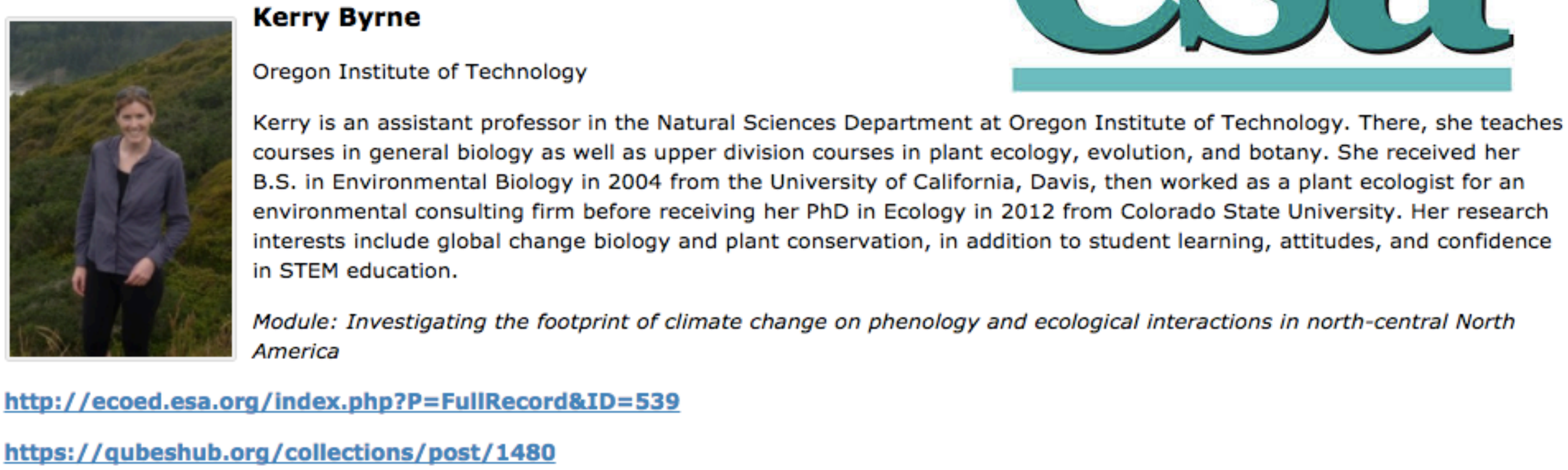
Carrie Kissman
St. Norbert College
Intro to Biology Lab II

Joshua Mays
Gaston College
Biology Lab

Professional recognition and tracking scholarly Impact

ECOLOGICAL SOCIETY OF AMERICA

esa



Kerry Byrne

Oregon Institute of Technology

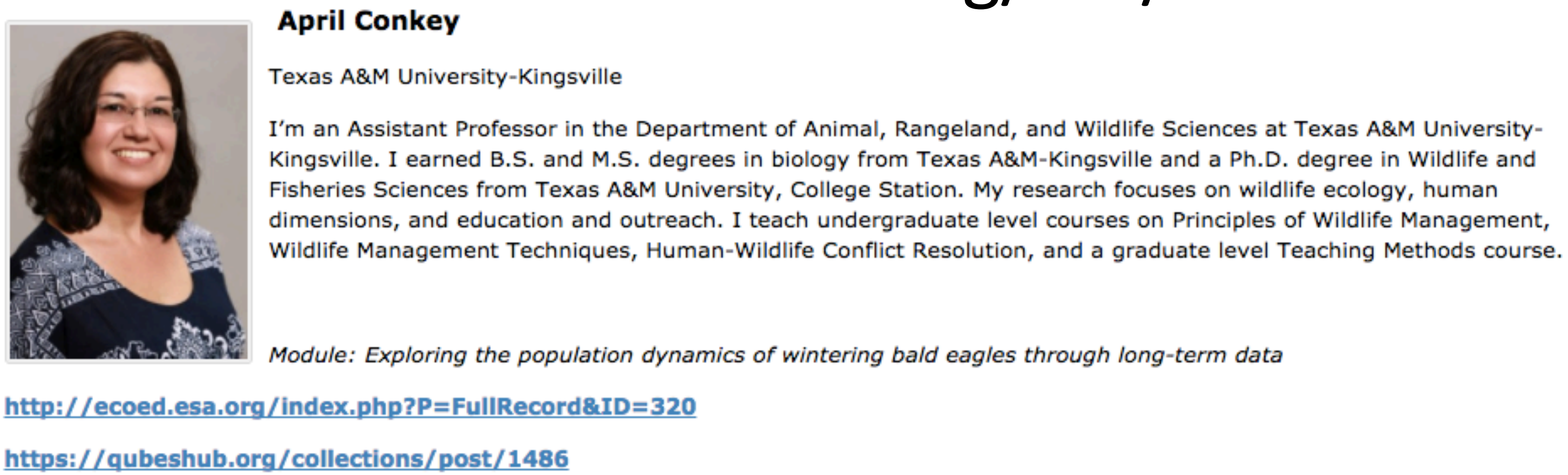
Kerry is an assistant professor in the Natural Sciences Department at Oregon Institute of Technology. There, she teaches courses in general biology as well as upper division courses in plant ecology, evolution, and botany. She received her B.S. in Environmental Biology in 2004 from the University of California, Davis, then worked as a plant ecologist for an environmental consulting firm before receiving her PhD in Ecology in 2012 from Colorado State University. Her research interests include global change biology and plant conservation, in addition to student learning, attitudes, and confidence in STEM education.

Module: Investigating the footprint of climate change on phenology and ecological interactions in north-central North America

http://ecoed.esa.org/index.php?P=FullRecord&ID=539

https://qubeshub.org/collections/post/1480

esa.org/fed/2016scholars/



April Conkey

Texas A&M University-Kingsville

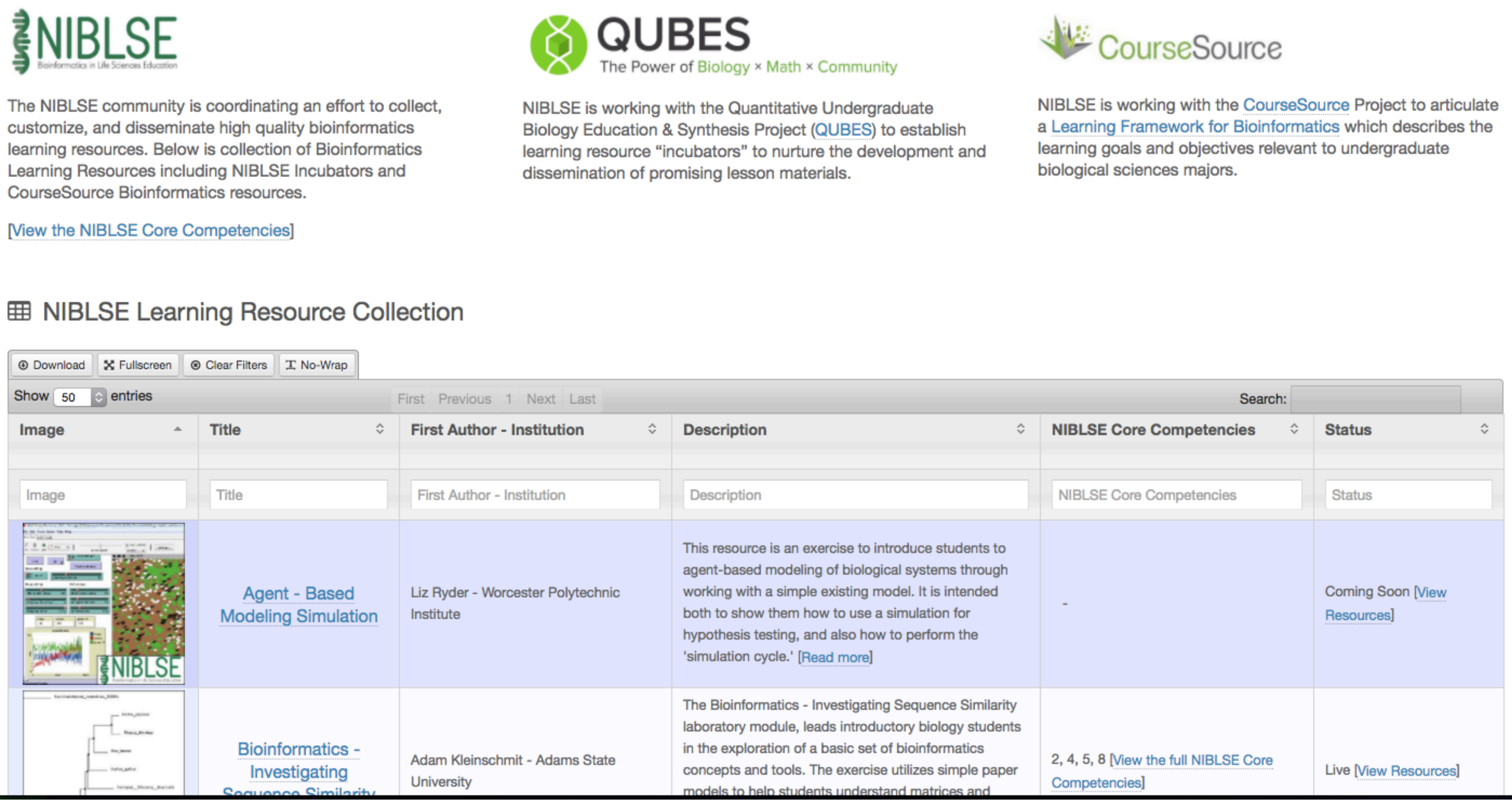
I'm an Assistant Professor in the Department of Animal, Rangeland, and Wildlife Sciences at Texas A&M University-Kingsville. I earned B.S. and M.S. degrees in biology from Texas A&M-Kingsville and a Ph.D. degree in Wildlife and Fisheries Sciences from Texas A&M University, College Station. My research focuses on wildlife ecology, human dimensions, and education and outreach. I teach undergraduate level courses on Principles of Wildlife Management, Wildlife Management Techniques, Human-Wildlife Conflict Resolution, and a graduate level Teaching Methods course.

Module: Exploring the population dynamics of wintering bald eagles through long-term data

http://ecoed.esa.org/index.php?P=FullRecord&ID=320

https://qubeshub.org/collections/post/1486

Incubating learning resources



NIBLSE
Bioinformatics in Life Sciences Education

The NIBLSE community is coordinating an effort to collect, customize, and disseminate high quality bioinformatics learning resources. Below is collection of Bioinformatics Learning Resources including NIBLSE Incubators and CourseSource Bioinformatics resources.

[View the NIBLSE Core Competencies]

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NIBLSE is working with the Quantitative Undergraduate Biology Education & Synthesis Project (QUBES) to establish learning resource "incubators" to nurture the development and dissemination of promising lesson materials.

CourseSource

NIBLSE is working with the CourseSource Project to articulate a Learning Framework for Bioinformatics which describes the learning goals and objectives relevant to undergraduate biological sciences majors.

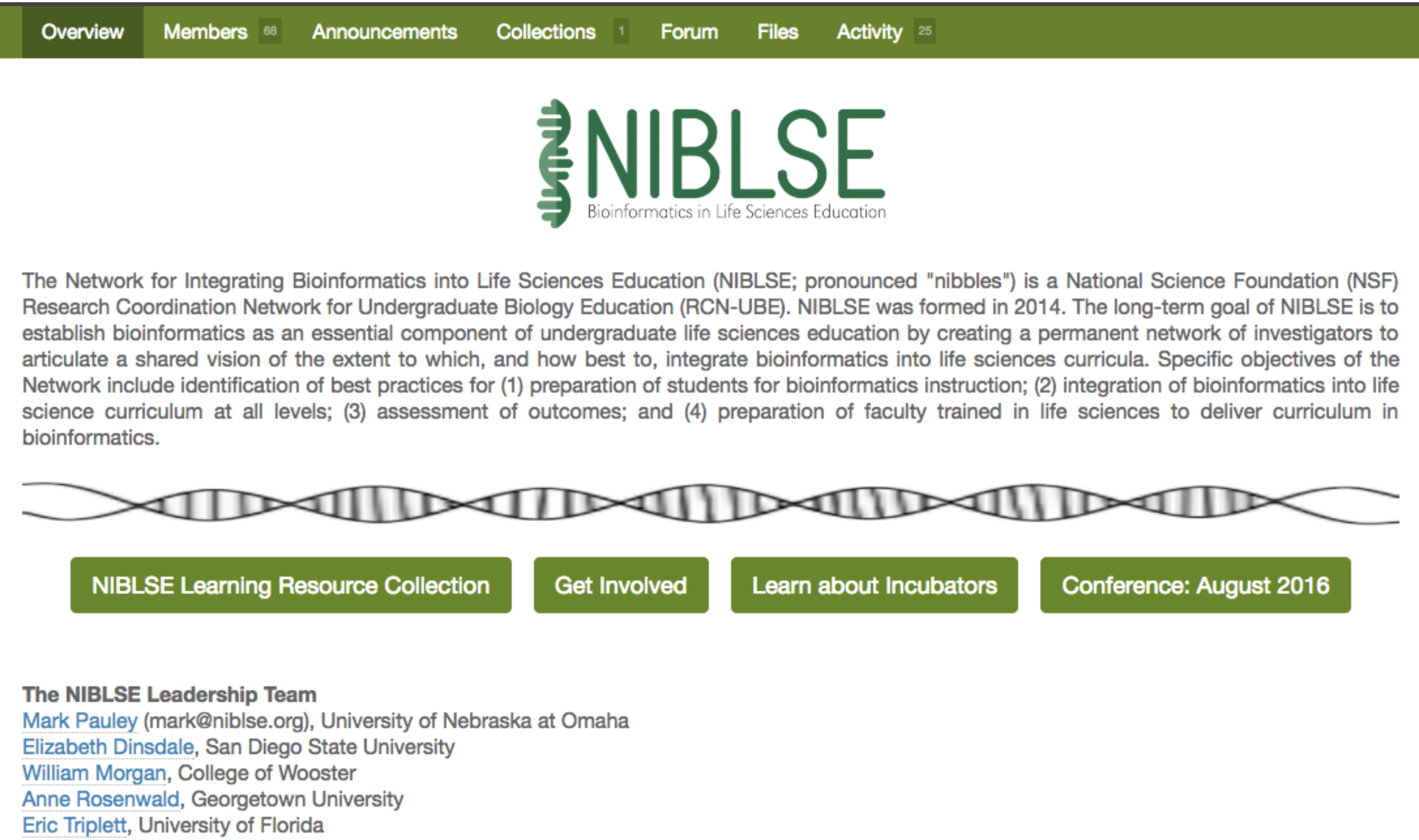
NIBLSE Learning Resource Collection

Download Fullscreen Clear Filters No-Wrap

Show 50 entries First Previous 1 Next Last Search:

Image	Title	First Author - Institution	Description	NIBLSE Core Competencies	Status
Image	Title	First Author - Institution	Description	NIBLSE Core Competencies	Status
	Agent - Based Modeling Simulation	Liz Ryder - Worcester Polytechnic Institute	This resource is an exercise to introduce students to agent-based modeling of biological systems through working with a simple existing model. It is intended both to show them how to use a simulation for hypothesis testing, and also how to perform the 'simulation cycle.' [Read more]	-	Coming Soon [View Resources]
	Bioinformatics - Investigating Sequence Similarity	Adam Kleinschmit - Adams State University	The Bioinformatics - Investigating Sequence Similarity laboratory module, leads introductory biology students in the exploration of a basic set of bioinformatics concepts and tools. The exercise utilizes simple paper models to help students understand matrices and	2, 4, 5, 8 [View the full NIBLSE Core Competencies]	Live [View Resources]

Turn-key web 2.0 infrastructure



The Network for Integrating Bioinformatics into Life Sciences Education (NIBLSE; pronounced "nibbles") is a National Science Foundation (NSF) Research Coordination Network for Undergraduate Biology Education (RCN-UBE). NIBLSE was formed in 2014. The long-term goal of NIBLSE is to establish bioinformatics as an essential component of undergraduate life sciences education by creating a permanent network of investigators to articulate a shared vision of the extent to which, and how best to, integrate bioinformatics into life sciences curricula. Specific objectives of the Network include identification of best practices for (1) preparation of students for bioinformatics instruction; (2) integration of bioinformatics into life science curriculum at all levels; (3) assessment of outcomes; and (4) preparation of faculty trained in life sciences to deliver curriculum in bioinformatics.

The NIBLSE Leadership Team
Mark Pauley (mark@niblse.org), University of Nebraska at Omaha
Elizabeth Dinsdale, San Diego State University
William Morgan, College of Wooster
Anne Rosenwald, Georgetown University
Eric Triplett, University of Florida

QUBES
The Power of Biology × Math × Community

constellation
HHMI Studios for Science Education

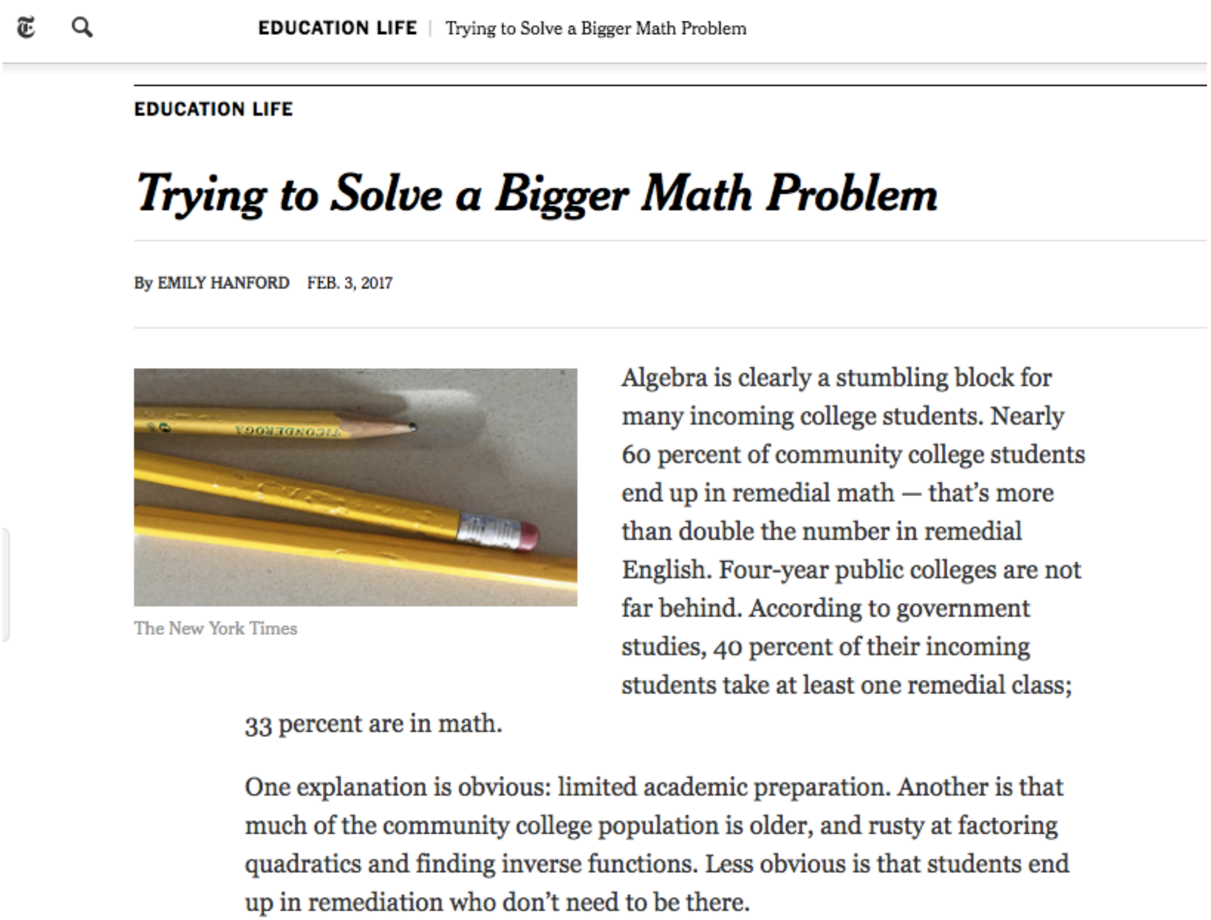
Initial brainstorming on your project plan

One of the goals of this meeting is to help the participants advance their own agendas with regard to improving undergraduate quantitative science education. This is an opportunity to articulate your agenda so that you enter the remainder of the meeting with a stronger sense of what you are hoping to take away from these interactions.

Briefly describe the goals of a project you are trying to advance.

Describe why you think this project is innovative or valuable.

List a few places where you think this project would benefit from outside expertise.



EDUCATION LIFE

Trying to Solve a Bigger Math Problem

By EMILY HANFORD FEB. 3, 2017

The New York Times

Algebra is clearly a stumbling block for many incoming college students. Nearly 60 percent of community college students end up in remedial math — that's more than double the number in remedial English. Four-year public colleges are not far behind. According to government studies, 40 percent of their incoming students take at least one remedial class; 33 percent are in math.

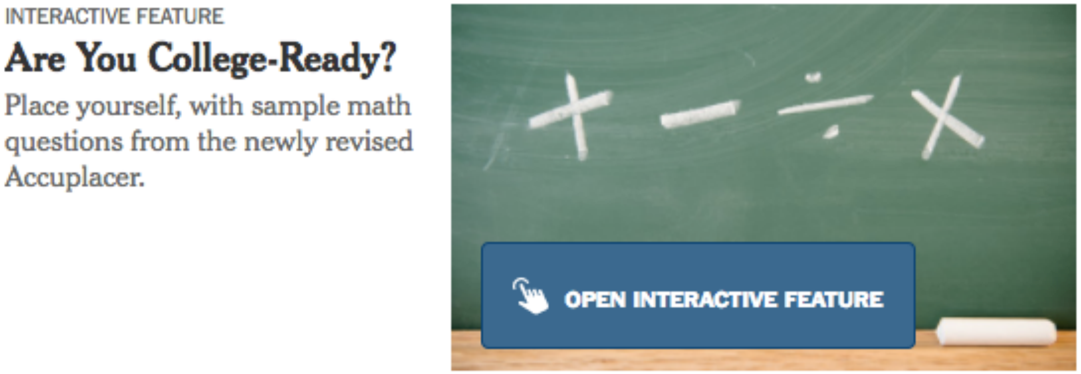
One explanation is obvious: limited academic preparation. Another is that much of the community college population is older, and rusty at factoring quadratics and finding inverse functions. Less obvious is that students end up in remediation who don't need to be there.

February 3, 2017
New York Times

Remedial Coursetaking at U.S. Public 2- and 4-Year Institutions: Scope, Experiences, and Outcomes

NCES 2016-405

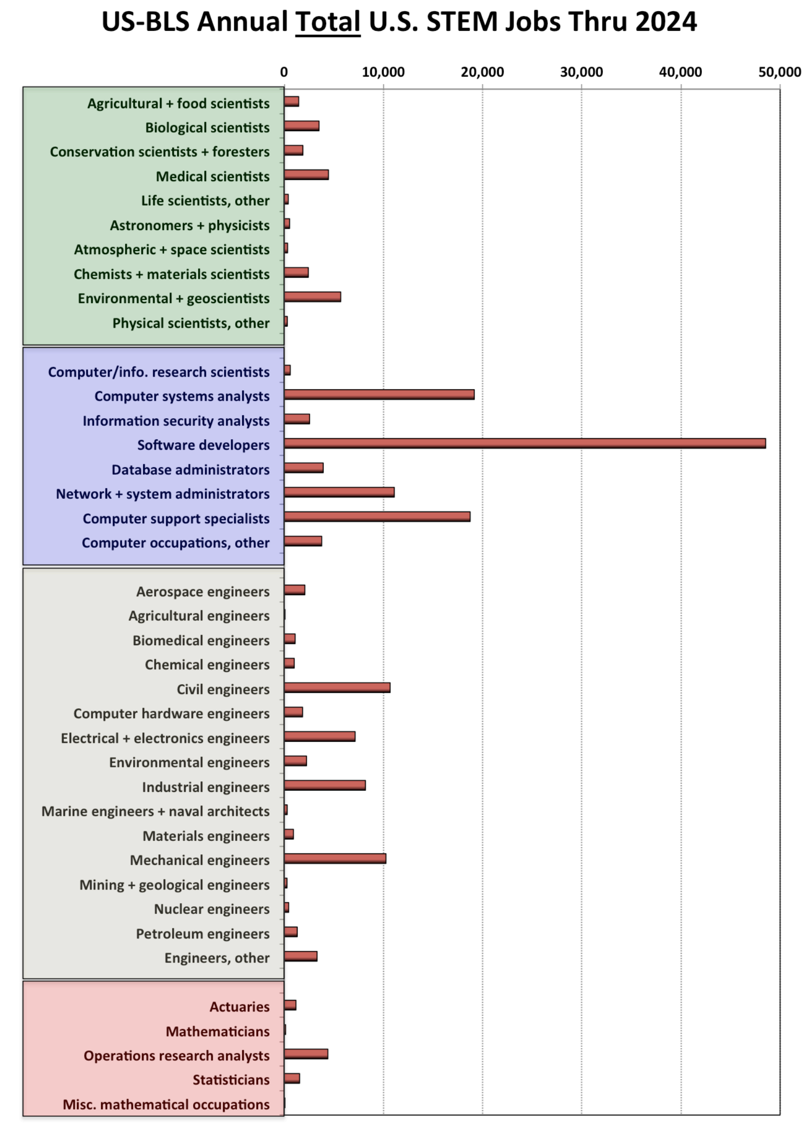
Many students who place into remidial math are considered "strongly prepared" and are more likely to graduate if they skip remedial courses.



INTERACTIVE FEATURE

Are You College-Ready?

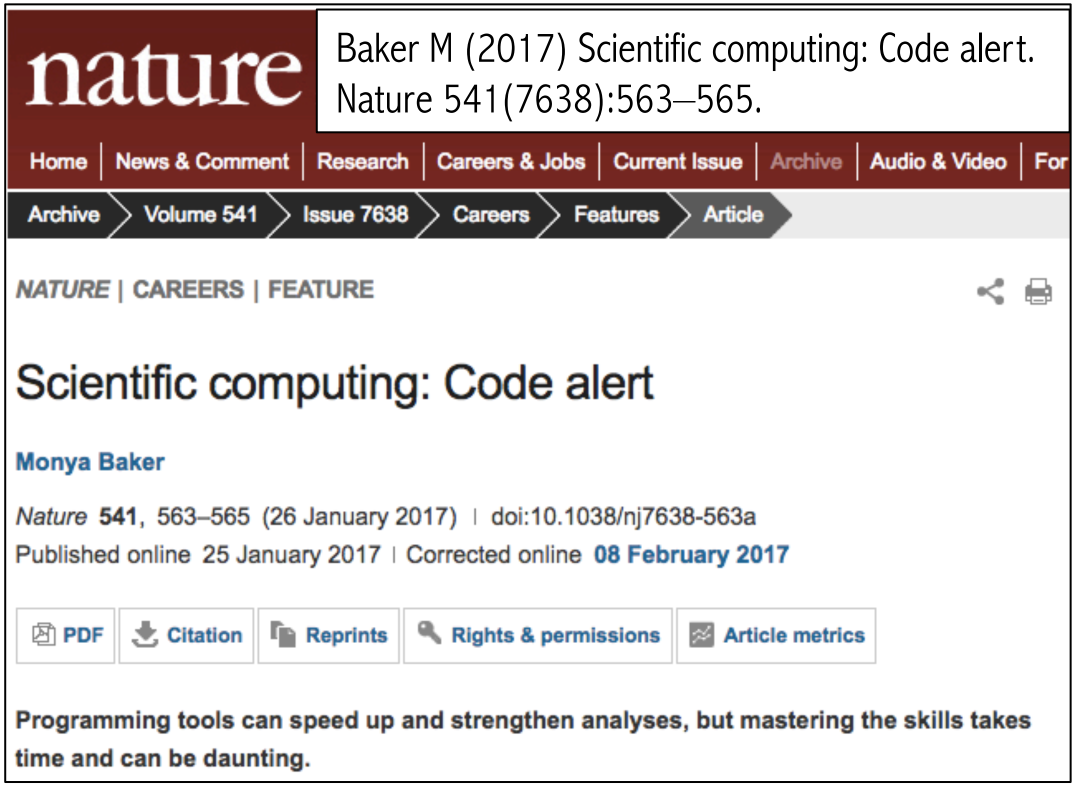
Place yourself, with sample math questions from the newly revised Accuplacer.



Data Source: US-BLS Employment Projections (*www.bls.gov/emp/ep_table_102.htm*)

Employment predictions from the United States Bureau of Labor Statistics indicate that between now and 2024, 75% of new STEM jobs will involve computation.

https://www.bls.gov/emp/



Baker M (2017) Scientific computing: Code alert. Nature 541(7638):563–565.

NATURE | CAREERS | FEATURE

Scientific computing: Code alert

Monya Baker

Nature **541**, 563–565 (26 January 2017) | doi:10.1038/nj7638-563a
Published online 25 January 2017 | Corrected online **08 February 2017**

Programming tools can speed up and strengthen analyses, but mastering the skills takes time and can be daunting.

"… researchers need to learn how to code — to formulate commands in a programming language that tell a computer what to do. Researchers who know just a bit of code gain access to a wealth of software packages that automate repetitive tasks and increase options for compiling, analysing, sharing and presenting data."

Complete How-to Guide

DESIGNING EDUCATIONAL INNOVATIONS FOR SUSTAINED ADOPTION

A How-to Guide for Education Developers Who Want to Increase the Impact of Their Work

Increase the Impact

Charles Henderson
Western Michigan University

Efforts to improve undergraduate STEM teaching methods have generated many great ideas and materials, but few have caught on and achieved widespread use. Funding agencies are noticing the lack of propagation in funded projects and are calling for change.

Mistake No. 1: Concentrate on dissemination by telling.
Mistake No. 2: Ignore the literature on change and adoption of innovations.
Mistake No. 3: Focus on product development and ignore multiple factors that will hinder adoption.
Mistake No. 4: Wait until near the end of the project to begin work on promoting adoption.

http://www.increasetheimpact.com/

Summer faculty institute on quantiative reasoning in biology

https://qubeshub.org/groups/summer2017

Making meaning through modeling
"Problem solving in biology"
BioQUEST CURRICULUM CONSORTIUM
QUBES
Biology × Math × Community
qubeshub.org
ScienceCaseNet
MICHIGAN STATE UNIVERSITY

July 23-28, 2017
Michigan State University, East Lansing

We all use models in the the classroom - visual, physical, mathematical, and symbolic representations abound in the curriculum. But are we making the best use of them as teaching tools? Scientists use models to explore new ideas, delve more deeply into complex phenomena, predict outcomes, explain events, structures and processes, and push past boundaries into the unknown (Odenbaugh, 2005). In a similar manner, students actively engaging with models use scientific concepts to explore complex systems and develop valuable skills in critical thinking, collaboration and communication. Models are an important component of science, however all models are only representations of reality. Effective and appropriate use of a model requires acknowledgement of the model's assumptions and limitations. Using models to teach requires making students aware of both what a model can tell us and what it cannot tell us.

https://qubeshub.org/groups/summer2016

QUBES is a team effort

The QUBES team

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QUBES partners, participants, & advisory board

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