Fostering and Sustaining Interdisciplinary Faculty Communities Around Undergraduate Teaching: Insights from the QUBES Project

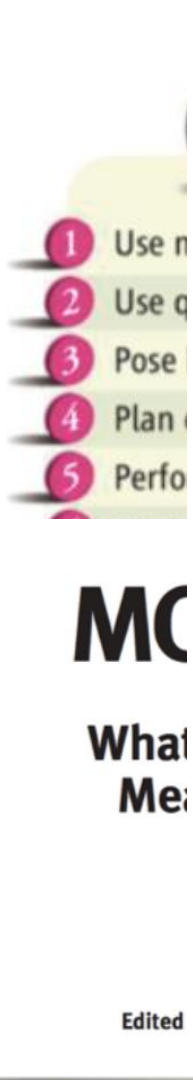
Part of the SIAM Ed Communities of Practice for Math Modeling Education symposium.

Sam Donovan

University of Pittsburgh

Are our current reform efforts just rearranging the deck chairs on the Titanic?


HHM
Scientific
Report of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GAIMME
GUIDELINES FOR ASSESSMENT & INSTRUCTION
IN MATHEMATICAL MODELING EDUCATION
CONSORTIUM FOR MATHEMATICS AND
ITS APPLICATIONS (COMAP)
SOCIETY FOR INDUSTRIAL AND
APPLIED MATHEMATICS (SIAM)

Explosive growth of information – Quantitative

Expanding role of technology – Computational

Changes in the nature of the discipline - Interdisciplinary

Bridging school and the real world – Connected to students

Outline for the talk

What is QUBES?

What are the core pedagogical commitments?

How and why an emphasis on community?

Outline for the talk

What is QUBES?

What are the core pedagogical commitments?

How and why an emphasis on community?

QUBES

The Power of Biology × Math × Community

As an scientific gateway for eductaion we:

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

S. Donovan, C. Diaz Eaton, S. T. Gower, K. P. Jenkins, M. D. LaMar, DB Poli, R. Sheehy, and J. M. Wojdak, *QUBES: a community focused on supporting teaching and learning in quantitative biology*, Letters in Biomathematics 2 (1) (2015)

Sam Donovan (PI – DUE-1446269; and Director of Collaborative Projects

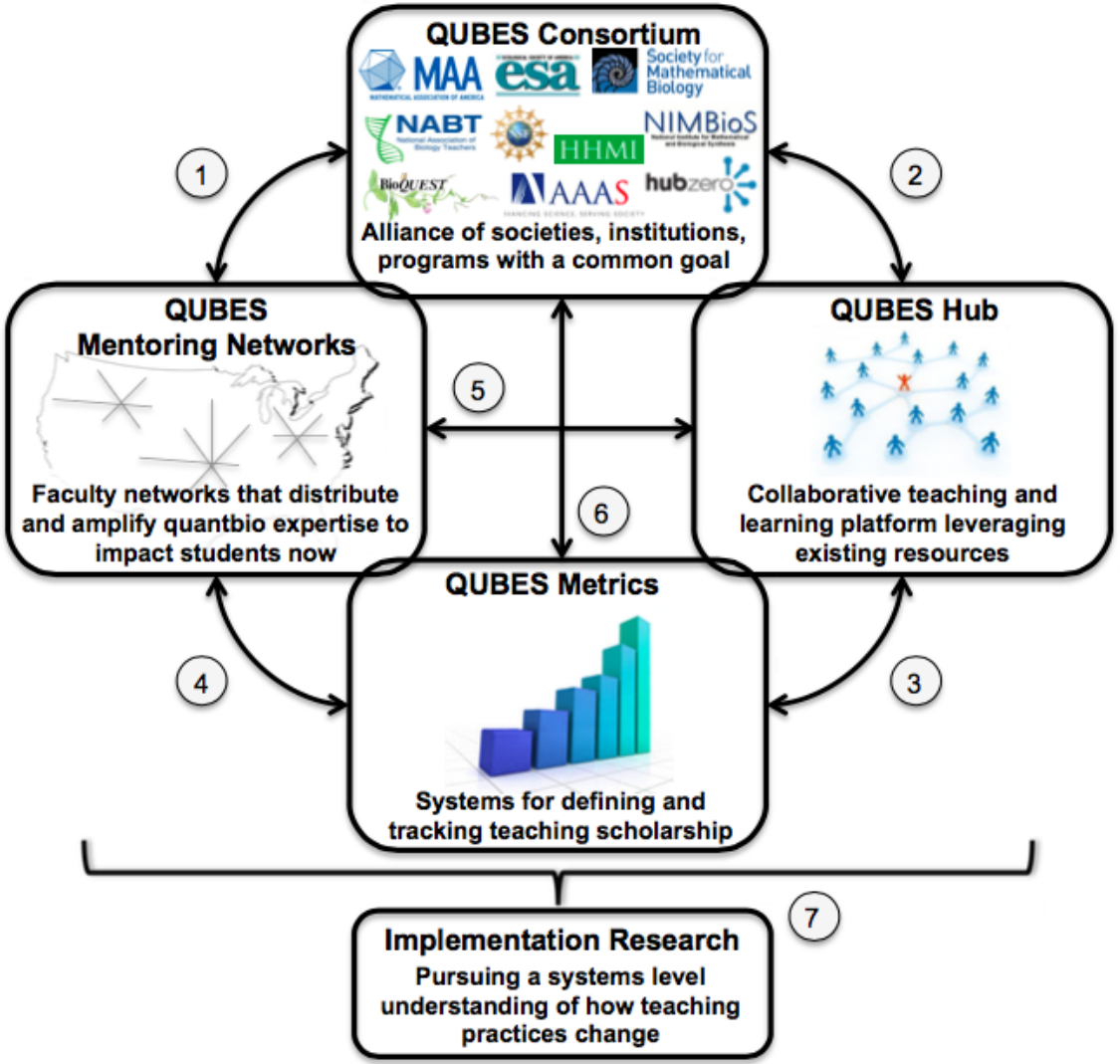
DUE-1446258 (PI – LaMar, College of William and Mary),

DUE-1446284 (PI – Gower, University of Wisconsin-Madison).

+ many other key collaborators

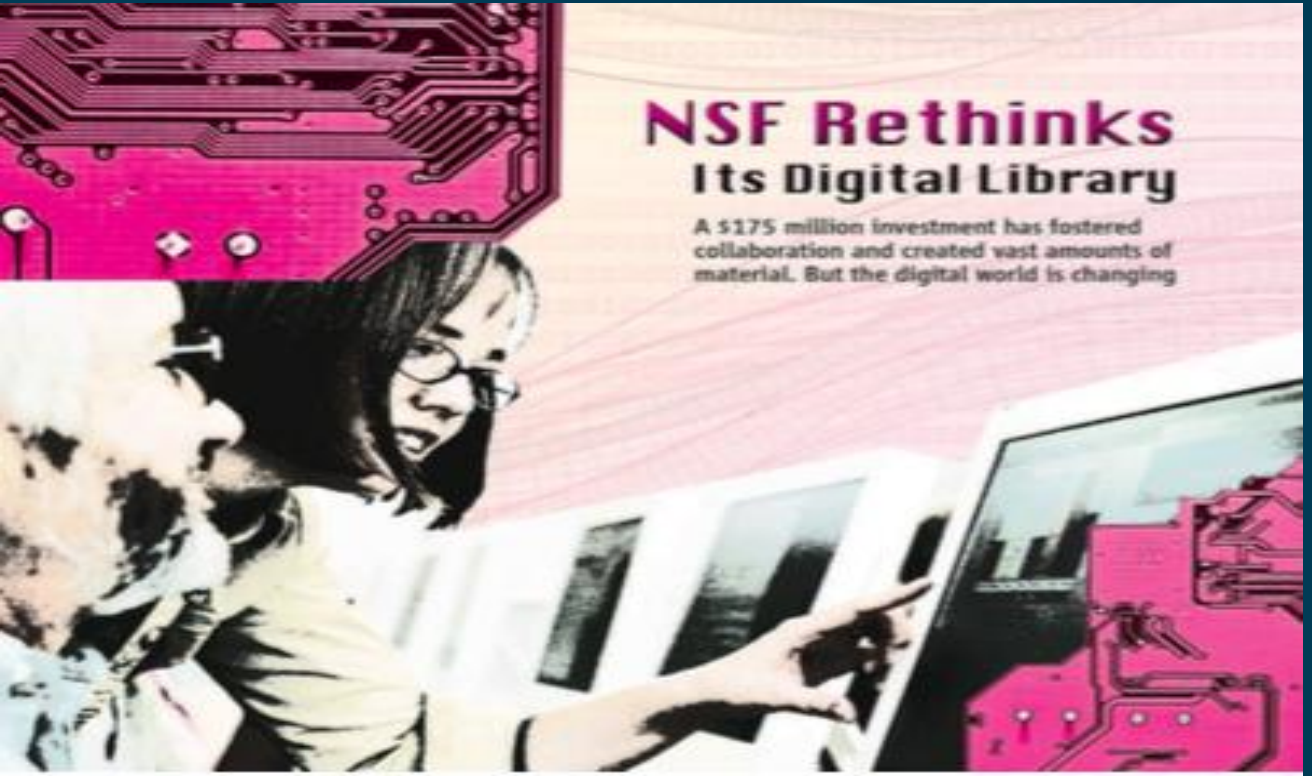
Collaborative Research: BIO IUSE Ideas Lab: Supporting Faculty in Quantitative Undergraduate Biology Education and Synthesis (QUBES).

qubeshub.org/



The “Last Mile” Problem

Access to quality content is generally perceived as the key barrier to getting more quantitative reasoning into biology



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

Published by AAAS

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

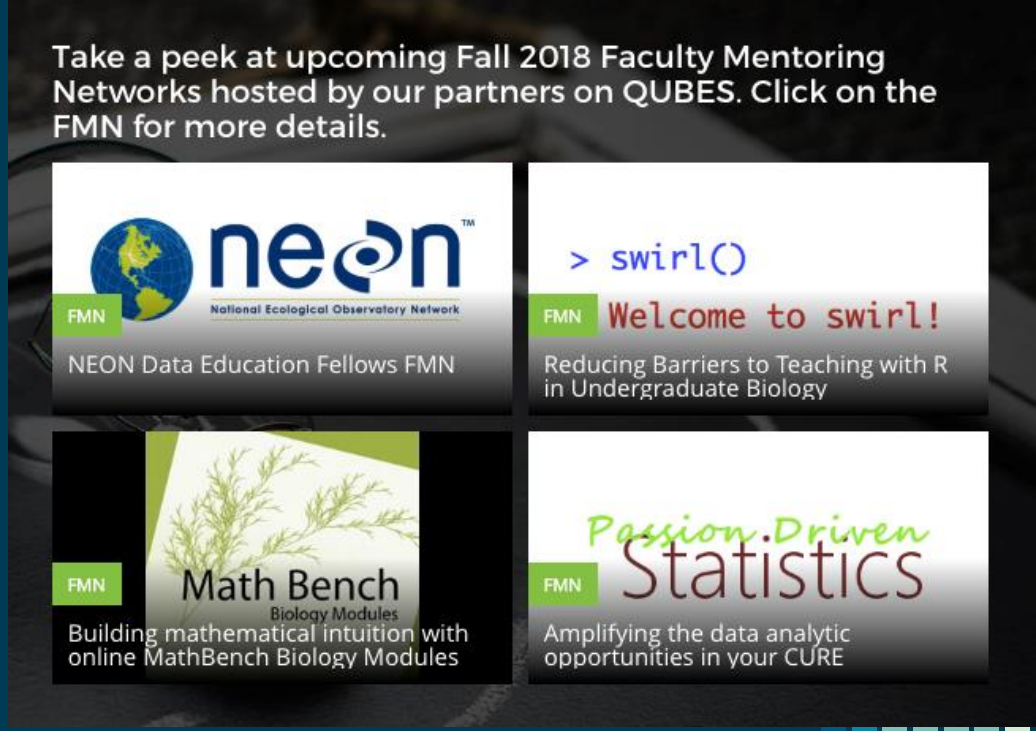
The real barrier to getting more quantitative reasoning into biology

Faculty need support to:

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

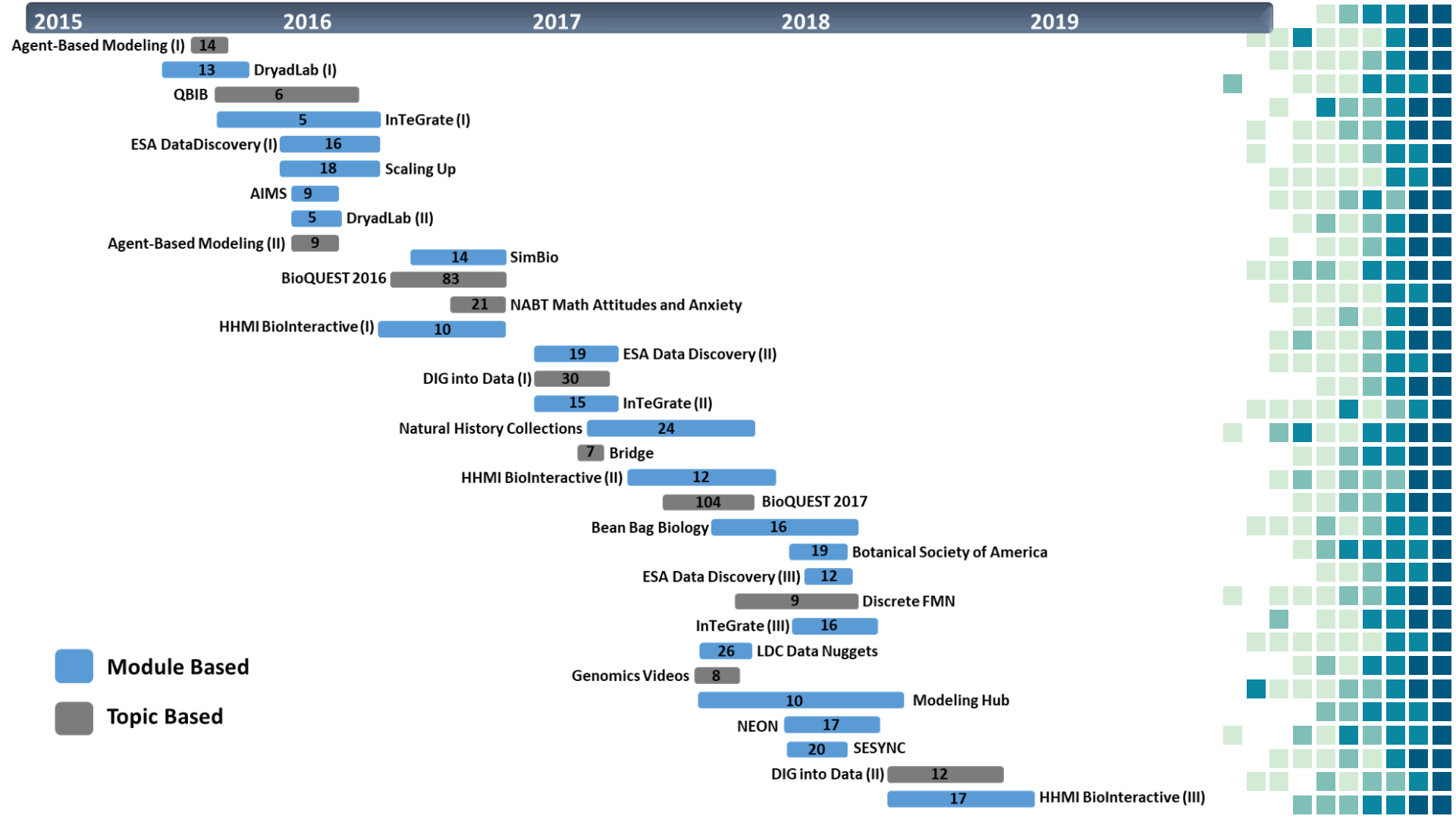
Faculty mentoring networks are:

- Online groups, typically 10-15 faculty members
- Focused on a specific topic or material
- Typically meet every two weeks over a period of several months
- Led by teams of expert content and pedagogy mentors



The benefits of participating in a faculty mentoring network include:

- Interacting with colleagues across the country who are teaching similar courses
- Discovering new teaching materials and incorporate them into your courses
- Learning about new pedagogical techniques proven to be effective in the classroom
- Becoming more comfortable incorporating quantitative content into your biology courses
- Providing evidence of your professional activities to your department


2015
2016
2017
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Agent-Based Modeling (I) 14
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QBIB 6
5 InTeGrate (I)
ESA DataDiscovery (I) 16
18 Scaling Up
AIMS 9
5 DryadLab (II)
Agent-Based Modeling (II) 9
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21 NABT Math Attitudes and Anxiety
HHMI BioInteractive (I) 10
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DIG into Data (I) 30
15 InTeGrate (II)
Natural History Collections 24
7 Bridge
HHMI BioInteractive (II) 12
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19 Botanical Society of America
ESA Data Discovery (III) 12
9 Discrete FMN
InTeGrate (III) 16
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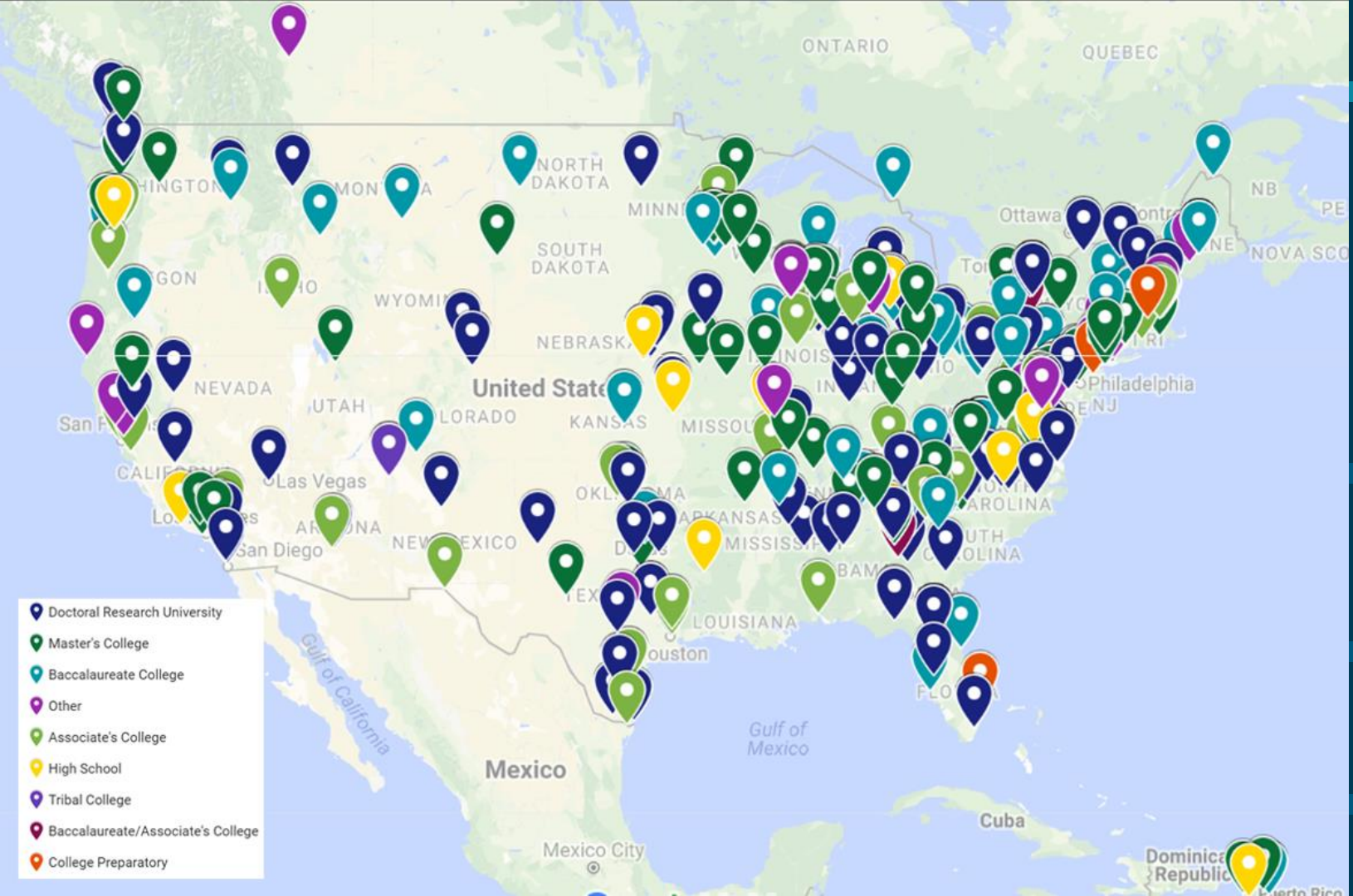
10 Modeling Hub
NEON 17
20 SESYNC
DIG into Data (II) 12
17 HHMI BioInteractive (III)
Module Based
Topic Based


Doctoral Research University
Master's College
Baccalaureate College
Other
Associate's College
High School
Tribal College
Baccalaureate/Associate's College
College Preparatory
ONTARIO
QUEBEC
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
NEVADA
UTAH
KANSAS
LOUISIANA
Las Vegas
San Diego
Philadelphia
Gulf of California
Gulf of Mexico
Mexico
Mexico City
Cuba

Situated learning (Lave & Wenger, 1991)

"learning is an integral part of generative social practice in the lived-in world" (p. 35)

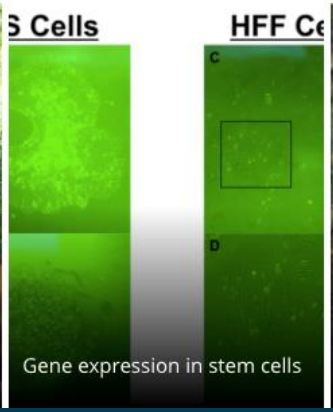
Through legitimate peripheral participation

Community of Practice (Wenger, 1998)

Social theory of learning – "learning…changes who we are by changing our ability to participate, to belong, to negotiate meaning" (p. 266)

Mutual engagement, joint enterprise, and shared repertoire

Hanselman, J., Scherer, H., Donovan, S., Hale, A. (2016). "Adapting geoscience materials for introductory biology courses using the Faculty Mentoring Network", Presentation at the *Earth Educators' Rendezvous*: Madison, Wisconsin, July. serc.carleton.edu/earth_rendezvous/2016/program/talks/mondayB/136530.html



Open Education Resources

Old model

Polished materials

Repositories

Teaching as private practice

New model

Always beta

Living documents

Teaching as scholarship

Original published TIEE Module

12 derivative versions shared by FMN participants

Professional recognition and tracking scholarly Impact

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-centra America

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

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

ECOLOGICAL SOCIETY OF AMERICA

esa

April Conkey

Texas A&M University-Kingsville

esa.org/fed/2016scholars/

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

ascb
the american society for cell biology

AVIDA-ED

DRYAD

AAAS
ADVANCING SCIENCE, SERVING SOCIETY

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MAA
MATHEMATICAL ASSOCIATION OF AMERICA

ASMcue.org

ECOLOGICAL SOCIETY OF AMERICA
esa

GSA
Genetics Society of America

NIMBioS
National Institute for Mathematical and Biological Synthesis

NABT
National Association of Biology Teachers

ABLE

MCRN
Mathematics and Climate Research Network

BOTANICAL SOCIETY OF AMERICA

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iDigBio
Integrated Digitized Biocollections

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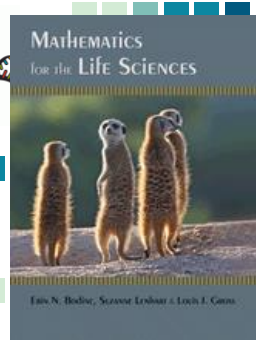


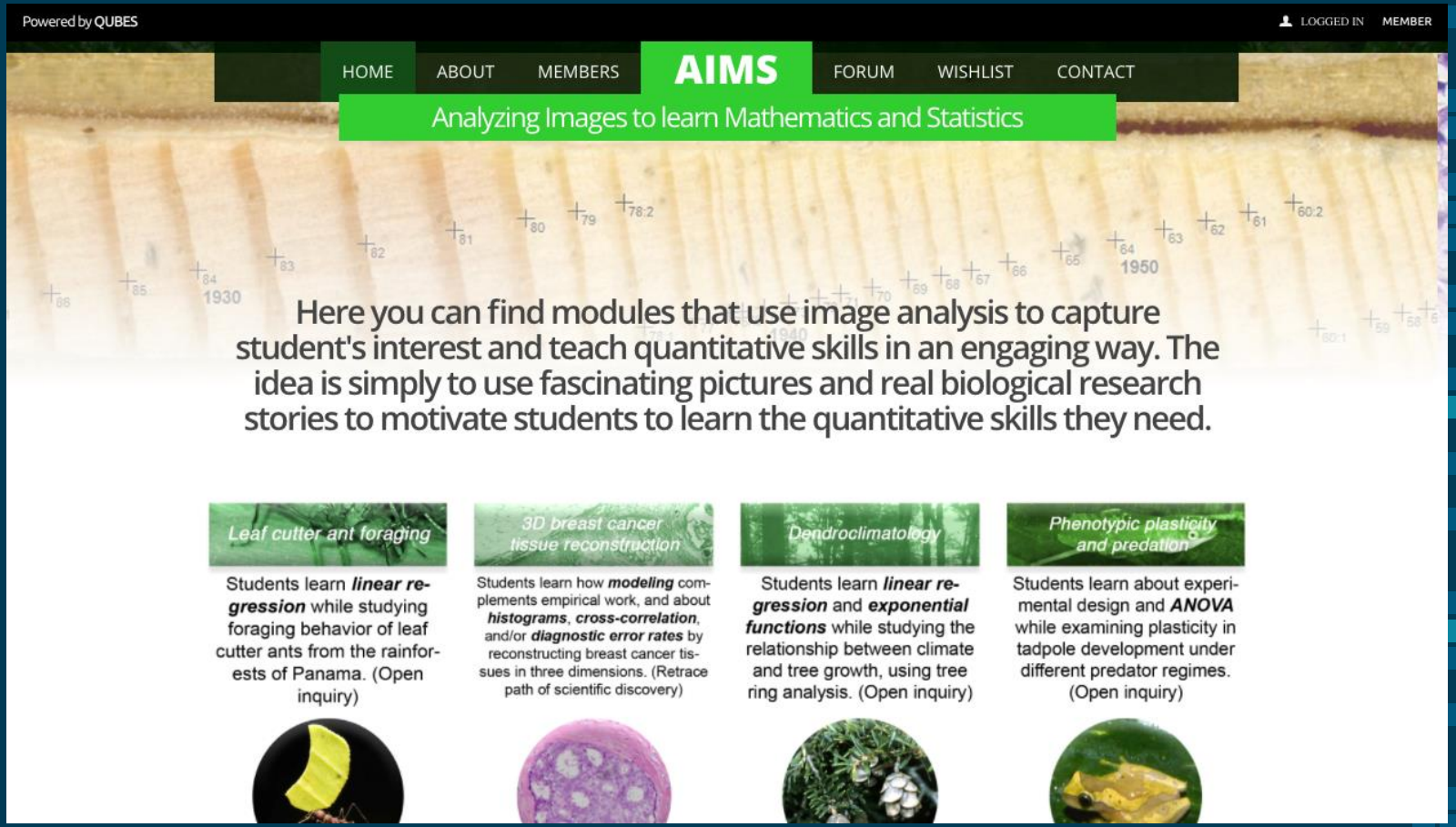
BioQUEST
CURRICULUM CONSORTIUM

SUMS4Bio
Strengthening Undergraduate Mathematics and Statistics for Biologists

Society for Mathematical Biology

Science gateways are a community-specific set of tools, applications, and data collections that are integrated together via a web portal or a desktop application, providing access to resources and services of distributed computing infrastructures.

We offer partners turn-key web 2.0 infrastructure



Running Computational Tools

No software installation required,
instructors can direct students directly to the material

R-Studio IDE for R

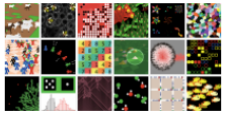
RStudio is a GUI for R, the statistical programming language.

Launch RStudio | RStudio page

Links of interest:

Using R in the Classroom

NetLogo



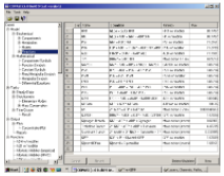
NetLogo is a multi-agent programmable modeling environment. It is used by tens of thousands of students, teachers and researchers worldwide.

Launch NetLogo | NetLogo page

Links of interest:

Using NetLogo in the Classroom

Copasi

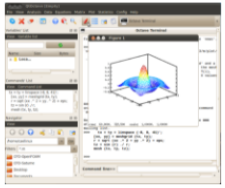


COPASI is a software application for simulation and analysis of biochemical networks and their dynamics. COPASI is a stand-alone program that supports models in the SBML standard and can simulate their behavior using ODEs or Gillespie's stochastic simulation algorithm; arbitrary discrete events can be included in such simulations.

COPASI carries out several analyses of the network and its dynamics and has extensive support for parameter estimation and optimization. COPASI provides means to visualize data in customizable plots, histograms and animations of network diagrams.

Launch Copasi | Copasi page

QtOctave



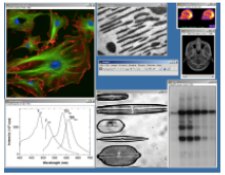
From the GNU Octave Wikipedia page:

> GNU Octave is a high-level programming language, primarily intended for numerical computations. It provides a command-line interface for solving linear and nonlinear problems numerically, and for performing other numerical experiments using a language that is mostly compatible with MATLAB. It may also be used as a batch-oriented language. As part of the GNU Project, it is free software under the terms of the GNU General Public License.

QtOctave is an open source GUI front-end application for GNU Octave.

Launch QtOctave | QtOctave page

ImageJ



From Introduction to ImageJ:

> ImageJ is a public domain Java image processing program inspired by NIH Image for the Macintosh. It runs, either as an online applet or as a downloadable application, on any computer with a Java 1.4 or later virtual machine. Downloadable distributions are available for Windows, Mac OS, Mac OS X and Linux. It can display, edit, analyze, process, save and print 8-bit, 16-bit and 32-bit images. It can read many image formats including TIFF, GIF, JPEG, BMP, DICOM, FITS and "raw". It supports "stacks", a series of images that share a single window. It is multithreaded, so time-consuming operations such as image file reading can be performed in parallel with other operations.

Launch ImageJ | ImageJ page

Mesquite

Mesquite is modular, extendible software for evolutionary biology, designed to help biologists organize and analyze comparative data about organisms. Its emphasis is on phylogenetic analysis, but some of its modules concern population genetics, while others do non-phylogenetic multivariate analysis. Because it is modular, the analyses available depend on the modules installed.

Mesquite also has many features for managing and processing data, including processing of chromatograms, sequence alignment, editing of morphometric data, and others.

Launch Mesquite | Mesquite page

Ways that QUBES facilitates research

Student Research

Promoting learning environments to reflect practice
Lowering barriers to the use of data and modeling tools
Collaborations among courses

Implementation Research

Studying the features of QUBES faculty development strategies that influence implementation success

QUBESHUB as a Research Platform

We invite proposal to study communities or activities that take place around the QUBES Project.

Outline for the talk

What is QUBES?

What are the core pedagogical commitments?

How and why an emphasis on community?

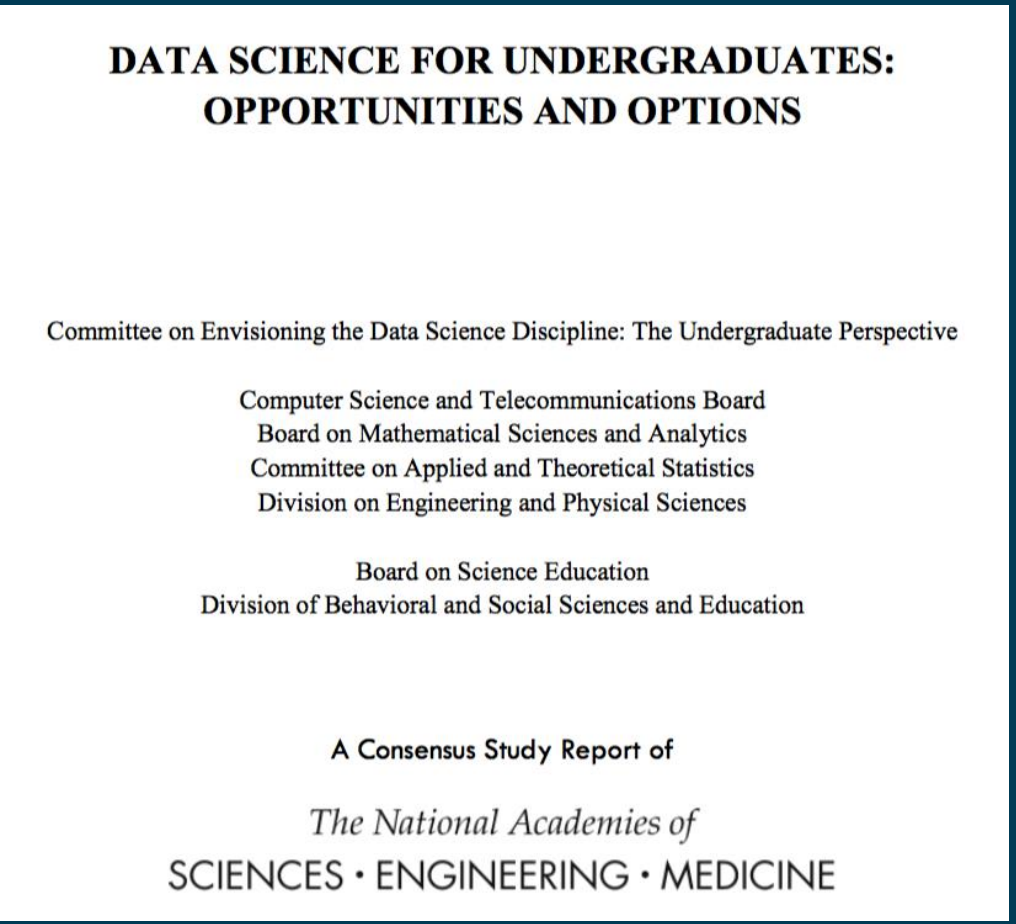
BIOQUEST CURRICULUM CONSORTIUM

32 years young!

- Problem Posing
- Problem Solving
- Peer Persuasion

FIGURE 1.1: ONE WAY OF TRANSFORMING A MATHEMATICS PROBLEM INTO A MODELING PROBLEM.

Bliss, K., Fowler, K., Galluzzo, B., Giordano, F., Godbold, L., Gould, H., ... & Pollak, H. (2016). GAIMME: Guidelines for Assessment & Instruction in Mathematical Modeling Education. Consortium for Mathematics and Its Applications.



Using real data will expose students to the messiness of real world problems.

Selecting applications with broad impact makes instruction more compelling, helping to attract and retain students.

Teaching commonly used current methods will prepare them for the workplace.

Working in teams

Data Acumen - the emergent skills and habits of mind that “enable data scientists to make good judgments and decisions with data.”

Productive Disciplinary Engagement

The design of learning environments that support:

- *Problematizing* –
  students are encouraged to take on intellectual problems in the subject.
- *Accountability* –
  students' intellectual work is made accountable to other using disciplinary norms.
- *Authority* –
  students are given authority to participate by contributing knowledge.
- Resources –
  students are given sufficient resources do participate this way.

Guiding Principles for Fostering Productive Disciplinary Engagement:
Explaining an Emergent Argument in a Community of Learners Classroom
Author(s): Randi A. Engle and Faith R. Conant. Cognition and Instruction, Vol. 20, No. 4 (2002), pp. 399-483

Outline for the talk

What is QUBES?

What are the core pedagogical commitments?

How and why an emphasis on community?

Productive Disciplinary Engagement (teachers)

The design of learning environments that support:

- *Problematizing* –
  teachers are encouraged to take on intellectual problems in the subject.
- *Accountability* –
  teachers' intellectual work is made accountable to other using disciplinary norms.
- *Authority* –
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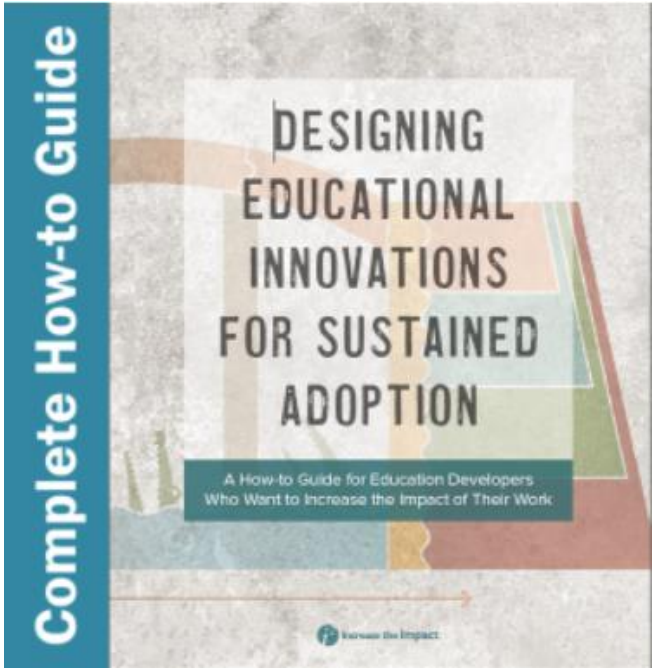
Increasing the Impact

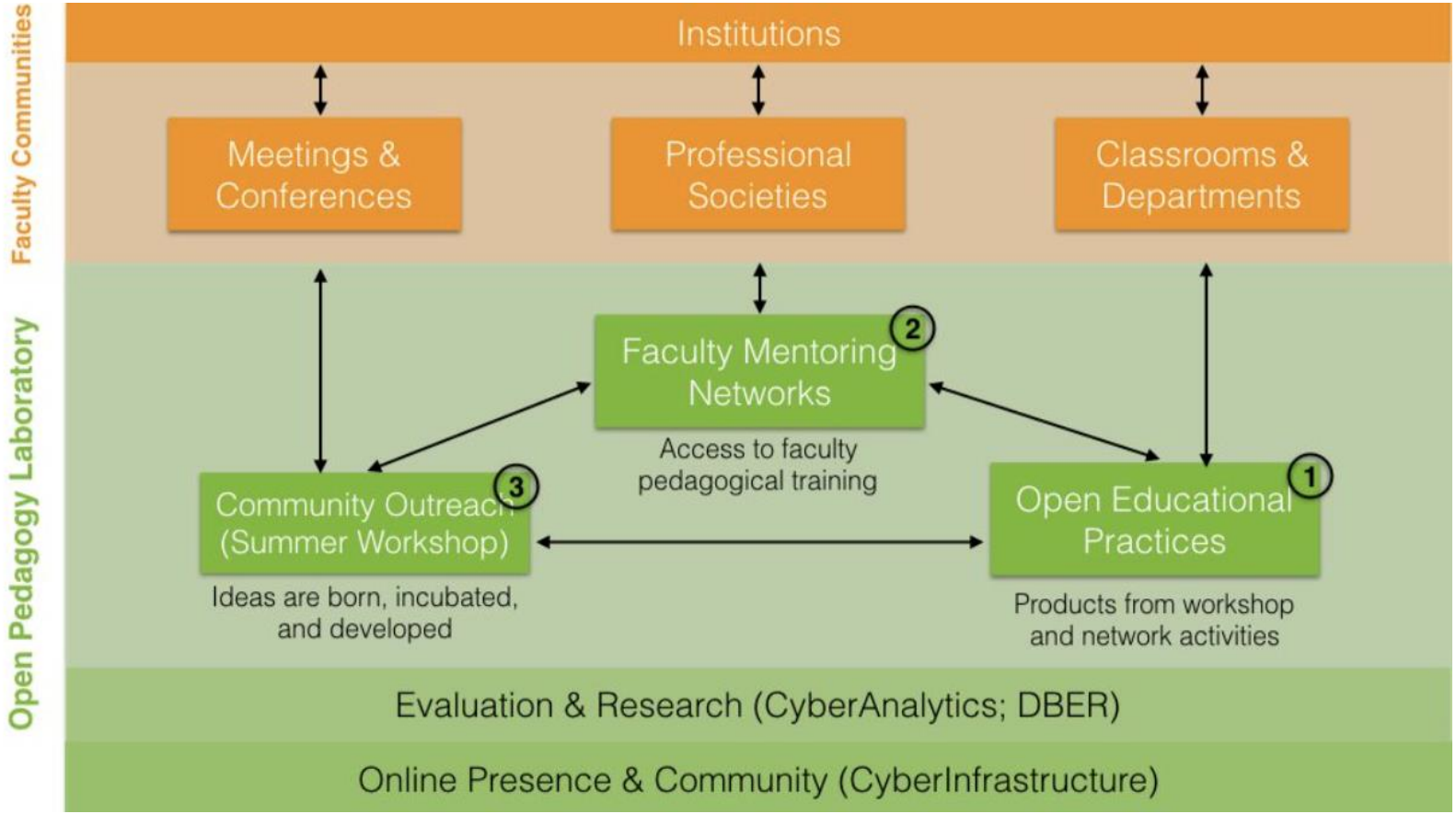
Charles Henderson



Efforts to improve undergraduate STEM teaching methods have generated many great ideas and materials, but few have caught on.

The 2014 NSF IUSE Program Solicitation states that “transferability and propagation are critical aspects for IUSE-supported efforts and should be addressed throughout a project’s lifetime by ensuring attention to designing for use in a large variety of institutions.”

Very few developers currently do this in their proposals, because, in large part, they aren’t sure how.



Supporting faculty in the adoption of open education scholarship requires the integration of tools, worksopsaces, and existing communities in a way that fit faculty needs.

HT Case Studies | Workshops | Get Involved | Resources | Contact us

HITS

High-throughput Discovery
Science & **I**nquiry-based Case
Studies for **T**oday's **S**tudents

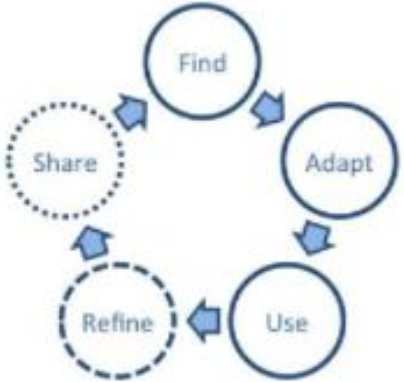
Overview

For modern life science researchers, high-throughput approaches can open the doors to discovery of novel genes, drugs, and regulatory networks. The effective design, implementation, and analysis of high-throughput research require fundamental quantitative skills. Taken together, the opportunity for new modes of discovery and development of associated quantitative skills make integration of high-throughput research into college biology curricula highly attractive. Yet, the high cost and technological demands of high-throughput discovery prohibit its use in most college laboratories. To address this need, *this Research Coordination Network in Undergraduate Biology Education (RCN-UBE) seeks to improve student quantitative skills and participation in high-throughput discovery.* Researchers and teaching fellows in the network will learn about high-throughput technologies and work together to create novel case studies that will demystify high-throughput approaches and promote discovery science to reinforce cornerstone STEM concepts and quantitative skills in the college classroom.

Five year Research Coordination Network - UBE
hits.qubeshub.org
www.nsf.gov/awardsearch/showAward?AWD_ID=1730317

DIG: Designing an infrastructure and sustainable learning community for integrating data-centric resources in undergraduate biology.

Bringing Research Data to the Ecology Classroom: Opportunities, Barriers, and Next Steps



Environment-Richness Relationships in Ephemeral and Permanent

Investigating Leaf Litter Decomposition and Invertebrate

Painting turtles: an introduction to species distribution modeling in R

Data Management using NEON Small Mammal Data with Accompanying

niblse.qubeshub.org

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.

QUBES
The Power of Biology × Math × Community

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.

All learning resources have been reviewed and assigned NIBLSE Core Competencies. To see a full description, click the competency or visit the NIBLSE Core Competency page.

Click the icon to the right to download a guide on how to navigate a QUBES Database: Database Guide

Image	Title	First Author	Description	Competencies	Status
Image	Title	First Author	Description	Competencies	Status
	Agent - Based	Liz Ryder - Worcester	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	Role of bioinformatics.	Reviewed at

BLUE
Biodiversity Literacy in Undergraduate Education

BLUE

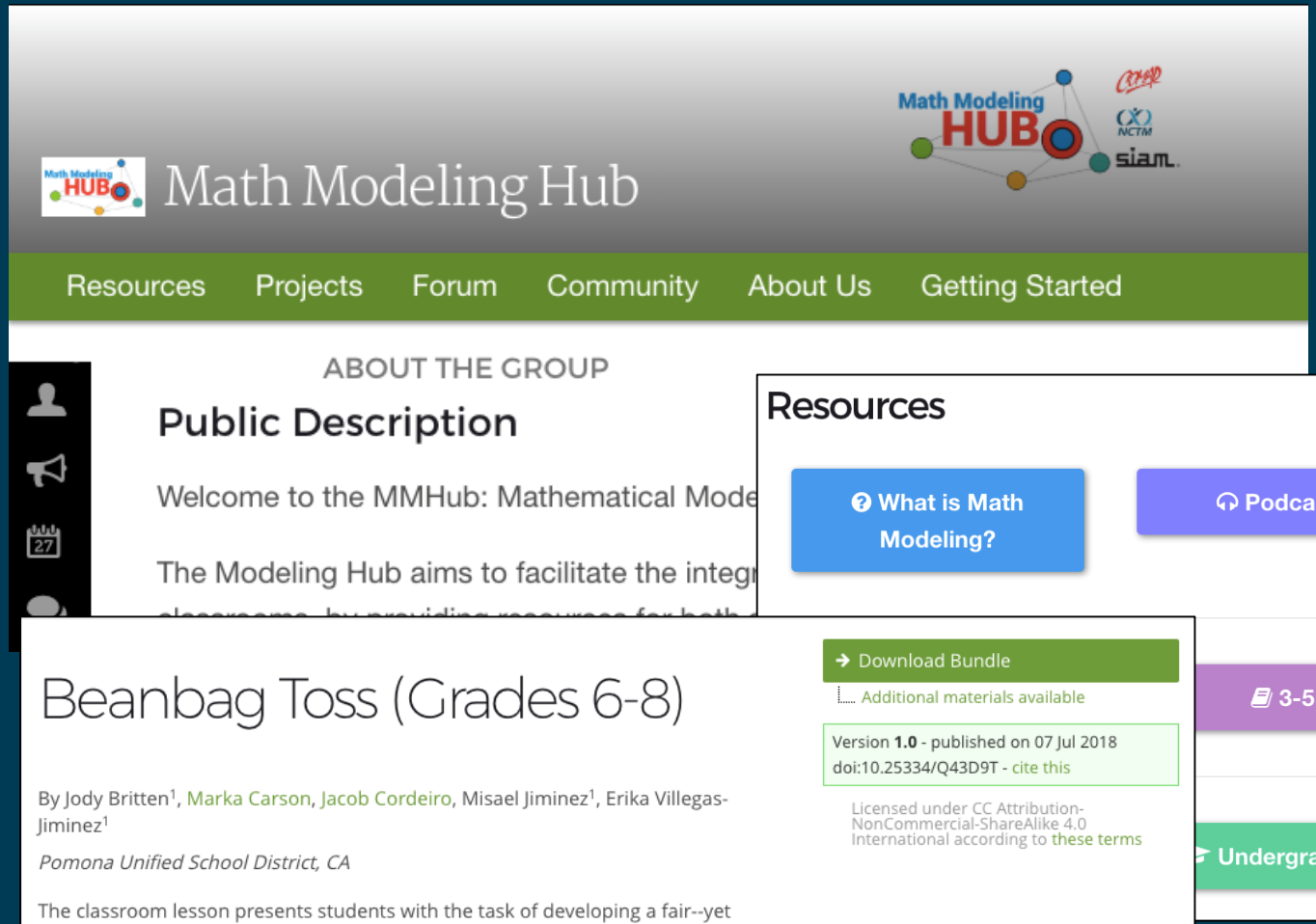
Biodiversity Literacy in Undergraduate Education

ABOUT

PRODUCTS

RECENT ACTIVITY

Anna Monfils - PI


Math Modeling Hub
Resources
Projects
Forum
Community
About Us
Getting Started
ABOUT THE GROUP
Public Description
Welcome to the MMHub: Mathematical Mode
The Modeling Hub aims to facilitate the integ
Resources
What is Math Modeling?
Podcasts
Videos
3-5
6-8
Undergraduate
Graduate
Beanbag Toss (Grades 6-8)
Download Bundle
Additional materials available
Version 1.0 - published on 07 Jul 2018
doi:10.25334/Q43D9T - cite this
Licensed under CC Attribution-NonCommercial-ShareAlike 4.0 International according to these terms
By Jody Britten[1], Marka Carson, Jacob Cordeiro, Misael Jiminez[1], Erika Villegas-Jiminez[1]
Pomona Unified School District, CA
The classroom lesson presents students with the task of developing a fair--yet challenging--beanbag toss game.
Listed in Teaching Materials | resource by group Math Modeling Hub

Explosive growth of information – Quantitative

Expanding role of technology – Computational

Changes in the nature of the discipline - Interdisciplinary

Bridging school and the real world – Connected to students

The QUBES team

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NISER Team

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Kevin Kidder (p)
Sondra LoRe

QUBES partners, participants, & advisory board

Funding: National Science Foundation DUE 1446269, DUE 1446258, DUE 1446284

qubeshub.org