Making Undergraduate Research a Key Part of Your Class or Curriculum

Lydia Fox
University of the Pacific

Meagen Pollock
College of Wooster



"advocate and provide for replacing standard laboratory courses with discovery-based research courses"

What are the Benefits of Undergraduate Research?

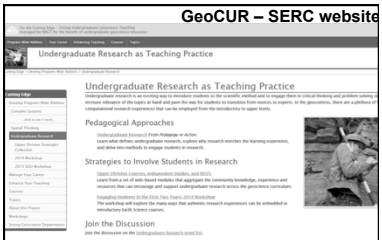
- Engages and empowers students in hands-on learning
- Enhances the student learning experience through mentoring relationships with faculty
- Increases student retention
- Provides effective career preparation & promotes interest in graduate education
- Develops critical thinking, creativity, problem solving, self confidence, and intellectual independence
- Promotes an innovation-oriented culture

Faculty Benefits of Undergraduate Research:

- Invigorates intellect and increases enthusiasm
- Enhances teaching effectiveness and job satisfaction
- Promotes advancements in research program
- Increases access to grant funding
- Encourages faculty to remain current in their field
- Promotes greater engagement with students, colleagues, and the community

Overview
Research in the first two years
Designing a research-based course
Examples of research in courses
Independent Research/Senior Theses

GeoCUR – SERC website



http://serc.carleton.edu/NAGTWorkshops/undergraduate_research/index.html

PennState Brandywine

Undergraduate Research in the first two years

Laura Guertin
Prof. Earth Science
CUR Geoscience Division

PennState Brandywine

Skill sets

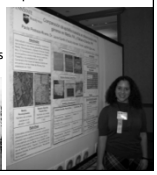
- Searching for and citing primary sources
- Generating testable questions/hypotheses
- Working with and evaluating data (results vs. discussion)
- Creating and reading graphs
- Reaching a comfort level with quantitative skills
- Teamwork
- Being held accountable, seeing project through to completion

Classroom-based research

- … or research "experience"
- Students must design and carry out a project, report in the end


Independent (or group) research

- Challenges with underclassmen
  - Still developing skills, lack of content mastery
  - May not get anything to publish or present
- Successes with students
  - Some welcome the challenge
  - Adult students, honors students
- Examples

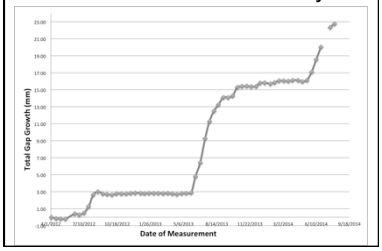



Community-based research

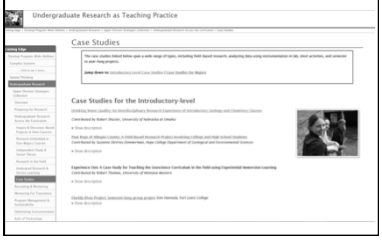
- Local students like to give back locally
  - Fits with civic & community engagement
- Citizen science


Global Tree Banding Project at Penn State Brandywine

Tree #219 – Black Cherry

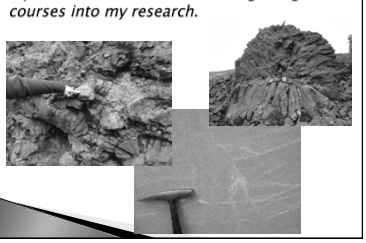


Other Examples of Research in Intro-level Courses

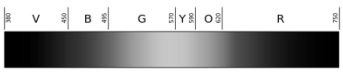


Undergraduate Research Embedded in Geo-Major Courses/Research Intensive Courses

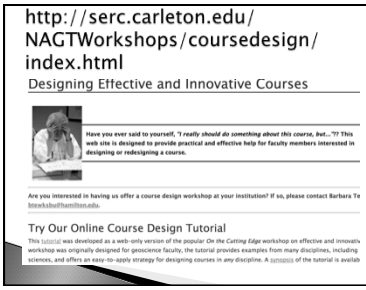
1. It's less about *integrating research into my courses* and more about *integrating courses into my research.*



2. Research involves a lot of different things, and I don't have to do them all in a single class.



http://serc.carleton.edu/NAGTWorkshops/coursedesign/index.html



Articulate course context and constraints:

- Igneous and metamorphic petrology
- ~20 students – sophomores to seniors
- Mineralogy and chemistry prerequisites
- Teaching assistants for each lab
- 3 50-minute "lectures" and 2 sections of 3-hour "lab"

Set goals:

Overarching goals–

- Identify and characterize common igneous and metamorphic rocks
- Use fundamental physical and chemical concepts (e.g., phase diagrams, thermodynamic principles) to analyze the petrogenesis of igneous and metamorphic rocks
- Present scientific information to a broad audience

Choose content:

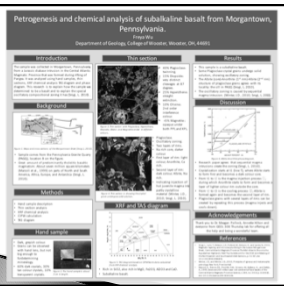
- This is where you choose the research project
- 3 projects:
  - BC xenoliths
  - Iceland intrusions
  - PA diabase
- Data: geochemistry, petrography

What might students do to get goal-related practice?

- Describe mineralogy and textures of mafic igneous rocks
- Classify mafic igneous rocks using modal mineralogy and bulk geochemistry
- Compare textures and chemistry to interpret petrogenesis
- Small, achievable activities

Course plan –

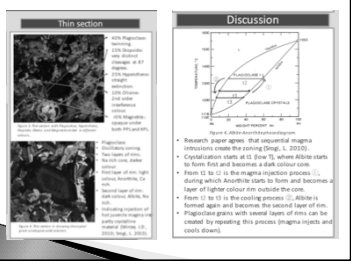
- Students each have 1 sample
- Each person does the following:
  - Makes a thin section
  - Describes mineralogy and textures (petrographic report)
  - Makes a pressed pellet and glass disk for XRF
  - Bulk rock chemistry (classification, petrogenesis)
- Semester-long project; application follows activity
- Culminating (synthesizing) presentation
- Independence and increasing complexity is built in



Set goals:

Overarching goals–

- Identify and characterize common igneous and metamorphic rocks
- Use fundamental physical and chemical concepts (e.g., phase diagrams, thermodynamic principles) to analyze the petrogenesis of igneous and metamorphic rocks
- Present scientific information to a broad audience



Challenges

Can I manage ~20 separate projects? Yes! But much out of class and lab time.

What existing content must be replaced? Didn't cover all tectonic associations, isotopes, other topics. Labs shortened.

How do I assess student learning? Poster presentation. Progress reports. Graded segments.

Best Practices

Decide what's important and focus on it

Be clear about expectations

Build research into class time

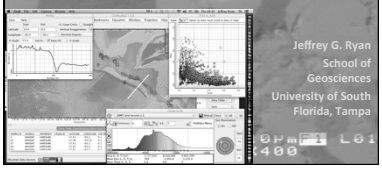
Make the experience authentic

Peer mentoring – balance individual and group efforts

Acknowledgements

Thank you to Dr. Meagan Pollock, Annette Hilton and everyone from GEOL 308 Thursday lab for offering all the help and being a wonderful team.

AUTHENTIC, LOW COST/NO COST STRATEGIES FOR RESEARCH EXPERIENCES FOR THE CLASSROOM: USING REMOTELY OPERABLE RESEARCH INSTRUMENTATION AND GEOINFORMATICS RESOURCES



Jeffrey G. Ryan
School of Geosciences
University of South Florida, Tampa

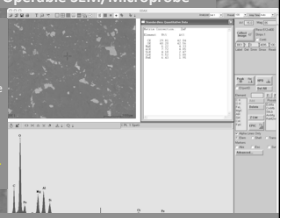
Two NSF-supported Low/No cost strategies:

- Data collection/ analysis via remotely operable instruments

Investigations of global (and planetary) geo-data (informatics)

Addressing Access: In-class data collection via Remotely Operable SEM/Microprobe

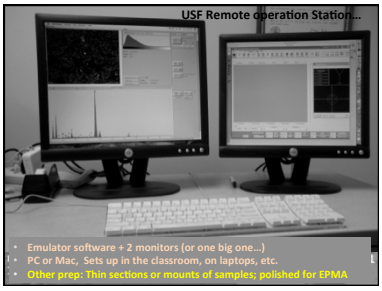
- Part of an educational intervention/ experiment piloting remote instrument usage in geoscience courses
- **funded by NSF-CCLI (2006)**



- **Results published: Ryan, 2013; in Tong, V.** (ed), Geoscience Research and Education: Teaching at Universities, Springer Verlag (pp. 149-162)

Remotely operable Microbeam facility: fcaem.fiu.edu

USF Remote operation Station…



- Emulator software + 2 monitors (or one big one…)
- PC or Mac, Sets up in the classroom, on laptops, etc.
- **Other prep: Thin sections or mounts of samples; polished for EPMA**

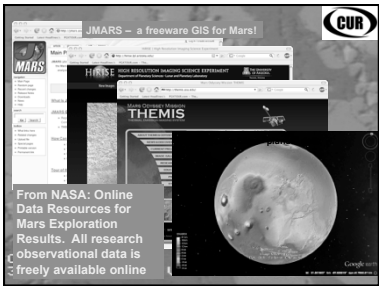
Geoinformatics and Research

- NSF, NASA, etc. requirement: all funded data must be accessible to the public! (Open Access…)
  - **Outcome: Federally supported Geoinformatics facilities**
    - Global gridded (map-based) and tabular data (chemistry, demography, etc.)
    - Planetary mission datasets (Mars, Moon, Saturn, etc…)
    - Both data and tools for data visualization/ interpretation

Investigating global datasets: some examples…

- **Integrated Earth Data Applications Portal (IEDA: www.iedadata.org): Geophysical, bathymetric, and geochemical data for the oceans and continental margins.**
- **GeoMapApp (www.geomapapp.org): Java-based geospatial information system tool for data integration and visualization**

JMARS – a freeware GIS for Mars!



From NASA: Online Data Resources for Mars Exploration Results. All research observational data is freely available online

Mentoring Independent Research Projects

or

Student Research Projects Connected to Your Research

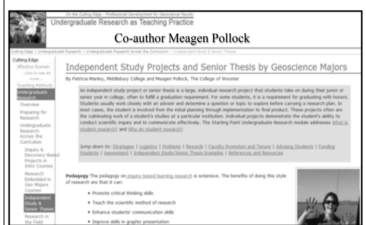
Patricia Manley
Geology Department
Middlebury College

Middlebury CUR

---

http://serc.carleton.edu/NAGTWorkshops/undergraduate_research/independent_study.html

Co-author Meagen Pollock



Senior/Semester projects

(Collaborative NSF Proposal)

❖ Chose a small portion of your research

NBP0101 – East Antarctic 2 month cruise → 12 Geographic Locations

18 Jumbo Piston cores

~540 m of sediment

~10,800 individual samples

•physical properties

•grain size

3 senior theses

3 semester projects

4 summer research assistants

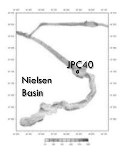
Semester/summer projects

5 peer reviewed papers

- Andrew Nichols – biogenic SiO_2
  - Abstract at AGU -2005
- Charlotte Bemis – Nielson Basin grain size
  - Abstract at AGU - 2007
- Kelsey Fredston-Hermann - biogenic SiO_2 and Emily Dawson – QXRD for biogenic SiO_2
  - Abstract at GSA - 2008

Senior Theses:

- Burgdorff, Katharine (2002)
  - High-resolution electrical resistivity measurements as a geophysical tool on East Antarctica Holocene ocean sediments
- Hommeyer, Matthew (2002)
  - Glacial climate change during the Late Quaternary as recorded in the Svenner Channel Prydz Bay, East Antarctica
- Ludwick, Susan (2002)
  - Geophysical investigation of the Mertz Drift, Antarctica



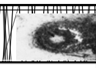
SHALDRIL (NSF)

- Involved 7 undergraduates – 2 research cruises
- 4 peer reviewed papers, numerous abstracts
- 4 senior theses

- Klein, Alison (2008)
  - Analysis of Holocene Marine Sediments, Antarctica
- Christopher, Annie (2007)
  - Climate Change History of Four Bays on the Antarctica Peninsula
- Kirsch, Katie (2006)
  - Tephro-chronological investigation of marine sediments from Maxwell Bay and Bransfield Strait, Antarctica
- Michalchuk, Brad (2006)
  - Paleoclimate archive and synthetic seismograms in Maxwell Bay, Antarctica.

Pedersen (1992)
Sayward (1996)
North (1997)
Gutierrez (2001)

Multi year project



12 years later: 2 papers and several abstracts

Manley, P.L., T.O. Manley, M. Watzin and J. Gutierrez ('01)*, 2004, Pockmarks in Burlington Bay: Implications of origin, biological implications and dynamics.

Watzin, M.C., **P.L. Manley**, T.O. Manley and S. Kyriakeas, 2004, Lakebed Pockmarks in Burlington Bay, Lake Champlain II. Habitat Characteristics and Biological Patterns, In Manley, T. , **P.L. Manley** and T. Mihuc (editors), *Lake Champlain Partnerships in research for the next millennium*. Kluwer Publishing.

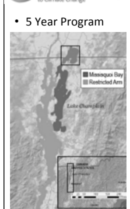
Pockmarks of Lake Champlain

Faculty research -multiyear

RACC Research on Adaptation to Climate Change

VT EPSCoR - RACC

- 5 Year Program



- Algal blooms → Eutrophication
- Large watershed
  - Agriculture
  - Phosphorus input
- How long: bay recovery?
  - …us stay in sediment?
  - How is it transported?
- Understand physical dynamics
  - *Circulation currents, sediment transport*

Emily Wei ('13) Senior thesis – initial hydrodynamic understanding

3 summer interns – STA, multibeam, sediment characterization

M. Kraft, P. Manley, J. Singer, T. Manley, and P. McLaren, 2013, Application of Sediment Trend Analysis in the Examination of Sediment Transport Dynamics of Missisquoi Bay, *Transactions*, Fall 2013. EP53B-0817.

Funding Sources for Undergraduate Research

CUR

- NSF
  - IUSE – Improving Undergraduate STEM Education
    - EHR (focus on student learning)
    - GEOPATHS (focus on workforce development)
  - MRI – Major Research Instrumentation
  - ROA - Research Opportunity Award
  - REU Supplements - Research Experiences for Undergraduates
- PRI (Petroleum Research Institute)
  - "petroleum-related" is pretty broad but excludes environmental resesarch
- Other government sources: EPA, DOE, etc.
- Other funding (get to know the folks in your Sponsored Programs/ Research office)

Undergraduate Research and the P&T Process

- Learn the "lay of the land"
  - Is UGR valued at your institution?
    - If so, go for it
    - If not, proceed, but cautiously
- Seek out Mentors (inside and outside your department)
- Compile your P&T binder all along the way
  - Every semester: course reflections, document activities
  - Every year: document progress, reflect on the proces