Making Undergraduate Research a Key Part of Your Class or Curriculum
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“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

Undergraduate Research in the first two years
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Skill sets
- Searching for and citing primary sources
- Generating testable questions/hypotheses
- Working with and evaluating data
- 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

Examples
- Local students like to give back locally
  - Fits with civic & community engagement
  - Citizen science
- Tree science
- Global Tree Banding Project at Penn State Brandywine

Tree #219 – Black Cherry

Other Examples of Research in Intro-level 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/NACWorkshops/coursedesign/index.html
Designing Effective and Innovative Courses

Try Our Online Course Design Tutorial
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
  – Cullminating (synthesizing) presentation
  – Independence and increasing complexity is built in

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

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

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Two NSF-supported Low/No cost strategies:

- Investments of global (and planetary) geo-data (informatics)
- Data collection/analysis via remotely operable instruments

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

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

Geoinformatics and Research

- NSF, NASA, etc.
- Requirement: all funded data must be accessible to the public (Open Access…)

- Geospatial / Geomatics supported Geoinformatics facilities
  - Radar, geophysical data - technology, micro-wave, etc.
  - Pedological/mineral datasets (maps, vectors, etc.)
  - Web data and tools for data accessibility / interpretation

Investigating global datasets: some examples…

- Integrated Earth Data Applications Portal (IEDA: iop.geo.ucar.edu)
- Google Earth: Mars “planet” data portal
- JMARS – a freeware GIS for Mars
- THEMIS

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

Acknowledgments

Acknowledgments

USF Remote Operation Station

Emulator software + 2 monitors (or one big one…)
PC or Mac, set up in the classroom, on laptops, etc.

Other prep: Thin sections or mounts of samples; polished for EPMA
Mentoring Independent Research Projects or Student Research Projects Connected to Your Research

Patricia Manley
Geology Department
Middlebury College

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

Co-author Meagen Pollock

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

Ø Andrew Nichols – biogenic SiO
Ø Charlotte Bemis – Nielson Basin grain size
Ø Kelsey Fredston-Hermann – biogenic SiO
Ø Emily Dawson – QXRD for biogenic SiO

• Abstract at AGU -2005
• Abstract at AGU - 2007
• Abstract at GSA - 2008

Nielsen Basin JPC40
5 peer reviewed papers
Ø Burgdorff, Katharine (2002)
• High-resolution electrical resistivity measurements as a geophysical tool on East Antarctica Holocene ocean sediments
Ø Hommeyer, Matthew (2002)
• Glacial climate change during the Late Quaternary as recorded in the Svenner Channel Prydz Bay, East Antarctica
Ø Ludwick, Susan (2002)
• Geophysical investigation of the Mertz Drift, Antarctica
• Involved 7 undergraduates – 2 research cruises
• 4 peer reviewed papers, numerous abstracts
• 4 senior theses
Ø Klein, Alison (2008)
• Analysis of Holocene Marine Sediments, Antarctica
Ø Christopher, Annie (2007)
• Climate Change History of Four Bays on the Antarctica Peninsula
Ø Kirsch, Katie (2006)
• Tephrochronological investigation of marine sediments from Maxwell Bay and Bransfield Strait, Antarctica

• Side-scan sonar
• 1992,1997,2000 Cores
• 1992, 1997, 2000 Cameras, dating, ADCP
• Multi year project
• Fred Fayette - “You should look at these bomb craters…”

12 years later: 2 papers and several abstracts


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

• 8 years collecting data-Whole Lake Survey
• Involvement of ~10+ students
• Map synthesis - 3 years ~5 students
• Publication of map

5 Year Program
Algal blooms - Eutrophication
Large watershed - Agriculture
Phosphorus input - How long: bay recovery?
How does Phosphorus stay in sediment?
How is it transported?
Understanding physical dynamics - Circulation currents, sediment transport

Emily Wei (‘13) Senior thesis – initial hydrodynamic understanding
3 summer interns – STA, multibeam, sediment characterization

Funding Sources for Undergraduate Research

• NSF
• IUSE – Improving Undergraduate STEM Education
• MRI – Major Research Instrumentation
• REU Supplements – Research Experiences for Undergraduates
• PRI – Petroleum Research Institute
• Other government sources: EPA, DOE, etc.
• Other funding sources: internal sources

Student research projects or mentor independent student projects connected to your research.
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 process