Learning at the Edge:
The Nature and Design of Inquiry-based Learning Environments for an Undergraduate Environmental Geoscience Program

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Abstract: As a research institution, Texas A&M’s Mission includes "providing the highest quality undergraduate and graduate programs", which "is inseparable from its mission of developing new understandings through research and creativity". This is a lofty goal that is not always achieved. A major initiative at TAMU is to embed inquiry experiences in all undergraduate courses, one of the best pedagogical practices to support the development of critical thinking skills and competencies in science learners including problem-solving, knowledge transfer, and decision making. Information technologies are often a central component of inquiry-based learning environments because these tools support student manipulation of data, the development and testing of conceptual models based on available evidence, and exposure to authentic, complex and ill-constrained problems. We are supporting this initiative through our participation in CIRTL (cirtl.net), an NSF-sponsored consortium of research institutions that seeks to develop a national STEM graduate student through faculty with the capability and commitment to implement and improve effective teaching and learning practices for all students.

This talk will discuss current efforts to develop and implement effective learning environments for the environmental geosciences programs at TAMU designed around inquiry-based (experiential) learning. I will discuss the complex nature and design of inquiry activities for geological and environmental sciences using the concept of “an environmental problem space”. A problem space is defined as “a cohesive suite of rules, policies, practices, conventions, standards, concepts, etc. that govern the conceptual domain where a particular problem needs to be solved”.

Finally, I will argue that authentic inquiry may serve as a boundary object to support structured synergy between research and teaching, serving to reduce the major dichotomy in faculty work. Boundary Objects (BO) serve as an interface between different groups in a community of practice. Boundary objects are flexible enough to adapt to local needs and have different distinct identities in different communities, but at the same time robust enough to maintain a common identity across the boundaries to be a place for shared work.
Nature of the Disciplines

Geosciences and Environmental Engineering

- Engineered versus natural systems
- The goals of Eng are driven by social issues and problems
- Geosciences includes historical inquiry
- Eng inquiry includes design
- Both require certification

Pasteur’s Quadrant

Stokes, 1997. Pasteur’s Quadrant: Basic Science and Technological Innovation
Learning Goals

Environmental Literacy
Agency Professional/Career
Learning Issues

Knowledge transfer

Problem focused
Knowledge transfer requires:

- Knowledge threshold
- Learning with understanding
- Knowledge taught in a variety of contexts
- Deliberate practice focused on meaningful questions (metacognitive skills)

Learning activities focused on authentic inquiry/design act as anchors in interdisciplinary programs (Cognition and Technology Group at Vanderbilt)

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<table>
<thead>
<tr>
<th>Topic</th>
<th>Traditional Hands-on</th>
<th>Structured Inquiry</th>
<th>Guided Inquiry</th>
<th>Student Directed Inquiry</th>
<th>Student Research Inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher/Student</td>
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<td>Materials</td>
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<td>Teacher</td>
<td>Student</td>
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<td>Teacher/Student</td>
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<td>Results/Analysis</td>
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<td>Student</td>
<td>Student</td>
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<tr>
<td>Conclusions</td>
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<td>Student</td>
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</tbody>
</table>
Learning activities focused on authentic inquiry/design act as anchors in interdisciplinary programs (Cognition and Technology Group at Vanderbilt)

Implementing authentic inquiry requires development of instructional materials, learning activities, and assessment tools.

Simulated Research Tasks

“In this lab, you are to act as if you are an environmental consultant bidding and completing a project report for the federal government. We will assume that the data on the server or USGS web sites is the data you have collected during your study. In this project, you are to write a proposal and a research report on a question of your choice concerning water quality in the South Platte River.”


Implementing Authentic Inquiry

This week we focus on watershed management. Watershed management is a set of activities that focus on the environmental quality of watersheds and geologic and environmental systems.

A wide range of indicators have been used by the EPA to characterize the quality of watersheds in the United States. View the latest data in map form.

Download the lectures (requires Adobe Acrobat Reader):

- Nutrients and Surface Water Quality (11/10)
- EPA Online Training in Watershed Management (11/17)
- Ecosystem restoration: The Everglades Project (11/14)
- South Platte Watershed Study (12/1)

The Watershed Initiative was conceived by the US EPA to encourage successful community-based approaches to restore, preserve, and protect the nation's watersheds. (Photo courtesy of EPA).

Required Readings

- EPA Online Training in Watershed Management
- Texas' Strategy for a Watershed Management Approach
- Stream Corridor Restoration: Principles, Process, and Practice

Additional Readings

- Contaminants in the Mississippi River: 1987-92
- Assessing the TMDL Approach to Water Quality Management
- EPA Watershed Quality Indicators

Case Study

- River Resource Management in the Grand Canyon (NAP)
- Downstream: Adaptive Management of Glen Canyon Dam and the Colorado River Ecosystem (NAP)
- Colorado River Ecology and Dam Management
- Science and the Greater Everglades (NAP)
- South Florida Ecosystem Restoration Task Force
Implementing authentic inquiry requires development of instructional materials, learning activities, and assessment tools.

Simulated Research Tasks

- Experiments with physical models
- Experiments with computer simulations
- Analysis of complex data sets
- Evidence evaluation
- Verbal design / thought experiments


Physical Models of Wetland Sediments
Implementing Inquiry/Design-Based Programs

**Inquiry/Design as Boundary Object**

Scientific research can be transferred to the classroom through authentic inquiry:

- Scientific models & data sets
- Explicit description of cognitive and metacognitive skills
- New information technologies, research equipment, or tools
- Support communities of learning as content specialists.

Teaching through inquiry as a boundary object between research and teaching.

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**EDITORIAL**

Rebalancing Teaching and Research

Science, 10 January 2003
<table>
<thead>
<tr>
<th>Productivity Measures by Type of Institution</th>
<th>All 4-Year Mean</th>
<th>SE</th>
<th>Research Mean</th>
<th>SE</th>
<th>Doctoral Mean</th>
<th>SE</th>
<th>Comprehensive Mean</th>
<th>SE</th>
<th>Liberal Arts Mean</th>
<th>SE</th>
<th>Other Mean</th>
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<tr>
<td>Research Productivity Publications, 2-year</td>
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<td>0.068</td>
<td>5.780</td>
<td>0.179</td>
<td>3.840</td>
<td>0.128</td>
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<td>0.072</td>
<td>1.741</td>
<td>0.142</td>
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<td>Principal investigator (%)</td>
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<td>0.557</td>
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<td>1.374</td>
<td>27.470</td>
<td>1.209</td>
<td>12.140</td>
<td>0.601</td>
<td>11.110</td>
<td>1.316</td>
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<td>Research dollars ($)</td>
<td>172,655</td>
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<td>198,654</td>
<td>17,391</td>
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<td>28,244</td>
<td>70,840</td>
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<td>Thesis/dissertation committees</td>
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<td>Instructional Approach Proportion using collaborative/active instruction</td>
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<td>0.342</td>
<td>0.020</td>
<td>0.171</td>
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Source: NSOPF 1993

Implementing Inquiry/Design-Based Programs

Myth of the Teacher-Scholar


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<tr>
<th></th>
<th>All 4-Year</th>
<th>Research</th>
<th>Doctoral</th>
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<td>Mean</td>
<td>SE</td>
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<td>High Research &amp; Teaching</td>
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<td>21.69</td>
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<td>High Res. &amp; Teach + Pedagogy</td>
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<td>8.07</td>
<td>1.20</td>
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2007 GSA National Meeting
Final Thoughts

- Inquiry/Design as anchor in interdisciplinary programs
- Inquiry/Design as boundary object integrating research and teaching (achieve the teacher-scholar ideal)
- Hiring patterns leading to mission separation in research universities and undergraduate institutions?

Sandra Metoyer, a biology teacher prepares a geospatial database of coastal ecosystems during the ITS Summer Institute

Information Technology in Science, Center for Learning & Teaching
(http://its.tamu.edu)