Geoscience Curriculum Reform Using a Design-Based Approach

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The World in a River Project Goals

• Redesign large introductory Earth Science course for preservice teachers (PST)
  – Elementary and early childhood education majors

• Understand impact of course redesign on PST learning
  – On PST content knowledge, self-efficacy for science teaching, and motivation
Curriculum Reform Principles

• Align with Next Generation Science Standards (NGSS)

• Field experiences & active learning

• Place-based investigations & contextualized content

• Include technological tools and data mining

Content Redesign – Watershed Story

White Clay Creek, Delaware – Our Backyard!
## Emphasis on Active, Place-based Learning and Real-time Data, Aligned with the NGSS

<table>
<thead>
<tr>
<th>Project</th>
<th>NGSS SEPs</th>
<th>NGSS PEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Watershed Research Project</td>
<td>Students <em>designed and conducted an experiment</em> out in the watershed. They started by <em>asking questions</em> (1) to develop a hypothesis. They <em>planned</em> (3) their field <em>investigation</em> and then <em>collected, analyzed, and interpreted the data</em> (4). They <em>constructed explanations</em> (6) and <em>communicated</em> (8) in both a group presentation and individual papers.</td>
<td>PE 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.</td>
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</table>
Research & Evaluation Principles

• Design-based approach
  – Iterative, responsive relationship between curriculum design and research development over multiple cycles of design, enactment, and reflection

• Quasi-experimental evaluation
  – Comparison of traditional and experimental courses using validated measures and observational tools

Design Based Approaches to Curriculum Reform

Classroom based, simultaneous integration of the designing of innovative educational environments and experimental studies of these innovations (Brown, 1992)

- Laboratory study findings alone limited in the ability to explain or predict learning in instructional settings
- Classroom based intervention research allows for fine-grained analysis of learning-in-context as well as a site to generate theories
- Engineering approach to design (Collins, 1992)
DBA Principles

• Integrating the goals of designing learning environments and developing theories of learning
• Using continuous cycles of design, enactment, analysis, and re-design
• Leading to shareable theories that can be used by both practitioners and other researchers
• Accounting for how design functions in authentic settings
• Relying on methods that appropriately connect aspects of the design with relevant outcomes

(DB research collective, 2003)
Is DBA a good choice for geoscience education research?

- Reliable methodological approach with 2+ decades of use
- Preserves values of contextual, situated educational research
- Most DB research comes from STEM educational research (science, mathematics, technology, learning sciences)
## Project Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Course Type</th>
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<tbody>
<tr>
<td>Winter 2017</td>
<td>Small traditional-format course</td>
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<tr>
<td>Spring 2017</td>
<td>Large traditional-format course, Small experimental-format course</td>
</tr>
<tr>
<td>Spring 2018</td>
<td>Large experimental-format course</td>
</tr>
<tr>
<td>Spring 2019</td>
<td>Large experimental-format course</td>
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</table>
# Measures

<table>
<thead>
<tr>
<th>Category</th>
<th>Measure</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td><strong>Content Knowledge</strong></td>
<td>Geoscience Concept Inventory (GCI)</td>
<td>Libarkin <em>et al.</em>, 2011; McConnell <em>et al.</em>, 2006</td>
</tr>
<tr>
<td><strong>Motivation to Learn Science</strong></td>
<td>Science Motivation Questionnaire (SMQ-II)</td>
<td>Glynn <em>et al.</em>, 2011</td>
</tr>
<tr>
<td><strong>Self-Efficacy for Science Teaching</strong></td>
<td>Science Teaching Efficacy Beliefs (STEBI-B)</td>
<td>Enochs &amp; Riggs, 1990; Bleicher, 2004</td>
</tr>
<tr>
<td><strong>Active Learning</strong></td>
<td>Classroom Observation Protocol for Undergraduate STEM (COPUS)</td>
<td>Smith <em>et al.</em>, 2013</td>
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<tr>
<td><strong>NGSS Practices</strong></td>
<td>NGSS Practice Observation Protocol</td>
<td>Gallo-Fox <em>et al.</em></td>
</tr>
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</table>
Findings

• No pre-post or cross-group changes in motivation, self-efficacy (STEBI-B, SMQ-II)

• Significant pre-post changes in content knowledge, though no group differences (GCI)

• Student and instructor activities shift to active learning; more NGSS practices observed (COPUS, NGSS)
# DB Research Focus

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<tr>
<th>Design</th>
<th>Conjecture</th>
<th>Analysis</th>
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| S17 Pilot - all dimensions of active learning and reform | Experiencing active learning will increase PST learning along 3 dimensions of NGSS | - No change in learning, but change in activity  
- Note that Watershed Project is key event (NGSS) |
| S18 - scale up to large lecture format | Focus on discipline-specific NGSS will increase PST learning | - Increase in content knowledge  
- Target specific practices (planning, explanation) |
| S19 - support TA development - refine observation tool | Focus on discipline-specific NGSS will increase PST learning |  |
Where We Are

• Success in design
  – Curriculum content story more coherent, contextualized
  – Content and activities are NGSS-aligned
  – Shift toward active learning, less lecture, more discourse-focused

• Challenge in seeing impact
  – No significant changes in motivation, self-efficacy
  – Increases in content knowledge, but same across conditions
Lessons Learned

• Selective DBA within the larger instructional reform
  – Narrowing focus to NGSS Practices helped us find productive contributions to theories of learning

• Tensions between methods within mixed methods study
  – Challenge of preserving quasi experimental design within larger DBA
Lessons Learned

• DBA takes time
  – Challenge to collect, analyze, refine within timeline
  – Challenge to get enough cycles into a funding period

• Ultimately a beneficial methodology
  – Instruction responsive to research findings
  – Challenges researchers to consider what context demands of theory
World in a River Project Team

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