Geoscience Curriculum Reform Using a Design-Based Approach

Danielle Ford, Education

Susan McGeary, Geological Sciences

Jennifer Gallo-Fox, Human Development and Family Sciences

Cheryl Ackerman, Delaware Environmental Institute

The World in a River Project Goals

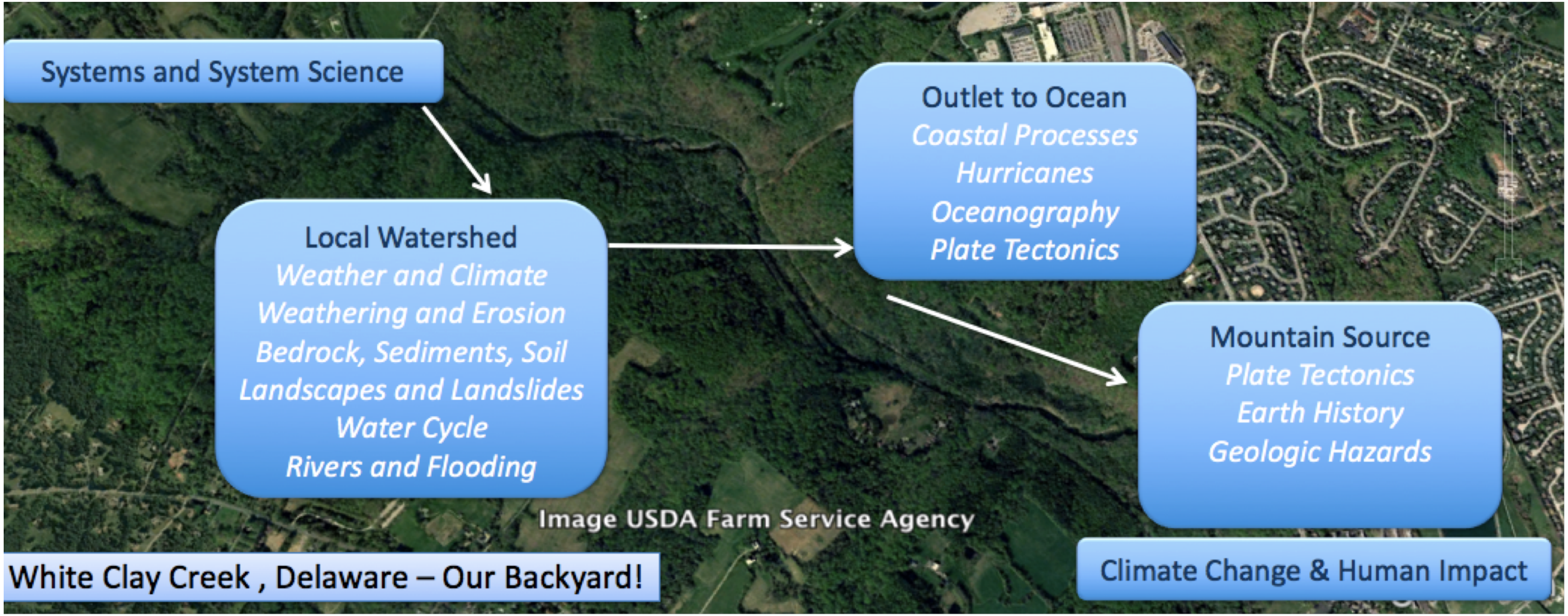
- Redesign large introductory Earth Science course for preservice teachers (PST)
  - Elementary and early childhood education majors
- Understand impact of course redesign on PST learning
  - On PST content knowledge, self-efficacy for science teaching, and motivation

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

NRC, 2012a, 2012b. Ausubel, 2000; Deslauriers et al., 2011; DeWitt & Osborne, 2007; Elkins & Elkins, 2007; Kern & Carpenter, 1986; Orion & Hofstein, 1994; NRC, 2000, 2005, 2007. Apple et al., 2014; Endreny, 2010; Semken & Butler-Freeman, 2008. Gill et al., 2014; Sinha et al., 2010.

Content Redesign – Watershed Story



Emphasis on Active, Place-based Learning and Real-time Data, Aligned with the NGSS

Project	NGSS SEPs	NGSS PEs
Group Watershed Research Project	Students *designed and conducted an experiment* out in the watershed. They started by *asking questions (1)* to develop a hypothesis. They *planned* (3) their field *investigation* and then *collected, analyzed, and interpreted the data (4)*. They *constructed explanations (6)* and *communicated* (8) in both a group presentation and individual papers.	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.

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

Brown, 1992; Collins, 1992; Design-Based Research Collective, 2003; Penuel et al., 2011. Creswell, 2003.

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

Winter 2017	Small traditional-format course	
Spring 2017	Large traditional-format course	Small experimental-format course
Spring 2018		Large experimental-format course
Spring 2019		Large experimental-format course

Measures

Content Knowledge	Geoscience Concept Inventory (GCI)	*Libarkin et al., 2011; McConnell et al., 2006*
Motivation to Learn Science	Science Motivation Questionnaire (SMQ-II)	*Glynn et al., 2011*
Self-Efficacy for Science Teaching	Science Teaching Efficacy Beliefs (STEBI-B)	*Enochs & Riggs, 1990; Bleicher, 2004*
Active Learning	Classroom Observation Protocol for Undergraduate STEM (COPUS)	*Smith et al., 2013*
NGSS Practices	NGSS Practice Observation Protocol	*Gallo-Fox et al.*

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

Design	Conjecture	Analysis
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

Susan McGeary (PI)
Geological Sciences

Danielle Ford (co-PI)
Education

Jennifer Gallo-Fox (co-PI)
Human Development & Family Sciences

Cheryl Ackerman (Evaluator)
Delaware Environmental Institute

Lauren Stegeman (Graduate Assistant)
Human Development & Family Sciences

This project is supported by the National Science Foundation, IUSE Program, Grant no. 1612007.