Fostering Undergraduate Students' Disciplinary Learning and Water Literacy

Cory Forbes[1,2], Nick Brozović[2,3] , Trenton Franz[1,2], Diane Lally[1], Destini Petitt[1]

University of Nebraska-Lincoln

[1]School of Natural Resources [2]Water for Food Global Institute [3]Dept. of Agricultural Economics

RATIONALE

- Water resource use and management is critical issue in the 21st Century - the 'Water Century' - in which "ensuring an adequate quantity and quality of freshwater for sustaining all forms of life is a growing challenge" (National Science Foundation, 2005, pg. 6)
- These challenges have led to increasing emphasis on systemic STEM education reform at the post-secondary level (National Research Council, 2012)
- Research has shown that water literacy in the United States remains underdeveloped
- Many studies of STEM-informed decision-making have been conducted at the K-12 level (Christensen & Rundgren, 2015; Eggert & Bögeholz, 2009; Grace, 2009; Grace & Ratcliffe, 2002; Gresch & Bögeholz, 2013; Gresch et al., 2013; Jime´nez-Aleixandre, 2002; Seethaler & Linn, 2004; Seigel, 2006) but fewer such studies have been conducted with undergraduate students (Halverson et al., 2009; Sadler & Zeidler, 2005)
- More work is therefore needed to understand of STEM-informed decision-making about water issues among undergraduate students

CONCEPTUAL FRAMEWORK

Water Literacy

An enhanced capacity, both at the individual and collective levels, to make effective decisions grounded in STEM-informed analyses of complex, real-world challenges associated with socio-hydrological systems

- Component of science literacy in the Food-Energy-Water-Nexus
- Grounded in broader perspectives on science literacy
  - Science education (Bybee, McCrae, Laurie, 2009; Feinstein, 2010; Rudolph, 2014)
  - Decision sciences (Arvai et al., 2004)

"Wide Dynamic" View of Interdisciplinary Teaching and Learning about Water

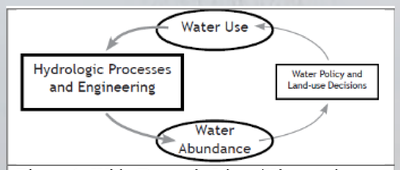

Figure 1: Wide Dynamic View (King et al., 2012)

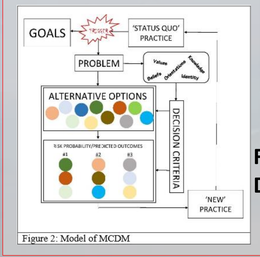

Figure 2: Model of MCDM

Framework for Multi-Criteria Decision-Making about Water Issues

PROJECT LOGIC MODEL

Project Goals

1. Support undergraduate students' learning to engage in STEM-informed analyses of socio-hydrological systems through instructional design
2. Empirical research to better understand the nature of, and strategies to support, undergraduate students' learning of disciplinary concepts and decision-making competencies

Inputs
Forbes & Brozovic (instructors)

Graduate student

Theoretical framework

Prior research

Institutional priorities

→

Course Elements
Structured decision-making tasks

Authentic, real-world challenges/problems

Decision-making heuristics

Instructional and curricular supports

→

Outputs
200 undergraduate students

Instructional materials and strategies

Results from empirical research

→

Outcomes

Short-term
Improved STEM-informed analyses of socio-hydrological systems (students)

Empirically- and theoretically-informed SCIL 109 course

Long-term
Improved science literacy in the United States

Increased capacity for fostering science literacy amongst undergraduates

←

↕ Project Research/Evaluation ↕

SCIL/AECN/NRES 109 – *Water in Society*

- New, interdisciplinary, introductory-level water course serving both STEM majors and non-majors at UNL
- General education course focused on global and local issues related to water and it's role in society
- Two course objectives:
  1. Explain fundamental hydrologic concepts and engage in scientific practices, including posing and answering scientific questions, exploring phenomena, analyzing and making inferences from data, and determining validity of conclusions
  2. Engage effectively in principled analysis of and reasoning about socio-hydrologic systems, including their scientific, ethical, social, economic, cultural, and civic dimensions, to make informed decisions about water issues
- General education requirements
  - ACE #4 - Use scientific methods and knowledge of the natural and physical world to address problems through inquiry, interpretation, analysis, and the making of inferences from data, to determine whether conclusions or solutions are reasonable.
  - ACE #8 - Explain ethical principles, civics, and stewardship, and their importance to society.
- Course highlights
  - Use computer-based models and simulations to learn core, introductory hydroscience concepts
  - Engage with contemporary economic, policy, social, and cultural dimensions of water
  - Benefit from expertise of scientific, communications, and industry experts
  - Use structured decision-making frameworks to propose solutions to local, regional, and global water challenges
  - Participate in site visits and field trips to local municipal water facilities
  - Work in small-group teams to conduct independent research
  - Present coursework to scientists, policymakers, and stakeholders at the Water for Food Global conference

RESEARCH

- DISCIPLINE- and DESIIGN-based education research (D^2BER)
- Iterative, empirically-based course development
- Research questions
  1. To what extent do undergraduate students learn to engage in more effective decision-making about socio-hydrological issues?
  2. How do undergraduate students engage in decision-making about socio-hydrological issues? Which course- and student-level factors influence their STEM-informed decision-making?
- Pre-/post-course evaluation
  - Assessment of core, introductory hydroscience concepts
  - *Inventories of Basic Dispositions* (IBD) for General Science
  - Decision making tasks
  - Clinical interviews

REFERENCES

- Christenson, N., & Rundgren, S-N.C. (2015). A framework for teachers' assessment of socio-scientific argumentation: An example using the GMO issue. *Journal of Biological Education, 49*(2), 204-212, DOI: 10.1080/00219266.2014.923486
- Eggert, S., Bögeholz, S. (2009). Students' use of decision-making strategies with regard to socioscientific issues: An application of the Rasch partial credit model. *Science Education, 2*, 230-258.
- Grace, M. (2009). Developing high quality decision-making discussions about biological conservation in a normal classroom setting. *International Journal of Science Education, 31*, 551–570. doi:10.1080/09500690701744595
- Grace, M.M. & Ratcliffe, M. (2002). The science and values that young people draw upon to make decisions about biological conservation issues. *International Journal of Science Education, 24*, 1157–1169. doi:10.1080/09500690210134848
- Gresch, H. & Bögeholz, S. (2013). Identifying non-sustainable courses of action: A prerequisite for decision-making in education for sustainable development. *Research in Science Education, 43*, 733-754.
- Gresch, H., Hasselhorn, M., & Bögeholz, S. (2013). Training in Decision-making Strategies: An approach to enhance students' competence to deal with socioscientific issues. *International Journal of Science Education, 35*(15), 2587-2607.
- Halverson, K.L., Siegel, M.A., Freyermuth, S.K. (2009). Lenses for Framing Decisions: Undergraduates' decision making about stem cell research. *International Journal of Science Education, 31*, 1249–1268. doi:10.1080/09500690802178123
- Jimenez-Aleixandre, M.-P. (2002). Knowledge producers or knowledge consumers? Argumentation and decision making about environmental management. *International Journal of Science Education, 24*, 1171–1190. doi:10.1080/09500690210134857
- King, E.G., O'Donnell, F.C., & Caylor, K.K., (2012). Reframing hydrology education to solve coupled human and environmental problems. *Hydrology and Earth System Sciences, 16*, 4023–4031.
- *National science education standards*. Washington, D.C.: The National Academies Press.
- National Science Foundation (2005). Complex environmental systems: Pathways to the future. Advisory Committee for Environmental Research and Education (AC-ERE). Washington, DC. National Research Council. (1996).
- Sadler, T. & Zeidler, D. (2005). The significance of content knowledge for informal reasoning regarding socioscientific issues: Applying genetics knowledge to genetic engineering issues. *Science Education, 89*, 71-93.
- Seethaler, S. & Linn, M. (2004). Genetically modified food in perspective: an inquiry-based curriculum to help middle school students make sense of tradeoffs. *International Journal of Science Education 26*, 1765–1785. doi:10.1080/0950069410001673784
- Siegel, M.A. (2006). High school students' decision making about sustainability. *Environmental Education Research, 12*, 201–215. doi:10.1080/13504620600689003

This material is based upon work supported by the National Science Foundation under Grant No. DUE-1609598. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. Contact cory.forbes@unl.edu.