Water in Society: Undergraduate Learning & Reasoning about Socio-hydrological Issues

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

University of Nebraska-Lincoln

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

WATER IN SOCIETY

- Introductory-level water course serving both STEM majors and non-majors focused on increasing student water literacy
- Course objectives: (1) Engage in Socio-hydrological reasoning to make informed decisions about water issues and (2) explain fundamental hydrologic concepts and engage in scientific practices
- Water literacy in the United States remains underdeveloped with many studies focusing on STEM-informed decision-making 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), however, fewer studies have been conducted with undergraduate students (Halverson et al., 2009; Sadler & Zeidler, 2005)

RESEARCH QUESTIONS & METHODS

- **RQ1**: At what level is students' knowledge of fundamental hydrology at the beginning and end of the semester? Does students' learning of hydrology concepts improve during the second iteration of the course?
  - Pre-test, post-test, and change scores (Fig. 3 and Fig. 4)
- **RQ2**:How did students perform on modeling tasks? What relationships are observed between students' model based reasoning about socio-hydrological issues and other student assessments? Do students improve on these tasks in the second iteration of the course?
  - Pre-test, post-test, change scores, Hydrogeology Challenge (Fig. 1), and Water Balance Model (Fig. 2)
- **RQ3:** How did students perform on QuASSR? What relationships are observed between students' SSR and other student assessments? What relationships are observed between students' SSR and the QuASSR subscores?
  - Pre-test, post-test, change scores, and QuASSR survey (Fig. 5 and 6)

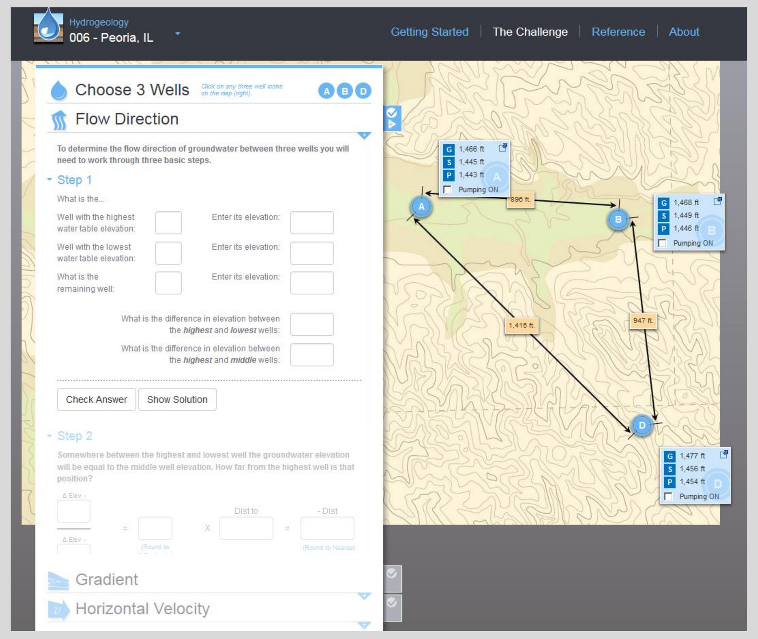
Figure 1: The Hydrogeology Challenge

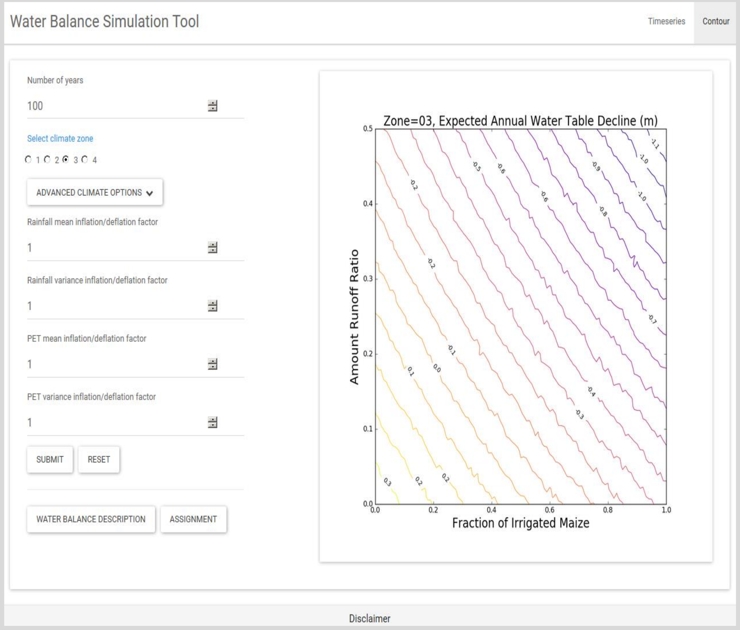

Figure 2: Water Balance Model

FINDINGS

RQ1:
- Students scored lower on the pre-test (*M* = .737, *SD* = 0.09) than on the identical post-test (*M* = .934, *SD* = 0.069).
- Paired t-test results indicate student scores on the pre-and post-test were statistically significant ($t(54) = -14.812$, $p < .001$, $d = 2.27$) (Fig 3).

RQ2:
Hydrogeology Challenge (HGC) (Fig 1, 4)
- There was a significant difference in performance on the HGC when compared to the post-test and change scores
- Results demonstrate no significant effect between the student tasks and the modeling task

Water Balance Model (WBM) (Fig 2, 4)
- There was a significant difference in performance on the WBM when compared to the pre-test, post-test, and change scores
- Results demonstrate a significant effect between pre-test and post-test scores and the modelling task.

RQ3:
QuASSR.
- There was a statistically significant difference between students performance on the pre/post and change scores when compared to their performance on the QuaSSR. However, results demonstrate there is no significant effect between the pre/post and change scores compared to the QuASSR (Figure 4)

Subscores
- Results of an ANOVA show there is a significant difference between the QuASSR subscores ((F(6,693) = 33.85, 6.59E-36) (Fig 6)
- Students scored highest on Perspective-Taking5 (Fig 5)
  - ($M = 3.45$, $SE = 0.10$)
- Students scored lowest on Skepticism (Fig 6)
  - ($M = 1.21$, $SE = 0.12$)

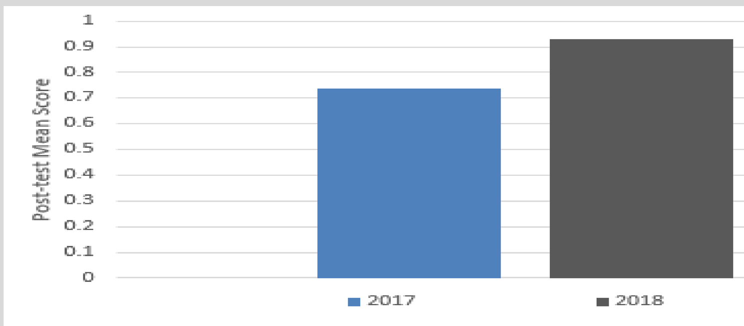

Figure 3: 2017 and 2018 post-test scores

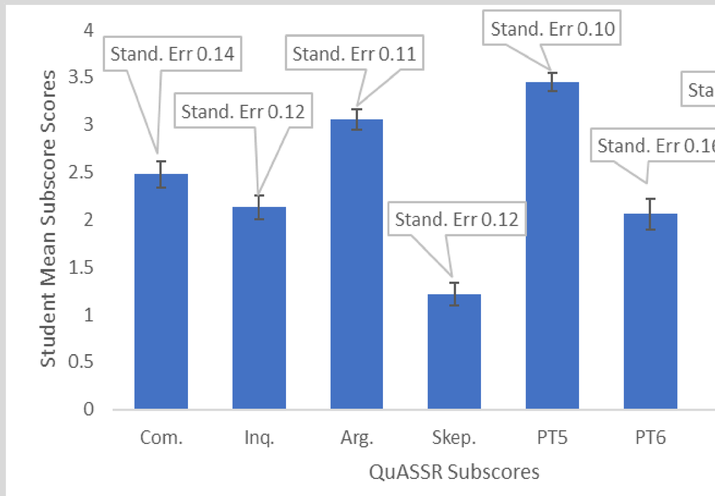

Figure 5: QuASSR subscore means with error bars

T.Test Table

Model	Pre-test	Post-test	Change Score
HGC	t (110) = .918 p = .180	t (110) =11.58 p = 9.07E-21	t (110) =13.94 p = 4.48e-26
WBM	t (107) = -2.32 p = 0.02	t (107) = 5.97 p = 3.1E-08	t (107) =13.43 p = 1.07E-24
QuASSR	t (172) = -10.14 p = 1.59E-19	t (123) = -18.87 p = 2.04E-38	t (197) = 16.29 p = 1.18E-38

Regressions Table

	Pre-test	Post-test	Change Score
HGC	R^2 = 0.015 F(1,53) = 0.83 p = 0.36	R^2 = 0.0001 F(1,53) =0.006 p = 0.93	R^2 = 0.012 F(1,53) =0.66 p = 0.41
WBM	R^2 = 0.054 F(1,53) =3.075 p =0.085	R^2 = 0.014 F(1,53) =0.789 p = 0.378	R^2 = 0.022 F(1,53) =1.199 p = 0.278
QuASSR	R^2 = 0.006 F(1,98) = 0.63 p = 0.43	R^2 = 0.01 F(1,98) = 1.09 p = 0.30	R^2 = 0.004 F(1,98) = 0.38 p = 0.54

Figure 4: Table of t.test and regression results

QuASSR Subscore ANOVA Table

	Com.	Inq.	Arg.	Skep.	PT5	PT6	Sci.Lim
Complexity	X						
Inquiry	P > 0.05	X					
Argumentation	p < 0.05	p < 0.05	X				
Skepticism	p < 0.05	p < 0.05	p < 0.05	X			
Perspective-Taking5	p < 0.05	p < 0.05	P > 0.05	p < 0.05	X		
Perspective-Taking6	P > 0.05	P > 0.05	p < 0.05	p < 0.05	p < 0.05	X	
Science Limitation	P > 0.05	P > 0.05	p < 0.05	p < 0.05	p < 0.05	P > 0.05	X

Figure 6: QuASSR subscore t.test results

IMPLICATIONS

- Students increased their hydrological knowledge over the course of the semester.
- Students need more support learning to use computer-based water models and in interpreting the results of the models. This could be achieved through more direct instruction of the models and iterative practice using the models prior to completing the summative assessment.
- Finding suggest there are differences in student understanding and retention between the two computer-based water models. More work needs to be done to unravel the reasons for these differences.
- In order to increase students socio-scientific reasoning, the nature of science should be the focus of science classrooms

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:10.1080/09500690410001673784
- Siegel, M.A. (2006). High school students' decision making about sustainability. *Environmental Education Research, 12*, 201–215. doi:10.1080/13504620600689003

Figure 8: Hydrogeology Challenge Link

Figure 9: Water Balance Model Link

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.