Use of a Water-Quality Themed Place-Based, Transformative Learning Experience to Support Student Interest Development, Self-Efficacy, and Knowledge Construction

Shondricka Burrell
Temple University
shondricka.burrell@temple.edu

Abstract

Geospatial data confirms that land use decisions have led to a disproportionate environmental risk to benefit ratio for poor and marginalized communities. Yet the children attending schools in these communities lack access to science curricula that facilitates learning the science content underlying their lived experience nor the investigative scientific practices to explore it. To address this gap in educational access, I propose a model of geoscience education grounded in the socio-cognitive constructs of interest development, self-efficacy, and knowledge retention, with each construct embedded within a water-quality themed transformative learning experience. Given recent cases of water quality in the greater Philadelphia area and nationally, this proposed model will (a) leverage the student's physical environment as both the context for learning Earth science and the science "laboratory"; (b) combine learning science content with the scientific practices of experimentation and investigation; and (c) frame Earth science as useful, relevant, and applicable. Using both quantitative and qualitative methods, I explore the following research questions: (1) for students who experience instruction that facilitates transformative learning, what are the pre to post differences in interest and self-efficacy to learn Earth science, perceived value and relevance of Earth science, knowledge and application of Earth science concepts?, and (2) do these learning outcomes differ for students who express more awareness of community level exposure to environmental hazard as compared to students who are less aware of community level exposure to environmental hazard?

Purpose

- To examine a 220-minute water quality themed academic intervention with respect to interest development, self-efficacy, perceived value and relevance of Earth science, and knowledge, in four school locations.

Research Questions

1. For students who experience instruction that facilitates transformative learning, what are the pre to post differences in interest and self-efficacy to learn Earth science, perceived value and relevance of Earth science, knowledge and application of Earth science concepts?
2. Do these learning outcomes differ for students who express more awareness of community exposure to environmental hazard compared to students who are less aware of community exposure to environmental toxins? (See Table 1)
3. What do students' written responses during transformative instruction reveal about their perceptions of value, relevance, and application of Earth science content?

Theoretical Framework

Interest
Self-efficacy
Transformative Experience

Conceptual Diagram

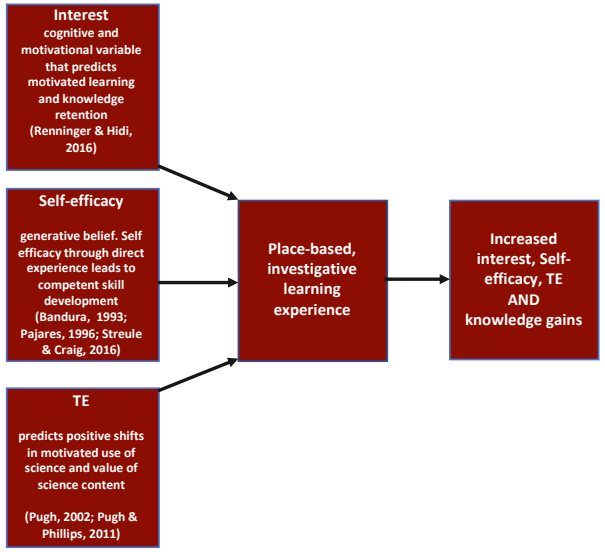


Table 1

Demographic statistics and environmental exposure to EPA-identified toxic chemicals for the counties of each school site

LOCATION	LW1	LW2	LW3	LW4	
POPULATION	771,410	2,188,649	10,163,507	129,046	Demographic Statistics
MEDIAN HOUSEHOLD INCOME	98,546	78,800	57,952	43,211	
PERSONS LIVING IN POVERTY (%)	6.6	9.3	16.3	19.2	
EDUCATIONAL ATTAINMENT (% HIGH SCHOOL GRADUATE OR HIGHER)	88.6	92.5	77.7	88.2	
SUPERFUND SITES	0	3	18	0	Statistics of community-level exposure to toxins
TOXIC RELEASE INVENTORIES FACILITIES (TRIs)	14	34	373	9	
TOTAL TOXIC WASTE DISPOSAL OR RELEASED (THOUSANDS LBS.)	363.5	506.6	7,200	.389	

Note. Source: US Census Bureau, compiled from https://www.census.gov and EPA data compiled from https://www.epa.gov

Methods

Participants

- High public school students enrolled in an Earth or environmental science course
- For $\alpha = .05$, $\eta_p = .3$ (medium effect size), and power of .9, minimum required *N* is 120

Methods cont…

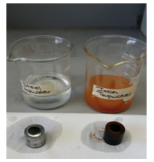
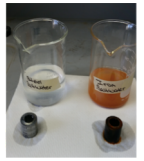
Data Sources

- Knowledge instrument (Likert-type scale items; 2015, 2017 Regents HS Examination of the NYS Education Dept. in Physical Earth Science)
- Learning experience survey (open response, Likert-type scale items)
  - Interest instrument, Cronbach's $\alpha = .752$ (acceptable reliability)
  - Self-efficacy instrument, Cronbach's $\alpha = .761$ (acceptable reliability)
  - TE instrument, Cronbach's $\alpha = .905$ (acceptable reliability)
  - Content validity established for each instrument
- Reflective prompts (*I CAN* statements…; Renninger et al., 2014)

Instructional Intervention

As part of the water-quality themed learning experience, students will work in collaborative learning groups to:

- Design a scientific investigation of a case of water quality based on the chronology of events of the Flint Michigan water crisis (Activity 1)
- Observe changes in two metals used in plumbing (iron and steel) when exposed to acidic solutions (Activity 2)


- Measure temperature, pH, and Total Dissolved Solids (TDS) of locally collected water samples (Activity 2)
- Compare water quality measurements to EPA standards (Activity 3)
- Compare community-level exposure to environmental toxins in 5 different locations (Activity 3)
- Summarize, interpret and present findings (Activity 4)

Table 2

Quantitative and qualitative methods

RQ	Methods of Analyzing Data	Anticipated Results
RQ1	Repeated measures ANOVA (on survey and knowledge instrument); Iterative qualitative content analysis of open-ended responses for emergent themes in evidence of interest, self-efficacy, and transformative learning experience (TE) (on survey) (Creswell, 2013) Iterative qualitative content analysis of written reflections in response to *I CAN* prompts (on intervention) for emergent themes in evidence of interest, self-efficacy, and transformative learning experience (TE) (Creswell, 2013)	Pre to post increases in interest, self efficacy, knowledge and TE (Baram-Tsabari, 2015; Blake, Liou-Mark & Lansiquot 2015)
RQ 2	Historic land use maps; geospatial mapping of CERCLA identified sites (Superfund sites) and TRI facilities	Greater gains for students who express awareness of community level exposure to environmental toxins (Basu & Barton, 2007)
RQ3	Iterative content analysis analysis of written reflections in response to I CAN prompts (on intervention) for emergent themes in evidence of interest, self-efficacy, and transformative learning experience (TE) (Creswell, 2013)	Pre to post increases in interest, self efficacy, knowledge and TE (Renninger, Austin, Bachrach, Riley & Stevens, 2014; Renninger & Riley, 2015)

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Please direct inquiries about this research project to Shondricka Burrell at shondricka.burrell@temple.edu

College of Education TEMPLE UNIVERSITY