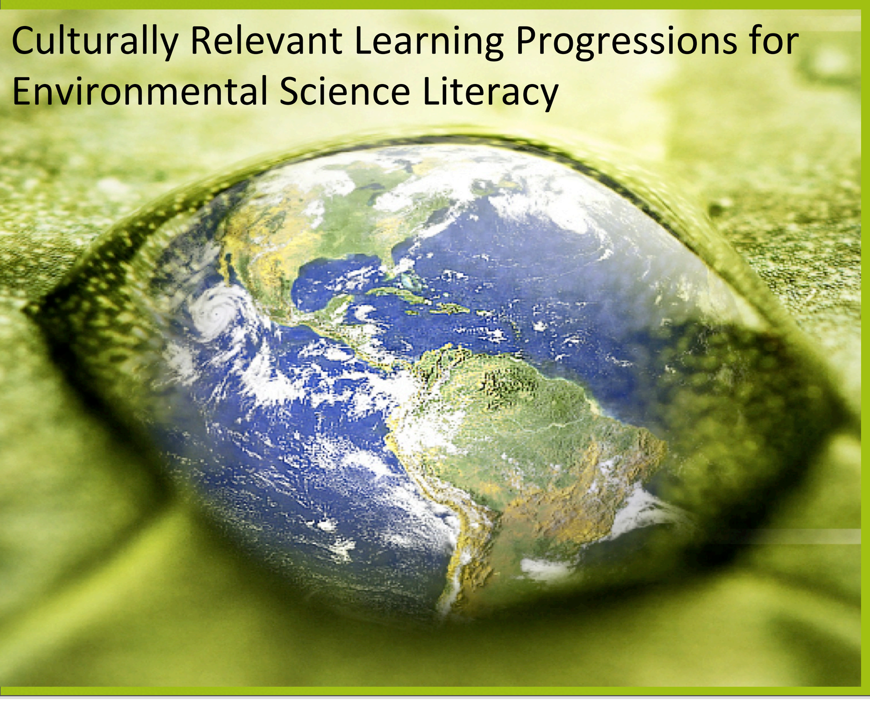


Culturally Relevant Learning Progressions for Environmental Science Literacy

A Learning Progression-based Biodiversity Teaching Unit: Investigating the impact of Teacher Knowledge and Implementation Fidelity on Student Learning

Laurel Hartley[1,D], Jennifer Doherty[2,B], Cornelia Harris[3,A], John Moore[4,D], Alan Berkowitz[3,A], Andy Anderson[5,B],

University of Colorado-Denver[1], University of Washington[2], Cary Institute of Ecosystem Studies[3], Colorado State University[4], Michigan State University[5]

B KBS LTER

D SGS-LTER

A BES

C

Introduction

Our goal is to develop a learning progression to describe how grade 6-12 students reason about the composition and function of ecosystems. Our research has involved developing frameworks, assessments, and a teaching unit. Here we explain the development and testing of a teaching unit we designed to give students experiences with the natural world (a local stream) and move them up in the learning progression.

Research Question:

What explains differences in student learning gains after participation in a teaching intervention?

- Student Level Variables: grade level, performance on pre-test
- Class Level Variables: teacher content knowledge, fidelity of implementation, whether teacher looked at student pre-test, whether students participated in a field trip, whether the unit was linked to a local environmental issue

Background: The LP Framework

The Learning Progression Framework: Our learning progression framework describes how students reason about settings, interactions, and change over time in ecological systems. Our intervention was designed to help students move upward in the learning progression.

Progression of Ideas about Structure of an Ecological System

Level	On what scale does the student focus?	How does the student describe the environment?	How does the student describe interactions among system components?
Low	Individual and immediate surroundings	In terms of general suitability; "likes" with fuzzy distinctions between biotic and abiotic factors	Describes direct interactions only, using many anthropomorphic analogies
Middle	Single populations	In terms of specific abiotic factor and tolerance ranges of organisms	Describes indirect interactions with links to population regulation
High	Multiple scales	With rich abiotic descriptions including spatial and temporal variation	Describes relative strengths and changes in interactions over life stages, space or time

Progression of Ideas about Change in an Ecological System

Level	On what scale does the student focus?	How does the student describe causes of change?	How does the student describe ecosystem responses to change?
Low	Individual and immediate surroundings	Describes change as result of free will of organisms, actions of humans, or disruption to the "natural order"	Describes ecosystem responses in overly simplistic terms (e.g. everything will go extinct or organisms will all "adapt"/learn)
Middle	Single populations	Describes change as an "event" with various causes	Describes adaptation with incomplete understanding of natural selection. Uses ideas about functional redundancy when making predictions
High	Multiple scales	Describes change as the result of events, stochastic factors, variability over time and space, or collective actions of multiple organisms	Describes responses to changes as dependent on genetic variation in a population, relative pace of change and the surrounding matrix

This project is supported by a Math Science Partnership Grant from the National Science Foundation DUE 0832173. Any opinions, finding, and conclusions or recommendations are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Background: The Teaching Intervention

We created ~2 week stream teaching unit in which students 1) explored functional and taxonomic diversity, 2) learned about food web relationships, and 3) learned about the ways in which abiotic and biotic factors determine what organisms are present in a community.

Lesson	Purpose	Time
1. What lives in leaves in a stream? Experiment design	Engage prior knowledge about how organisms interact with the abiotic environment around them (incl. dispersal) and why they think communities are structured the way they are.	45 min
2. What lives in leaves in a stream? Experiment	Engage students in setting up the experiment.	25 min
3. What lives in leaves in a stream? Making a stream food web poster	Engage prior knowledge about how organisms interact (focusing on food webs) and why they think communities are structured the way they are.	45 min
4. What is biodiversity?	Engage students in biodiversity in their schoolyard and help them explain the components of biodiversity (richness, evenness, and abundance) and why they are important.	45 min
5. What lives in leaf packs? Macroinvertebrate data collection.	Explore macro-invertebrate diversity living in leaf packs.	90 min
6. Who eats whom?	Explain how macroinvertebrates interact with other organisms while getting food. Explain how an organism's mouthparts affect how it obtains food, and how this feeding affects the abiotic environment.	45 min
7. Exploring Your Data	Explore leaf pack data and Explain why the communities are they way they are, including a discussion of functional redundancy.	45 min
8. What lives in leaf packs?	Explore microorganism diversity living in the packs. Explain how decomposition works and affects the abiotic environment.	90 min
9. How are organisms related?	Explain how organisms found in leaf paks are related and classified.	45 min
10. Disturbance and Dispersal	Explain how an organism's traits influences how it interacts with specific parts of the abiotic environment using the interactions process tool.	45 min
11. Who eats whom? Revisited	Explain the feeding groups of major organisms in a freshwater stream, and how different types of feeding can change the abiotic environment to influence other organisms.	45 min

Research and Analysis Methods

We report results from pre-post testing of students and make sense of results based on metadata about individual students, their teacher's content knowledge and classroom-level implementation of the teaching unit.

Teaching Training, Support, and Feedback: Teachers who implemented the teaching unit attended a week-long summer institute. During the school year, teachers kept a detailed log of which specific activities they used, when they used them, how they used them, and why they used or omitted specific activities.

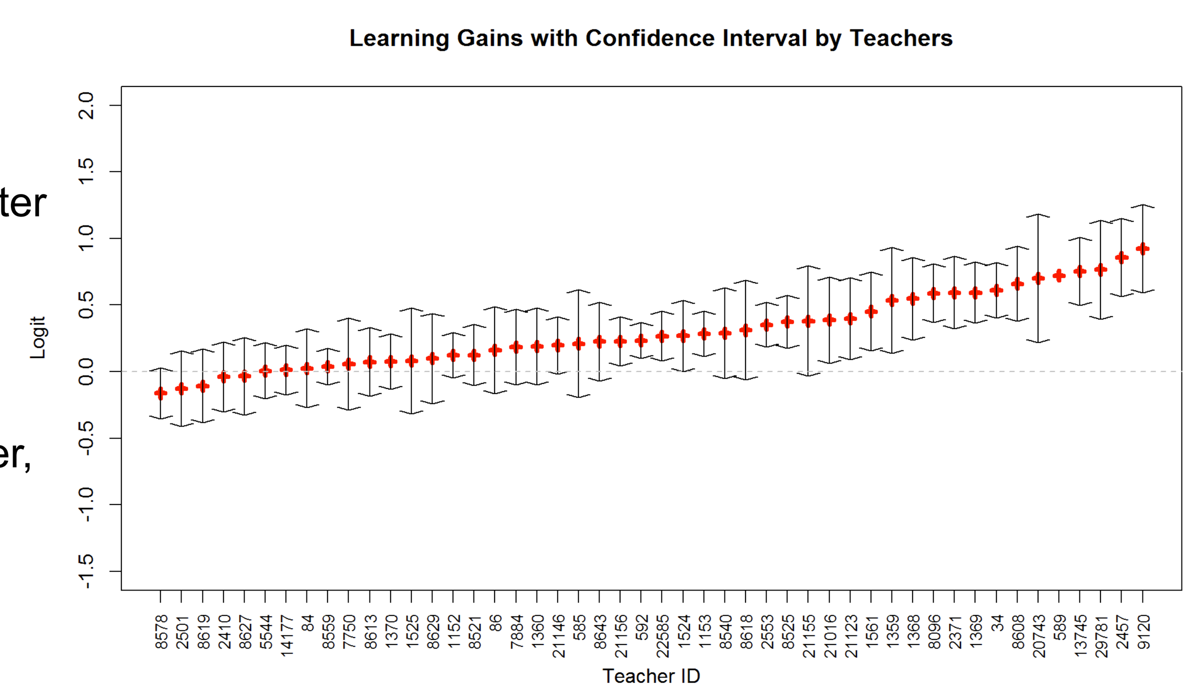
Written Assessments: We administered written assessments to students (N = 3393) in five states (CA, CO, MD, MI, and NY) before and after their participation in a two-week teaching unit. Items asked students to address recognition of biodiversity and three concepts that ecologists view as the drivers of community assembly: biotic interactions, abiotic constraints, and dispersal of organisms. We used a subsample of student answers from all grade levels to develop a four-level coding rubric that was iteratively refined until two coders reached 90% agreement. A single researcher coded all student answers and a second researcher coded 10% of the answers to ensure inter-rater reliability.

Data Analysis: We used data for classes (N = 40) in which students completed both the pre and post assessments. We used a paired t-test to compare the mean EAP scores for student pre and post testing. We used multi-level modeling in R (n = 23 classes) to examine student post instruction EAP as a function of student-level and classroom level variables including the following:

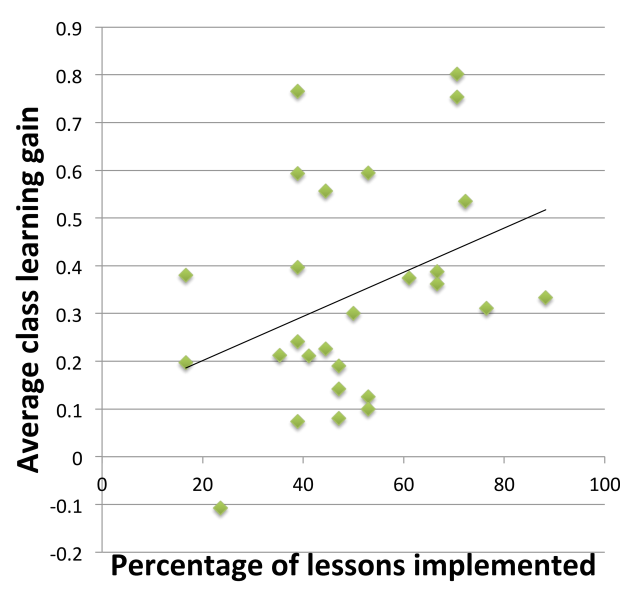
- Student Level Variables: grade level, pre-test EAP
- Class Level Variables: teacher content knowledge (EAP), whether teacher looked at student pre-test, whether students participated in a field trip, whether the unit was linked to a local environmental issue, % of core lessons implemented, % of optional lessons implemented, % of total lessons implemented

Results

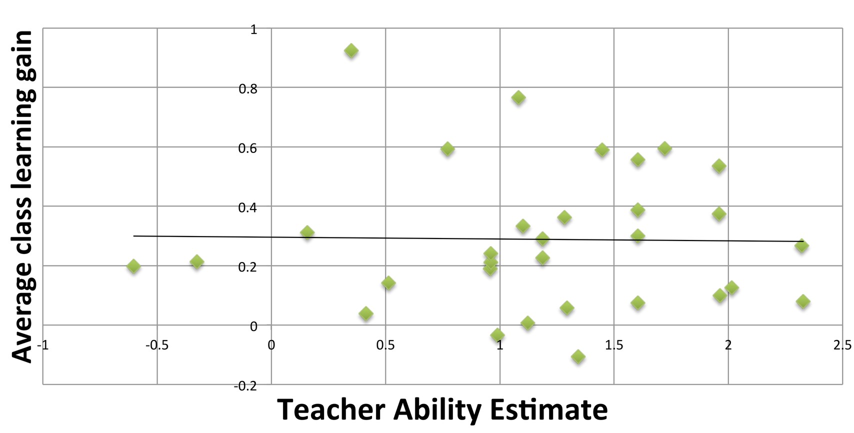
Students performed signigicantly better on the post-test than on the pre-test ($t = 13.78$, $df=1416$, $p = 2.2e^{-16}$). However, learning gains varied by class.



Learning gains were higher in classes where a higher % of lessons were implemented.



Average class learning gains were not related to teacher content knowledge.



In the two-level model, class accounted for 32% (ICC = 32.12%) of the variation and the student-level variables accounted for an additional 16% of the variation in post-test scores. Student pre-test score, student grade level, and percentage of all lessons implemented were the significant factors that accounted for the bulk of variance in post-test score. Teacher ability estimate was not a significant factor.

	Estimate	Std. Error	t value
intercept	-1.172	0.277	-4.226
Student pre-test EAP	0.463	0.038	12.155
Teacher EAP	-0.127	0.068	-0.188
% of all lessons implemented	0.007	0.003	2.190
Version (2012 or 2013)	0.155	0.092	1.686
grade level	0.105	0.023	4.647

Conclusions and Implications

An understanding of the structure and function of ecological communities is critical because humans are altering ecosystems to an unprecedented extent, resulting in both press and pulse disturbances We believe we have made significant progress in:

- describing how students reason about communities and ecosystems
- developing useful ways of assessing this complex subject.

We have demonstrated that a learning progression framework can be a powerful tool for designing teaching units. Questions remain about how to help students at different levels learn from the same contextual experience, teachers' motivations for implementation decisions, and how to help teachers understand the links between the LP and the lessons.