Empirical Validation of a Learning Progression
(Using the BEAR Assessment System)

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Abstract

Over the past several years, we have been working with the **Environmental Literacy** group at Michigan State University (see Mohan et. al in this symposium) on the development of a learning progression for the **Carbon Cycle**. In this poster, we will discuss our process of empirically validating this learning progression.

The Michigan State group has collected assessment data from elementary, middle, and high school students to better understand how students explain the role of carbon in biogeochemical processes. Like other learning progressions, we used assessment data to develop potential upper and lower anchors for a carbon cycle learning progression and focused our analysis on identifying intermediate stages between those two anchor points. We apply **item response modeling techniques** and **graphical methods** to investigate the levels of the learning progression and the average performance levels of students at various grade levels.

Introduction

Overview of the Carbon Cycle Project

- A part of the NSF-funded **Environmental Science Literacy Project** that aims to integrate Environmental Science Literacy into contemporary K-12 curriculum
- Expected products are 1) research-based learning progressions, 2) assessment resources, and 3) teaching resources

The BEAR Assessment System (BAS)

- Four building blocks (or principles) that are aligned with National Research Council (2001) assessment triangle

[NRC] [BAS]

- An iterative approach that not only enables inference about a construct, but also guides to the building of a sound assessment system to measure that construct

Research Questions

- What are the empirical **procedure to validate learning progressions** for the Carbon Cycle project?
- What does the empirical **evidence** look like?
- What **criteria** can we get to test?

Process of Validation

Construct Map Building theTheory of Learning Progression

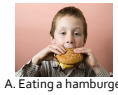
- Current Learning Progression Framework for the Carbon Cycle

Levels of Achievement	*Progress Variables (Carbon-transforming processes)*				
	Photosynthesis	Transformation of organic carbon	Cellular Respiration	Combustion	Large-scale processes
5: Qualitative model-based accounts	***Learning performances*** for specific processes and Levels of Achievement: Accounts of processes in socio-ecological systems				
4: "School science" narratives					
3: Events with hidden mechanisms					
2: Event-based narratives	* Many versions have been continuously questioned and modified				
1: Human-based narratives					

Items Design Designing the Stimuli to Observe Student Performances

- An example item designed to provoke student performances at different developmental levels of understanding three processes

DIFEVENTS (EMH) – similar or different events?


A. Eating a hamburger


B. Filling up a car with gasoline


C. Watering plants

The pictures above show that three things are happening. Are they alike or different? Please explain your answer.

A scientist says that A and B are similar events, but picture C is different from A and B. Do you know why? Please explain why C is different from A and B.

Outcome Space Making Sense of the Observations

- Defining "characteristics of responses", a set of finite, exhaustive and research-based categories to sort the responses and then score the responses to represent certain location of the construct

DIFEENTS		Scores
Characteristics of Responses	**Exemplar Responses**	
Recognizes that foods and fuels are energy sources and trace energy separately from matter.	only A and B beacuse these are both forms to restore energy. I think it is because C is a source to make the restore of the energy work. plants need water and Co2 to make Glucose and O2. Plants use glucose as energy therefore watering the plants doesn't give them energy but helps them to make energy source	5
Recognize that foods and fuels are different from water and attempt to trace energy, but cannot successfully trace energy separately from matter.	All the events are alike because they are both absorbing energy the boy is eating a hamburger for energy. The car is taking in gas. So it can run. And the plant are absorbing water so the plant can give off oxygen I think this because A and B are taking the energy and using it for them selves but C is taking energy and giving it off as oxygen.	4
Identify feeding or eating as a way to provide energy/matter for bodily function, but does not recognize any changes of matter/energy associated with the event.	These three events are alike Because al 3 are Basically eating But in different ways. Because we eat food, car's eat gasoline, and Plants get fed with water! Maybe because people can drive cars and plants can't!	3
Describe behaviors and do not recognize that these three events provide energy/matter.	They are alike because they all use your hands I don't know why.	2 and/or 1

Empirical Evidence

Measurement Models Evaluating Models for Analysis & Inference

- Item Response Modeling technique allows you to make inference about not only a construct, but also the characteristics of both the students and the assessment items, and the relationship between them
- A variety of models to choose from, based on the data and the research questions
- The simplest Rasch model: $P(Y_{pi}=1|\theta)=\frac{\exp(\theta_p-\beta_i)}{1+\exp(\theta_p-\beta_i)}$

Item Response Model Estimates

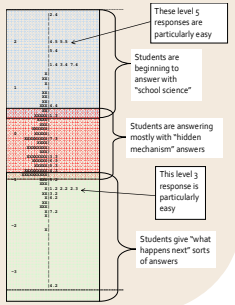
- **Person ability (θ_p)** estimates tells you the location of each person on the learning progression
- **Item difficulty (β_i)** estimates tells you whether your items tapped the levels of achievement as you planned
- **Reliability** coefficients tells you how reliable your estimation of person abilities is
- Other things that you can get from more complex models:
  - ✓ **Item-person interaction** effect (DIF) on the responses
  - ✓ Effect of the **characteristics of items** on the responses
  - ✓ Effect of the **characteristics of persons** on the responses
  - ✓ **Multidimensional structure of person abilities** related to the assessment

Fit Statistics

- **Model fit** to the dataset
- **Item fit** tells you how well the model explains each item
- **Person fit** tells you how well the model explains each person

Graphical Results

- **Wright Map** helps you to compare the distributions of persons and items on the same scale



More to come..

More Information

- **Environmental Literacy website**
  - http://edr1.educ.msu.edu/EnvironmentalLit/index.htm
- **Berkeley Evaluation and Assessment Research (BEAR) Center**
  - http://bearcenter.berkeley.edu

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