Examining a Process for Developing a Learning Progression for Sea Level Rise

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Why Sea Level Rise (SLR)?

- A major impact of climate change.
- Little research on student understanding of SLR.
- Highly relevant to students in MD and DE.

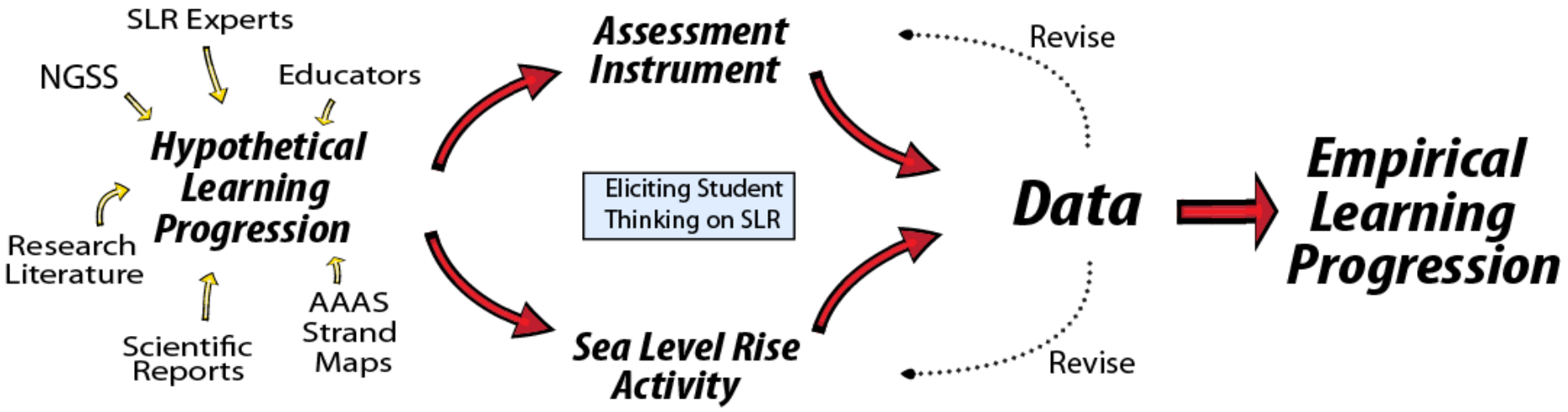
Research Question

How can learners come to understand sea level rise in a progressively more sophisticated manner?

Goal

Develop an empirically supported learning progression (LP) on sea level rise, proceeding from a hypothetical LP to an empirical LP.

LP Research Design Model



Literature

The Next Generation Science Standards, and the literature on conceptual change and alternative conceptions contributed predominately to the development of our hypothetical learning progression and our assessment instrument used to gather data on learners' thinking of SLR.

Climate Change Alternative Conceptions

Alternative Conceptions	Study
Global warming is caused by a hole in the ozone	Dove (1996); Ekborg and Areskoug (2006); Hestness et al. (2011); Lambert et al. (2012); Matkins and Bell (2007); Michail et al. (2007); Papadimitriou (2004); Wise (2010)
Global warming causes skin cancer	Dove (1996); Ekborg and Areskoug (2006); Groves and Pugh (1999); Michail et al. (2007)
The greenhouse effect is caused by a lid or blanket that traps heat	Dove (1996); Ekborg and Areskoug (2006); Lambert et al. (2012); Papadimitriou (2004)
The carbon cycle acts like a filter that cleans the air	Lambert et al. (2012)
Confusion about weather vs. climate	Lambert et al. (2012); Papadimitriou (2004)
Greenhouse gases are "trapped" in the atmosphere	Lambert et al. (2012)
Global warming will cause decreased precipitation (drier conditions) in all locations	Dove (1996)
Global warming will enhance photosynthesis through increased solar radiation	Dove (1996)
Climate change is controversial in the scientific community	Matkins and Bell (2007); Wise (2010)
Increasing the greenhouse effect would increase earthquake frequency	Groves and Pugh (1999)
Using unleaded gasoline can reduce the greenhouse effect	Groves and Pugh (1999)
Nuclear power or weapons contribute to the greenhouse effect as much as coal power	Groves and Pugh (1999); Papadimitriou (2004)
Environmental pollution generally causes global warming	Papadimitriou (2004)
Acid rain causes global warming	Groves and Pugh (1999); Papadimitriou (2004)
The greenhouse effect is unnatural	Matkins and Bell (2007); Michail et al. (2007)

Hestness, E., McDonald, R. C., Breslyn, W., McGinnis, J. R., & Mouza, C. (2014). Science Teacher Professional Development in Climate Change Education Informed by the Next Generation Science Standards. *Journal of Geoscience Education*, *62*(3), 319-329.

Section of Initial Hypothetical LP

Mechanisms of Sea Level Rise

	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Potential SLR LP indicator based on Gunckel, Covitt, Salinas & Anderson (2012, p. 854) "SM" stands for scale and mechanisms	SM1: Students explain sea level rise on a macroscopic scale only, focusing on immediately visible structures or phenomena without including mechanisms for phenomena.	SM2: Students explain sea level rise on a broad macroscopic to large-scale focus across familiar and visible dimensions. Students can identify a mechanism, though they rely on actors or agents.	SM3: Students explain sea level rise on the microscopic to the landscape scale, though they may refer to smaller particles such as atoms or molecules. Students are able to put events in order, but do not include driving forces or constraining factors.	SM4: Students explain sea level rise on the atomic-molecular scale. Students use driving forces (e.g. gravity), as well as constraining factors (e.g. topography) to explain changes in sea level.

Sea Level Rise Assessment Instrument

- Developed based on our hypothetical LP.
- Piloted with middle school students (N=60).
- Tested and revised with:
  - pre-service teachers (N=50)
  - in-service teachers (N=30)
  - middle school students (N=5)

- Received feedback from sea level rise experts (N=3).

Sea Level Rise Assessment Item

Description of Situation	The amount of greenhouse gases in the atmosphere is increasing.
Question	How is this related to sea level rise?
Select the ***best*** response.	***More greenhouse gases will lead to an increase in global temperature causing***: **A.** oxygen and nitrogen gases to dissolve in water, increasing sea volume. **B.** ice on land melting and thermal expansion of sea water, increasing sea volume. **C.** the number and size of water molecules to increase, increasing sea volume. **D.** the atmospheric pressure above the seas to increase and push water towards land.

Why is this the best explanation?

AAAS Project 2061, n.d.; Herrmann-Abell & DeBoer, 2008

Conditional SLR Learning Progression
Cause and Mechanisms

Causes and Mechanisms

	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Conditional SLR LP indicator about causes and mechanisms of sea level rise. Causes and Mechanisms	Students identify global warming due to the enhanced greenhouse effect as a cause of sea level rise.	Students recognize that global warming causes ice melt (not distinguishing between terrestrial and sea ice) leading to rising sea levels but do not identify thermal expansion as a factor in sea level rise. Students can identify a mechanism that relies on thinking about sea level rise anthropomorphically.	Students understand that sea level rise scenarios are based on thermal expansion and ice melt (not distinguishing between terrestrial and sea ice), though they do not consistently relate these factors to atomic-molecular models.	Students understand that sea level rise scenarios are based on thermal expansion and terrestrial ice melt, and they are able to explain these factors using atomic-molecular models consistently.

Thank you. Questions?

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Conditional SLR Learning Progression
Scale and Representations

Scale and Representations

	Level 1 (Lower Anchor)	Level 2	Level 3	Level 4 (Upper Anchor)
Conditional SLR LP indicator based on Scale and Representations of sea level rise. Scale and Representations	Students explain sea level rise on a macroscopic scale only, focusing on immediately visible structures or phenomena and are able to obtain useful information from representations related to sea level rise, although they do not connect these representations to the physical world.	Students explain sea level rise with a broad, large-scale focus across familiar and visible dimensions and are able to make limited connections between the physical world and representations related to sea level rise.	Students explain sea level rise on the landscape scale and are able to connect representations of sea level rise to the three-dimensional physical world, and begin to connect driving forces (e.g. gravity) or constraining variables (e.g. topography).	Students explain sea level rise on the macroscopic and atomic-molecular scale. Students use driving forces (e.g. gravity), as well as constraining factors (e.g. topography) to explain changes in sea level. They can interpret data from graphs and tables to describe varying projections of sea level rise.

Conditional SLR Learning Progression

Impacts

Impacts of Sea Level Rise

	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Conditional SLR LP indicator about impacts of sea level rise. Impacts	Students identify that an impact of sea level rise is that some land will be covered by water, though they are not able to elaborate on specific consequences of sea level rise.	Students understand that sea level is projected to rise in the future and are able to identify a limited number of specific consequences, though they do not understand that sea level rise will have local effects including those related to storm surge.	Students understand that local impacts of sea level changes can differ, but cannot explain primary factors that can cause this difference. Students are able to elaborate on specific consequences of sea level rise such as loss of habitat, in-land flooding during storms, property loss, and erosion.	Students understand that local sea level changes can differ from global trends based on regional variations in factors such as geographic uplift or subsidence and ocean currents. Students are able to elaborate on specific consequences of local sea level rise. Students recognize that sea level rise projections are based on available data and may be lower or higher than predicted.

New SLR Alternative Conceptions

- **Significance of Scale** of sea level rise.
- **Timeframe** over which sea level rise takes place.
- **Role of Ozone**