Examining Middle School Learners' Scientific Explanations about Sea Level Rise

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BACKGROUND

Using a case study methodology, our study investigated seventh grade students' construction of scientific explanations about sea level rise. Sea level rise is an increasingly important issue, especially for learners living in coastal areas. Learners living in coastal areas may have everyday knowledge of the effects of sea level rise, such as increased storm surge and flooding during severe weather events (National Climate Assessment and Development Advisory Committee, 2013). At the same time, the recently released Next Generation Science Standards (NGSS Lead States, 2013) are the first U.S. national science education standards to address the climate change topic explicitly. Additionally, the NGSS are innovative in that each disciplinary core idea is integrated with a scientific practice, such as constructing scientific explanations. Our study seeks to better understand how leaners are able to construct scientific explanations about sea level rise within the context of targeted classroom instruction.

RESEARCH QUESTIONS

How do seventh grade students construct scientific explanations about sea level rise?

STUDY CONTEXT

Our study context was seventh grade students (n = 28) taking a science course in a single middle school located in a Mid-Atlantic state during the 2014-5 school year. The middle school was a public school in a large school district serving students in grades 6-8. It was located in a suburban area just outside of a major city. School enrollment was between 700 and 800 students, with approximately equal division among the three grades. The school was racially and ethnically diverse, though Caucasian students made up just over half of the population. Hispanic, Asian, and African-American students also made up large percentages of the population (greater than 10% for each group). All students not taking a "self-contained" science course were enrolled in the same science course.

Seventh grade participants were learning about sea level rise as a real-world application of atomic-molecular theory and phase transitions in their science classes. Additionally, participants were developing their abilities to engage in the scientific practice of constructing explanations from evidence, as this was an instructional focus for science teachers at the school.

FINDINGS

Three themes emerged from the written assessment and interview data:

Quality and structures of scientific explanations*:* Participants' explanations varied in terms of the inclusion and coordination of evidence, claim, and reasoning.

- On the baseline written assessment (before targeted instruction):
  - 54% of participants provided sufficient evidence to support their claims
  - 88% of participants included reasoning about scientific principles to explain their claims
  - 65% of learners connected the claim and evidence using scientific principles.
- Second written assessment (after targeted instruction):
  - 91% of participants provided sufficient evidence to support their claims
  - 39% of participants included reasoning about scientific principles to explain their claims
  - 35% of learners connected the claim and evidence using scientific principles

Global warming and ice melt cause sea level rise: Many participants explained sea level rise in terms of increased temperatures and melting ice.

Global warming is making the Earth warmer, causing the ice caps to melt. After the ice caps melt, there will be more water in the ocean, causing sea levels to rise.
(participant response on baseline written assessment)

Alternative conceptions about sea level rise: Other participants explained sea level rise using alternative conceptions: (baseline written assessments)

- *Sea level rises due to the moon and polar ice caps*
- *The amount of rainfall and wind increases the sea level's hight.*
- *When waste goes into the sea, the sea level starts to rise due to the weight of the waste.*
- *The melting of ice berg (global warming in a sense) ice berg melt in the heat so where does the melted ice go? Exactly the ocean! the ocean takes all the water and with the extra water the ocean sea level rises.*
- *The ice in the north and south pole is melting, which makes there be an overall higher sea level. It is predicted that it will get at least a foot higher in 5 years.*

Two themes emerged when analyzing the classroom observation, written assessment, and interview data:

Thermal expansion: During the observed lesson, participants began to incorporate thermal expansion into their explanations about sea level rise.

Since Earth's temperature is rising, um, the water in the oceans is expanding. It's only expanding a little bit, but it's so much water, that it causes sea level rise.
(participant quote from classroom observation)

Students learn to incorporate authentic scientific data: During the observed lesson, participants learned to use data from climate change reports (e.g., IPCC, 2013) as evidence to support their claims.

Researcher: *How has sea level changed around the Chesapeake Bay over the past 50 years or so?*
Participant: *It has risen more than it was before 50 years, and that it's like not a small change, but also it's like a significant kind of change, according to the graph.*
(interview transcript)

RESEARCH DESIGN

Methods. Our data sources were two written assessments, classroom observations, and semi-structured interviews. The written assessments included scaffolding used in prior research (e.g., McNeill et al., 2006), prompting learners for claim, evidence, and reasoning. One of the researchers conducted semi-structured interviews with individual students. Interview questions were audio recorded and probed leaner thinking about constructing explanations about sea level rise, repeating and expanding upon questions from the written assessments. Interview data were triangulated with data from written assessments and observations.

Design. Prior to instruction about sea level rise, participants completed a baseline written assessment in which they constructed a scientific explanation to answer the question, what causes sea level rise. Two months later, we observed participants engaging in a lesson on constructing explanations about sea level rise, including the construct thermal expansion. At the conclusion of this lesson, participants completed a second written assessment, similar in structure to the baseline written assessment. Each participant responded to one of four prompts. One of these prompts was, "Write a scientific explanation that answers the question: How has the global average sea level changed over the past 50 years?" During the sea level rise lesson, learners watched and discussed two short video clips about thermal expansion. Then, learners worked in small groups to explore data (in the form of graphs) related to sea level rise. Finally, participants engaged in a whole class discussion about the graphs before completing the second written assessment. Following the lesson on sea level rise, a subset of participants participated in individual interviews.

CONCLUSIONS

In this study, we found that participants learned to incorporate thermal expansion and authentic scientific data into their explanations about sea level rise through targeted instruction. However, when learning to focus on authentic scientific data, participants relied on scientific reasoning to connect their evidence and claim to a lesser extent.

Many participants explained sea level rise using the constructs global warming and ice melt. However, many participants also held alternative conceptions about sea level rise. Rather than serving as obstacles for further learning about sea level rise, these alternative conceptions can be viewed as productive understandings that teachers can leverage during instruction.

IMPLICATIONS

This study provides the science education research community with a better understanding of the way that seventh grade students explain sea level rise. These explanations include both scientifically normative understandings about sea level rise and alternative conceptions about sea level rise. This study also demonstrates that seventh grade students can learn to incorporate both thermal expansion and authentic scientific data into their explanations after experiencing targeted instruction.

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