

Conceptual Challenges in Climate Change Education: Reasoning Across Time Scales

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Background/Question

There are many conceptual difficulties in understanding climate change. Some arise from the imbedded science concepts (e.g. Shepherdson, Choi, Niyogi, & Charusombat, 2009). Others relate to the inherent causal complexity, including domino, cascading, and cyclic causal patterns with feedback loops and tipping points. This complexity includes thinking about patterns of space and time very differently: analyzing at different scales; including spatial gaps and time delays; and monitoring steady states rather than focusing on event-based causality.

Students have difficulty reasoning about causal complexity (e.g. Chi, 2005; Grotzer, 2003; Hmelo-Silver & Pfeffer, 2004; Wilensky & Resnick, 1999) in the context of climate change (Grotzer & Lincoln, 2007; Sterman & Booth Sweeney, 2002). Reasoning about deep time is especially problematic (Dodick & Orion, 2003a; 2003b)—students have little notion of how to contrast concepts that happen over billions of years to those that happen in more familiar time spans. In the context of climate change, time scales impact how we interpret patterns and can influence whether people believe the scientific evidence relevant to climate change. In this work, we asked, “What kinds of learning supports can help students reason about climate change and deep time?”

Methods

Working with an eighth grade class (n = 24) in an urban, low SES, middle school, we investigated students’ understanding of events over time and how the time scale of the patterns that we see can influence our interpretations. In the context of a broader unit, students’ understanding of patterns of change in ecosystems was assessed. This included assessment of how they understood the relationship between balance and flux and whether they viewed balance as event-like or as a process that plays out over time.

Using a design research methodology, where instruction was designed to respond to students’ questions and difficulties of understanding, we documented class conversations and students’ individual responses to questions about time and scale. The students raised the following questions: “Why do some people think that climate change isn’t really happening?” “If it is so cold and snowy, how can climate change be happening?”

We introduced an analogous problem in which students contrasted three “snapshots” of the batting average of a Boston baseball player without knowing whose averages the data represented. In a similar manner, students contrasted snapshots of temperature patterns over time. The teacher then led a discussion analyzing each set of snapshots and contrasting them. We documented the class discussion and four students’ experience in the session and how their ideas shifted. We also introduced a homework assignment asking students to use what they learned in justifying a hypothetical drop in the pattern of their grades to see how students would respond.

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Copies of the research papers for the project can be downloaded from the Project Zero website at:
[http:// pzweb.harvard.edu/Research/UnderCon.htm](http://pzweb.harvard.edu/Research/UnderCon.htm)

Our teacher website is located at:
<http://www.pz.harvard.edu/ucp/causalpatternsinscience>

Time Span 1: 2003-2005

Year	Batting Average
2003	.325
2004	.308
2005	.292

1. How would you interpret this graph? What are your thoughts about this baseball player? I think that he is getting older which is making him worst at the sport.

1. How would you interpret this graph? What are your thoughts about this baseball player?
he is getting older and better, every year his batting average drops each year.

Time Span 2: 2003-2008

Year	Batting Average
2003	.325
2004	.308
2005	.292
2006	.321
2007	.296
2008	.332

2. How would you interpret the graph now? What are your thoughts about this baseball player? 1) doing worse. What he was getting was getting older I think that he was just getting more in shape. 2) getting more used to baseball. 3) becoming more focus. 4) practicing more.

2. How would you interpret the graph now? What are your thoughts about this baseball player?
this person had a really bad year and bad average, and now he hasn't had have a remarkable comeback and he may had have a lot of practice.

Time Span 3: 1993-2008

Year	Batting Average
1993	.170
1994	.269
1995	.308
1996	.309
1997	.328
1998	.294
1999	.333
2000	.351
2001	.306
2002	.349
2003	.325
2004	.308
2005	.292
2006	.321
2007	.296
2008	.332

3. How would you interpret this graph now? What are your thoughts about this baseball player?

I think that at some years he was probably going through a stress level but then later on he got more confident.

3. How would you interpret this graph now? What are your thoughts about this baseball player?
he is a good ball player he may have had some bad times/moments but then he came back better than ever with more confidence.

What Did the Students Say?

Students realized that a small glimpse could make the batter look bad, a little more information and he looked okay, and with a fuller picture, it was clear that he was a really good hitter. Even from the outset when given just three years of data, while students initially reacted with comments like “This guy can’t hit” or “He should be traded,” their interpretations were about what is happening over time:

“I think that this player is becoming worse. He is probably becoming older.”

“He may have been good when he first started playing, maybe he is getting weak.”

Their interpretations shifted with the amount of pattern that they had available to them, reflecting the increased amount of pattern revealed. The students did not ask for additional data. They were always very willing to interpret the amount of pattern in the graph. However, they referred to past and present factors in their interpretations (learning, getting weak, getting old).

“How did the activity affect your thinking?”

“I was surprised at how much my ideas changed. I didn’t think that he was a good player at first or maybe he was but was too old. The third graph showed how good he really was.”

“My reasons changed for what I thought each time. I was explaining the pattern but then the pattern looked different with more information. You can be wrong without even realizing why.”

“I thought he was really bad or having a bad year, but I couldn’t tell which, then I saw that there are ups and downs but he is a good batter.”

“If someone is learning something, it is important to look at what they do in a longer time, because they might get better.”

“It is really important to have enough information, you will get the wrong idea if you only have one or two examples.”

“With baseball, you can compare to other players, but with the Earth you don’t have other earths to compare it to really. How do you know what is good or bad, hot or cold?”

