Learning Sciences Research Team

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www.ClimateEdResearch.org; www.madeclear.org

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Learning Sciences Research Team

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Goal 2: Build and sustain the capacity of educators to deepen student understanding of climate change.

2.1: Infuse undergraduate and preservice teacher education with climate change science and its implications.

2.2: Enhance the climate change learning content of pre-service teacher preparation programs.

2.4: Include climate change in the in-service professional development for middle school teachers and informal educators.
Goal 3. Utilize learning principles and the sociocultural diversity of the region to develop effective, scalable, and transferable modes of climate change education.

Objective 3.1: Advance learning sciences research to create new understanding of how individuals from diverse backgrounds learn about climate change.

Objectives 3.2: Assess approaches to professional development that foster changes in teacher knowledge, skills, and dispositions.
Primary Research Questions

1. How is climate change education introduced and accommodated in the variety of learning environments in Maryland and Delaware? (SIP 3.1, 3.2)

2. How does climate change education vary depending on the cultural context: demography, geography, and risk to climate impact (e.g., sea level rise versus forest change) of the learning environment? (3.1)

3. How can we support the design of professional development programs that promote changes in teacher learning, instructional practice, and student beliefs around climate change? (3.2)
Research Question One

Investigation One

How is climate change education introduced and accommodated in the variety of learning environments in Maryland and Delaware?

**Investigation 1:** *Science Educators’ Conceptions of Climate Change and Learning Progressions in a Professional Development Academy on Climate Science Education*
Research Question One
Investigation One

**Context:** 5-day residential summer 2013 professional development Climate Science Academy - University of Delaware, Virden Center

**Participants (N=27):** Middle school (n=14), high school (n=7), higher education (n=2), informal science educators (n=4) from MD and DE

**During the Academy, participants:**
- Interacted with science content experts, learning sciences experts, and each other around climate change content and pedagogy issues (key topics: sea level rise, learning progressions)
- Developed climate change learning segments to implement in their diverse teaching contexts
**Research Question One**

Investigation One: Findings

**RQ:** How did participants evolve in their understandings of climate change through participation in the Academy?  
**Data source:** Climate Science Knowledge Inventory (CSKI) (Lambert & Bleicher, 2012)

**Key findings:**
- Overall improvement from pre (mean score: 9.6; S.D. = 2.5) to post (mean score: 10.8, S.D. = 1.8) [14 points possible]  
- Variable change in participants’ levels of content knowledge as measured by CSKI
Research Question One
Investigation One: Findings

RQ: How did participants’ understandings of learning progressions (LPs) inform their consideration of climate change teaching practices?

Data source: Individual interviews (What did you learn about how LPs can guide your teaching...?)

Key findings: Participants saw LPs as relating to:

1. Advancement of student understandings; often blended with participants’ existing theories of learning
2. Assessing student understandings; using LPs to gain insight into “where students are at”
3. Instructional planning; using LPs to discern “where you want students to go”
4. Instructional supports; using LPs to make decisions about differentiating instruction to scaffold student learning
Investigation Status:
- Presented findings at 2014 National Association for Research in Science Teaching (NARST) Annual International Conference (Pittsburgh, PA)
- Manuscript currently under review in the *Journal of Research in Science Teaching*

Next Steps: Disseminate findings to inform climate change education research and practice related to the professional development of science educators
How is climate change education introduced and accommodated in the variety of learning environments in Maryland and Delaware?

**Investigation 2:** Case studies of climate change education implementation in three middle school contexts
Study contexts:

<table>
<thead>
<tr>
<th>Delaware Middle Schools</th>
<th>Maryland Middle School</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Diverse urban, dual-language public charter school (57% Hispanic/Latino, 24% White, 15% African American, 3% Asian, 1% Hawaiian, Native American and Multiracial)</td>
<td>• Diverse suburban blended learning public charter school (57% Black/African American, 16% White, 14% Hispanic/Latino, 6% Asian, 7% Multiracial)</td>
</tr>
<tr>
<td>• Two 6&lt;sup&gt;th&lt;/sup&gt; grade science classes taught by one science teacher</td>
<td>• Five 6&lt;sup&gt;th&lt;/sup&gt; grade science classes taught by one science teacher</td>
</tr>
<tr>
<td>• Suburban public middle school: two 8&lt;sup&gt;th&lt;/sup&gt; grade science teachers.</td>
<td></td>
</tr>
</tbody>
</table>

Participants:

• DE: Science teachers (N=3); 6<sup>th</sup> grade students (N=42) and 8<sup>th</sup> grade students (N= 235)
• MD: Science teacher (N=1); 6<sup>th</sup> grade students (N=39)
**Research Question One**

**Investigation Two**

### Data sources:
Observations and field notes, artifacts (lesson plans, assignments), teacher interviews

### Preliminary findings:

<table>
<thead>
<tr>
<th>Delaware Middle School</th>
<th>Maryland Middle School</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Climate change introduced within 6th grade science unit on <em>Earth’s History and 8th grade weather/climate unit</em>.</td>
<td></td>
</tr>
<tr>
<td>• Instruction via traditional classroom setting. Teachers supplemented with online resources and interactive learning experiences.</td>
<td></td>
</tr>
<tr>
<td>• Climate change introduced within 6th grade science unit on <em>Weather and Climate</em></td>
<td></td>
</tr>
<tr>
<td>• Instruction via online curriculum; teacher supplemented with active learning experiences (in collaboration with researchers)</td>
<td></td>
</tr>
</tbody>
</table>
Investigation Two Status:
• Conference proposals submitted (AERA, 2016; NARST, 2016)
• Manuscript currently in production.

Next Steps:
Continue analyzing data collected in winter/spring 2015; write up findings for presentation and publication
Research Question Two

How does climate change education vary depending on the cultural context: demography, geography, and risk to climate impact (e.g., sea level rise versus forest change) of the learning environment? (3.1)

Investigation 1: Examining a Process for Developing a Learning Progression for Sea Level Rise
Research Question Two
Investigation One

Examining a Process for Developing a Learning Progression for Sea Level Rise
Research Question Two
Investigation One: Findings

Assessment Instrument and SLR Activity:

- 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).
Select Findings for *Impact of SLR Construct*

**Middle School Students**

In the Online SLR Activity, middle school students responded to the prompt “*Write down three things (or more) you already know about sea level rise...*” in a more limited manner citing melting of ice sheets, ozone as a cause of sea level rise, and global warming as a cause for sea level rise. For impacts the focus was on flooding and on polar bears and penguins.

**Elementary Science Methods Students (Preservice Teachers)**

<table>
<thead>
<tr>
<th>Impacts of Sea Level Rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooding (15)</td>
</tr>
<tr>
<td>Islands/Beaches/Land disappearing (12)</td>
</tr>
<tr>
<td>Erosion (10)</td>
</tr>
<tr>
<td>Property loss (6)</td>
</tr>
<tr>
<td>More powerful storms (6)</td>
</tr>
<tr>
<td>Coastlines under water (4)</td>
</tr>
<tr>
<td>Pop. near coast affected (2)</td>
</tr>
<tr>
<td>Communities will need to relocate. (2)</td>
</tr>
<tr>
<td>Land “sinks” (not subsidence) (2)</td>
</tr>
<tr>
<td>Human habitats affected (2)</td>
</tr>
<tr>
<td>Coastal cities uninhabitable. (1)</td>
</tr>
<tr>
<td>Threat to communities below sea level. (1)</td>
</tr>
<tr>
<td>Longer planting seasons. (1)</td>
</tr>
<tr>
<td>Negative impact on farmland/plants. (1)</td>
</tr>
</tbody>
</table>
Section of the Conditional SLR Learning Progression: 
*Impacts of Sea Level Rise*

<table>
<thead>
<tr>
<th>Level 1 (Lower Anchor)</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4 (Upper Anchor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential SLR LP indicator about impacts of sea level rise</td>
<td>I1: Students identify that an impact of sea level rise is that some land in coastal areas and islands will be underwater, though they are not able to elaborate on specific consequences of sea level rise.</td>
<td>I2: 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 change will have local effects including those related to storm surge.</td>
<td>I4: 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 sea level rise such as loss of habitat, in-land flooding during storms, property loss, and erosion.</td>
</tr>
</tbody>
</table>

“L” stands for impacts.

Investigation One Status: Currently under review in the *Journal of Research in Science Teaching*

Next Steps: Act on *JRST* reviewer instructions when received. Collect more empirical data from learners.
Research Question Two

Investigation Two

How does climate change education vary depending on the cultural context: demography, geography, and risk to climate impact (e.g., sea level rise versus forest change) of the learning environment? (3.1)

Investigation 2: Developing a Climate Change Learning Progression
## Research Question Two
### Investigation Two: Participants

<table>
<thead>
<tr>
<th>Category</th>
<th>DE</th>
<th>MD</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Student Interviews</td>
<td>12</td>
<td>14</td>
<td>26</td>
</tr>
<tr>
<td>Student Content Assessments</td>
<td>277</td>
<td>31</td>
<td>308</td>
</tr>
<tr>
<td>Classroom Observations</td>
<td>15</td>
<td>10</td>
<td>25</td>
</tr>
</tbody>
</table>
## Research Question Two
### Investigation Two: Preliminary Findings (MD Data)

### Table 1: Selected Student Climate Change Conceptions

<table>
<thead>
<tr>
<th>Conceptions</th>
<th>What Students Know</th>
<th>Prevalent and Persistent Alternative Conceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal of CO(_2) from Atmosphere</td>
<td>Plants absorb carbon dioxide for food (45% pre, 61% post).</td>
<td>CO(_2) escapes into space (29% pre, 26% post).</td>
</tr>
<tr>
<td>Ozone as Cause of Climate Change</td>
<td>Aware of ozone in atmosphere and of the ozone hole.</td>
<td>CO(_2) destroys ozone. (37% pre, 30% post). Intense storms related to ozone (42% pre, 26% post).</td>
</tr>
<tr>
<td>Nature of Climate Change Predictions</td>
<td>Aware that predictions may be lower or higher (pre 35%, post 45%).</td>
<td>“complete accuracy” (26% pre, 23% post) “uncertain ... based on scientists’ opinions” (pre 33%, post 33%).</td>
</tr>
<tr>
<td>Level 1 (Lower Anchor)</td>
<td>Level 2</td>
<td>Level 3</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Students are able to explain that human activity is contributing to a warming earth. Students may state that human activity is producing gases or air pollution but they do not relate this to CO₂ or use of fossil fuels.</td>
<td>Students are able to explain that human use of fossil fuels for energy generates CO₂ and is the primary cause of climate change. Students can explain that the ozone hole is not a significant factor in climate change.</td>
<td>Students are able to name specific fossil fuels (e.g. coal, oil, gas) and can distinguish between non-fossil fuel energy sources (nuclear, wind, solar).</td>
</tr>
</tbody>
</table>

*Impacts of Human Activity from the Climate Change Learning Progression*
Status:
• Data collection for middle students complete.
• Joint coding and analysis underway.
• Preparing manuscript submission for publication.

Next Steps:
• Extend data to include pre-service teachers.
• Complete and submit manuscript for publication.
How does climate change education vary depending on the cultural context: demography, geography, and risk to climate impact (e.g., sea level rise versus forest change) of the learning environment? (3.1)

Investigation 3: A sociocultural analysis of middle school learners’ climate change ideas and information sources
**Study contexts (case study schools):**

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<th>Delaware Middle School</th>
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<tbody>
<tr>
<td>• Diverse urban, dual-language public charter school (57% Hispanic/Latino, 24% White, 15% African American, 3% Asian, 1% Hawaiian, Native American and Multiracial)</td>
<td>• Diverse suburban blended learning public charter school (57% Black/African American, 16% White, 14% Hispanic/Latino, 6% Asian, 7% Multiracial)</td>
</tr>
</tbody>
</table>

**Participants:**

- **DE:** 6th grade students (N=13)
- **MD:** 6th grade students (N=15)

Selection based on the following factors, with effort to represent the diversity of the 6th grade students:

  - teacher recommendation (DE only), qualitative responses on content assessment, availability on interview dates
Data sources: Individual interviews with 6th grade students, classroom observations and field notes

Purpose: To gain potential insight into ways in which learners' cultural and regional contexts may influence their thinking about climate change.

Sample interview questions:
1. Have you ever heard of climate change? If so, how did you hear about it?
2. How do you think climate change relates to your life?
### Data analysis:

<table>
<thead>
<tr>
<th>Deductive Approach Phase (DAP)</th>
<th>Inductive Approach Phase (IAP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To gain insight into the ways learners’ ideas might reflect regionally-specific understandings of climate change, developed a deductive coding scheme derived from the National Climate Assessment (USGCRP, 2014) detailing climate change impacts in the NE U.S. region and along U.S. coasts.</td>
<td>Structural coding entails the use of questions to examine the data (Saldaña, 2012). Used to index and initially categorize portions of the data that provide insight into two focal questions:</td>
</tr>
<tr>
<td>Included regionally-relevant:</td>
<td></td>
</tr>
<tr>
<td>A. Physical impacts (e.g., sea level rise)</td>
<td>1. What are learners’ sources of information on climate change?</td>
</tr>
<tr>
<td>B. Ecological impacts (e.g. species change)</td>
<td>Structural code:</td>
</tr>
<tr>
<td>C. Social impacts (e.g., health)</td>
<td>¹SOURCES OF INFORMATION</td>
</tr>
<tr>
<td>D. Infrastructure impacts (e.g., roads)</td>
<td>2. How to learners see climate change as connected to their lives?</td>
</tr>
<tr>
<td>E. Economic impacts (e.g., agriculture)</td>
<td>Structural code:</td>
</tr>
<tr>
<td></td>
<td>²PERSONAL CONNECTIONS</td>
</tr>
</tbody>
</table>
Top codes:

**Public health and safety** (social impacts); focus on human injury, death, disease, scarcity of resources for survival

**Flooding** (physical impacts); focus on damage to houses, beaches, disruption to recreation

**Heat waves** (physical impacts); focus on personal experiences of hotter temps
Research Question Two
Investigation Three: Preliminary Findings

**Inductive approach – Information sources**

<table>
<thead>
<tr>
<th>Frequency of Inductive Codes</th>
<th>School</th>
<th>Internet</th>
<th>Family</th>
<th>Print media</th>
<th>TV</th>
<th>Other people (not family or teachers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>16</td>
<td>12</td>
<td>8</td>
<td>10</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

**Top codes:**
- **School:** Hearing about climate change in school; also informal conversations, language arts, projects for enrichment classes.
- **Internet:** Internet mentioned often as a source, but distrust of Internet also mentioned.
- **Print media:** Often referred to publications we inferred were read in school (Scholastic, Time for Kids, etc.)
Research Question Two
Investigation Three: Preliminary Findings

Inductive approach – Personal connections

Frequency of Inductive Codes (overarching categories)

Top codes:
**Recreation:** Focus on changes to beaches, ability to play outdoors

**Health/survival:**
Dehydration, spread of disease, injury, poor air quality, skin cancer (alt. conception)

**Driving:** Traveling often in cars

**Wasting energy:**
Focus on leaving lights and TVs on at home
Investigation Status:
• Data analysis in progress

Next Steps: Complete analysis for both sites; examine potential similarities and differences; write up and disseminate findings.

Collect more empirical data from MADE CLEAR participants' classrooms.
Research Question Three
Investigations One and Two

• How can we support the design of professional development programs that promote changes in teacher learning, instructional practice, and student beliefs around climate change? (3.2)
  – *Impact of the MADE CLEAR climate academy on teachers’ learning of content and pedagogical strategies for teaching climate change*
  – *Focal case study on the impact of the MADE CLEAR climate academy on teacher learning, classroom practice, and student attitudes towards climate change.*
Research Question Three
Investigations One and Two

• Study Context
  – MADE CLEAR hybrid professional development program

• Participants
  – Science educators in grades 5-16 (N=27), including 14 middle school, 7 high school and 2 higher education.

• Data Collection
  – Daily reflections on professional development activities
  – Instructional units on climate change developed during the professional development
Research Question Three
Investigations One and Two

• Findings
  – Teachers indicated learning new content related to:
    • Causes of climate change (88%)
    • Relation between carbon cycling and climate change (70%)
    • Impacts of climate change related to sea level rise (59%)
  – Teachers learned pedagogical strategies for teaching about climate change:
    • Familiarity with NGSS (53%)
    • Use of data and models (59%)
    • Integration of technological resources (70%)
    • Formative assessment practices (70%)
  – Teachers applied new learning in the design of instructional units
Research Question Three
Investigations One and Two

• Focal Case Study Context (teacher in 7\textsuperscript{th} and 8\textsuperscript{th} grades)
  – Sub-urban middle school
  – Teacher attended all professional development events

• Participants
  – Middle School teacher (N=1) and Students (N=150)

• Data
  – Classroom observations (N=12)
  – Teacher interviews (pre and post)
  – Student beliefs on climate change (Six Americas Survey) (pre and post)
Research Question Three
Investigations One and Two

• Teacher Findings
  – Teacher implemented content learned during the professional development (fossil fuels and CO$_2$ changes in levels of CO$_2$, ice melt and volume of water)
  – Teacher implemented pedagogical strategies for teaching about climate modeled during the professional development (use of physical models and data)

• Student Findings
  – Students appeared more aware about climate change and its importance in the post administration of the survey.
Research Question Three
Investigations One and Two
Research Question Three
Investigations One and Two

– Investigations One and Two Status
  • Manuscript currently under review in the *Journal of Science Teacher Education*
**Publications – Refereed Journals**


**Publications – Book Chapters**


Online products and publications


Presentations


Learning Sciences Research Team website:
www.climateedresearch.org
Post-Academy Participation

- Online professional learning community participation
- Saturday professional development sessions
- Submit final draft of lesson segment and a final reflection form

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