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www.ClimateEdResearch.org; www.madeclear.org

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Virden Center, 2013
Academy
Photo by Emily Hestness

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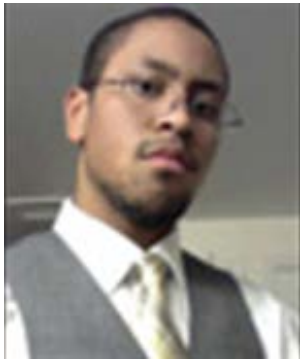


Will Lacy
Undergraduate Student

MADE CLEAR Strategic Implementation Plan: Goal Two

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.*

MADE CLEAR Strategic Implementation Plan: Goal Three

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*

SIP 3.2

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:

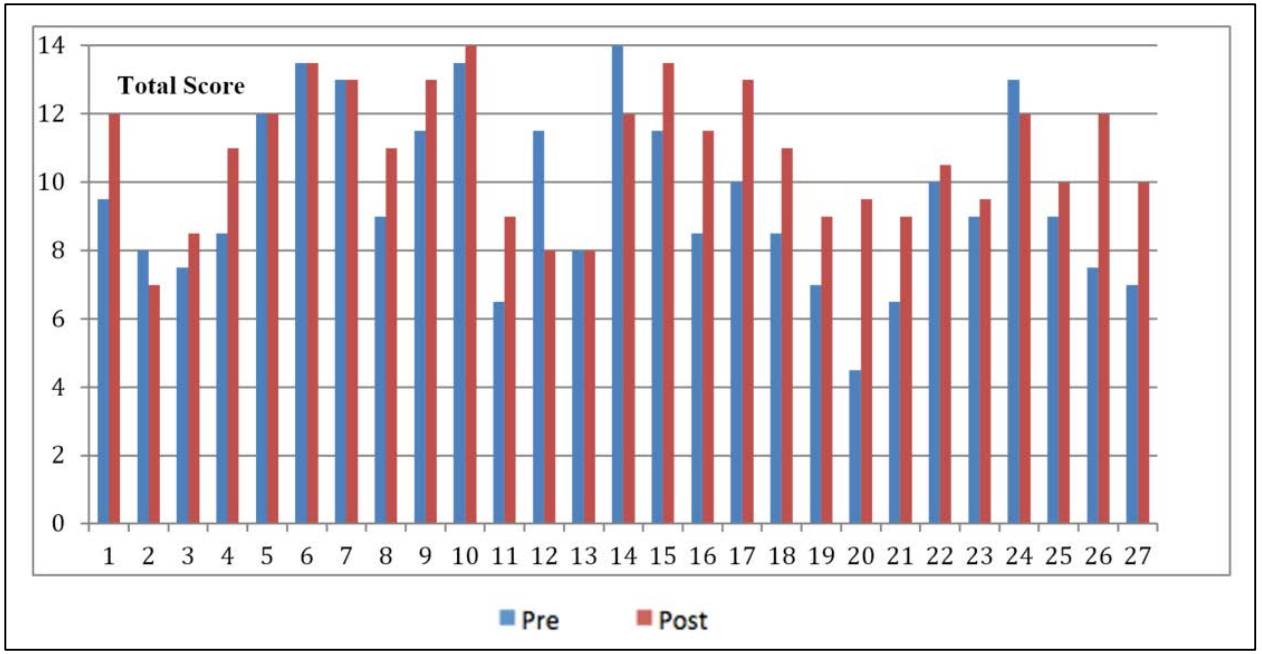
- Interacted with science content experts, learning sciences experts, and each other around climate change content and pedagogy issues (key topics: sea level rise, learning progressions)
- Developed climate change learning segments to implement in their diverse teaching contexts

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

Research Question One

Investigation One: Status and Next Steps

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

Research Question One
Investigation Two

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*

SIP 3.2

Research Question One

Investigation Two

Study contexts:

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

Participants:

- DE: Science teachers (N=3); 6th grade students (N=42) and 8th grade students (N= 235)
- MD: Science teacher (N=1); 6th grade students (N=39)

SIP 3.1

Research Question One

Investigation Two

Data sources:

Observations and field notes, artifacts (lesson plans, assignments), teacher interviews

Preliminary findings:

Delaware Middle School	Maryland Middle School
• Climate change introduced within 6th grade science unit on *Earth's History and 8th grade weather/climate unit.* • Instruction via traditional classroom setting. Teachers supplemented with online resources and interactive learning experiences.	• Climate change introduced within 6th grade science unit on *Weather and Climate* • Instruction via online curriculum; teacher supplemented with active learning experiences (in collaboration with researchers)

SIP 3.1

Research Question One

Investigation Two: Status and Next Steps

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)

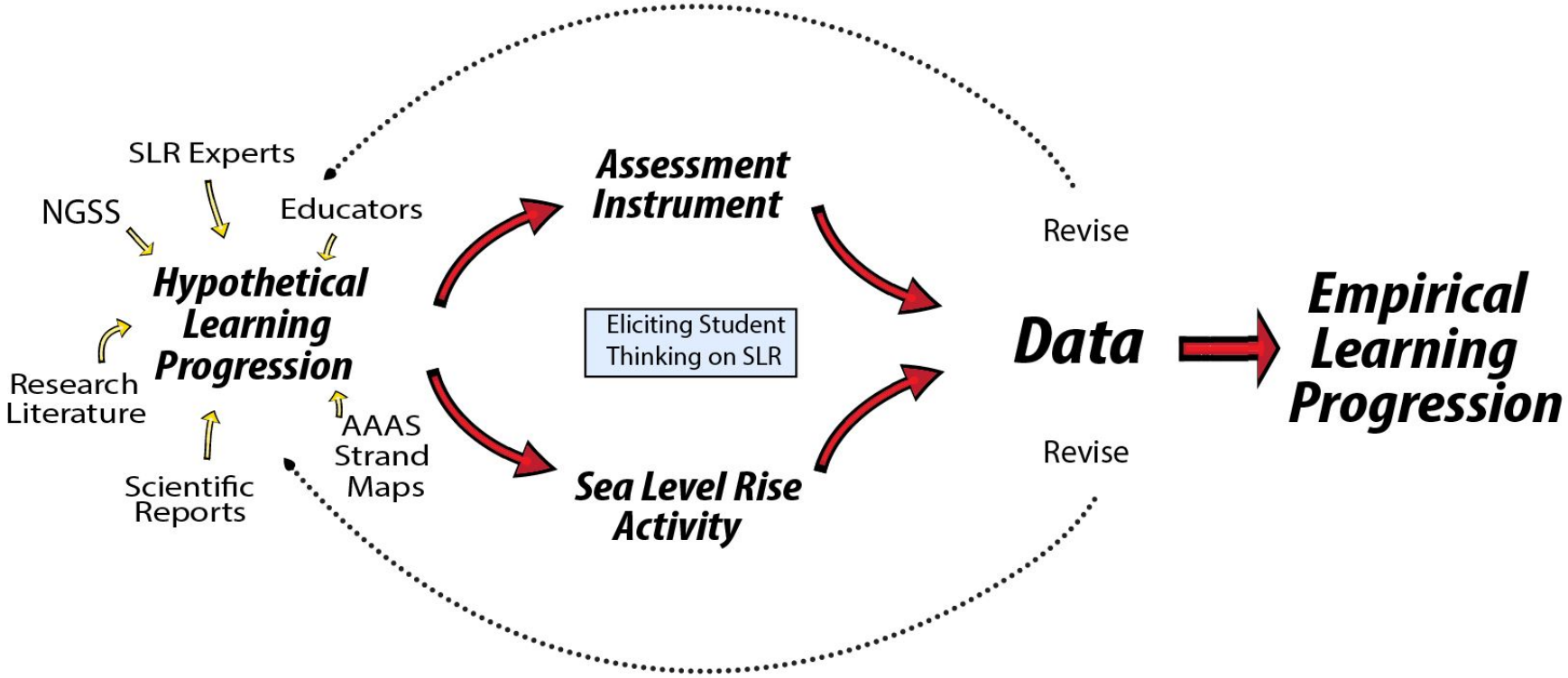
Investigation 1: *Examining a Process for Developing a Learning Progression for Sea Level Rise*

SIP 3.1

Research Question Two

Investigation One

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



Learning Progression Developmental Model

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).

Research Question Two
Investigation One: Findings

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)

Impacts of Sea Level Rise		
Flooding (15)	More powerful storms (6)	Human habitats affected (2)
Islands/Beaches/Land disappearing (12)	Coastlines under water (4)	Coastal cities uninhabitable. (1)
Erosion (10)	Pop. near coast affected (2)	Threat to communities below sea level. (1)
Property loss (6)	Communities will need to relocate. (2)	Longer planting seasons. (1)
	Land "sinks" (not subsidence) (2)	Negative impact on farmland/plants. (1)

Research Question Two
Investigation One: Findings

Section of the Conditional SLR Learning Progression: *Impacts of Sea Level Rise*

	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Potential SLR LP indicator about impacts of sea level rise "I" stands for impacts	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.	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.	I3: 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.	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 local sea level rise. Students recognize that sea level rise projections are based on available data and may be lower or higher than predicted.

Full learning progression available at www.ClimateEdResearch.org.

Research Question Two

Investigation One: Status and Next Steps

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*

SIP 3.1

Research Question Two

Investigation Two: Participants

	DE	MD	Total
Teachers	3	1	4
Student Interviews	12	14	26
Student Content Assessments	277	31	308
Classroom Observations	15	10	25

Research Question Two

Investigation Two: Preliminary Findings (MD Data)

Table 1: Selected Student Climate Change Conceptions

Conceptions	What Students Know	Prevalent and Persistent Alternative Conceptions
Removal of CO_2 from Atmosphere	Plants absorb carbon dioxide for food (45% pre, 61% post).	CO_2 escapes into space (29% pre, 26% post).
Ozone as Cause of Climate Change	Aware of ozone in atmosphere and of the ozone hole.	CO_2 destroys ozone. (37% pre, 30% post). Intense storms related to ozone (42% pre, 26% post).
Nature of Climate Change Predictions	Aware that predictions may be lower or higher (pre 35%, post 45%).	"complete accuracy" (26% pre, 23% post) "uncertain … based on scientists' opinions" (pre 33%, post 33%)

Research Question Two

Investigation Two: Findings

Impacts of Human Activity from the Climate Change Learning Progression

Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
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 CO_2 or use of fossil fuels.	Students are able to explain that human use of fossil fuels for energy generates CO_2 and is the primary cause of climate change. Students can explain that the ozone hole is not a significant factor in climate change.	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). 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).	Students are able to describe the rate at which humans burn fossil fuels for energy and rate at which CO_2 is recaptured by natural sinks (e.g. oceans, vegetation). Students should also be able to describe the current imbalance between these two rates.

Research Question Two

Investigation Two: Status and Next Steps

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.

Research Question Two

Investigation Three

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*

SIP 3.1

Research Question Two
Investigation Three

Study contexts (case study schools):

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

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

SIP 3.1

Research Question Two
Investigation Three

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?*

SIP 3.1

Research Question Two

Investigation Three: Data Analysis Approaches

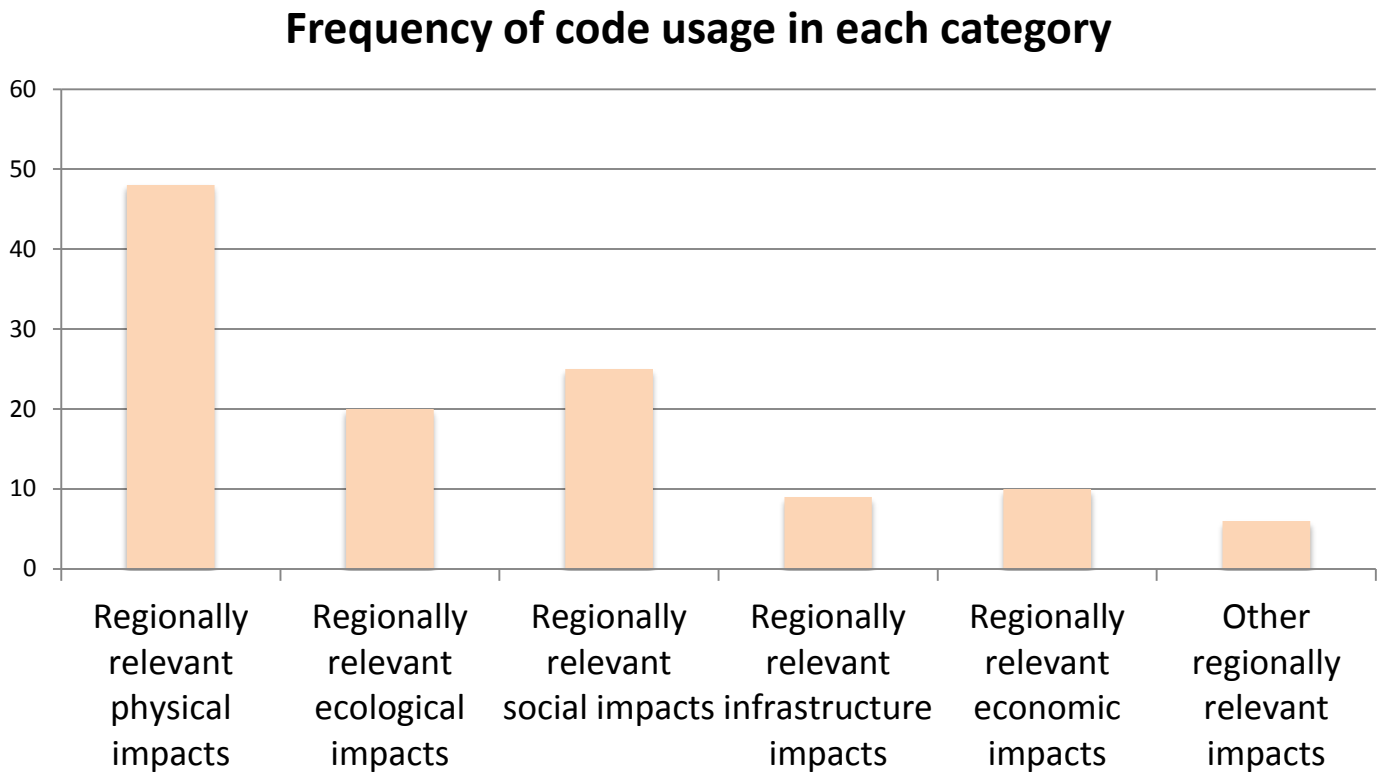
Data analysis:

Deductive Approach Phase (DAP)	Inductive Approach Phase (IAP)
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. Included regionally-relevant: A. Physical impacts (e.g., sea level rise) B. Ecological impacts (e.g. species change) C. Social impacts (e.g., health) D. Infrastructure impacts (e.g., roads) E. Economic impacts (e.g., agriculture)	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: *1. What are learners' sources of information on climate change*? Structural code: [1]SOURCES OF INFORMATION *2. How to learners see climate change as connected to their lives*? Structural code: [2]PERSONAL CONNECTIONS

Research Question Two

Investigation Three: Preliminary Findings

Deductive approach



Top codes:

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

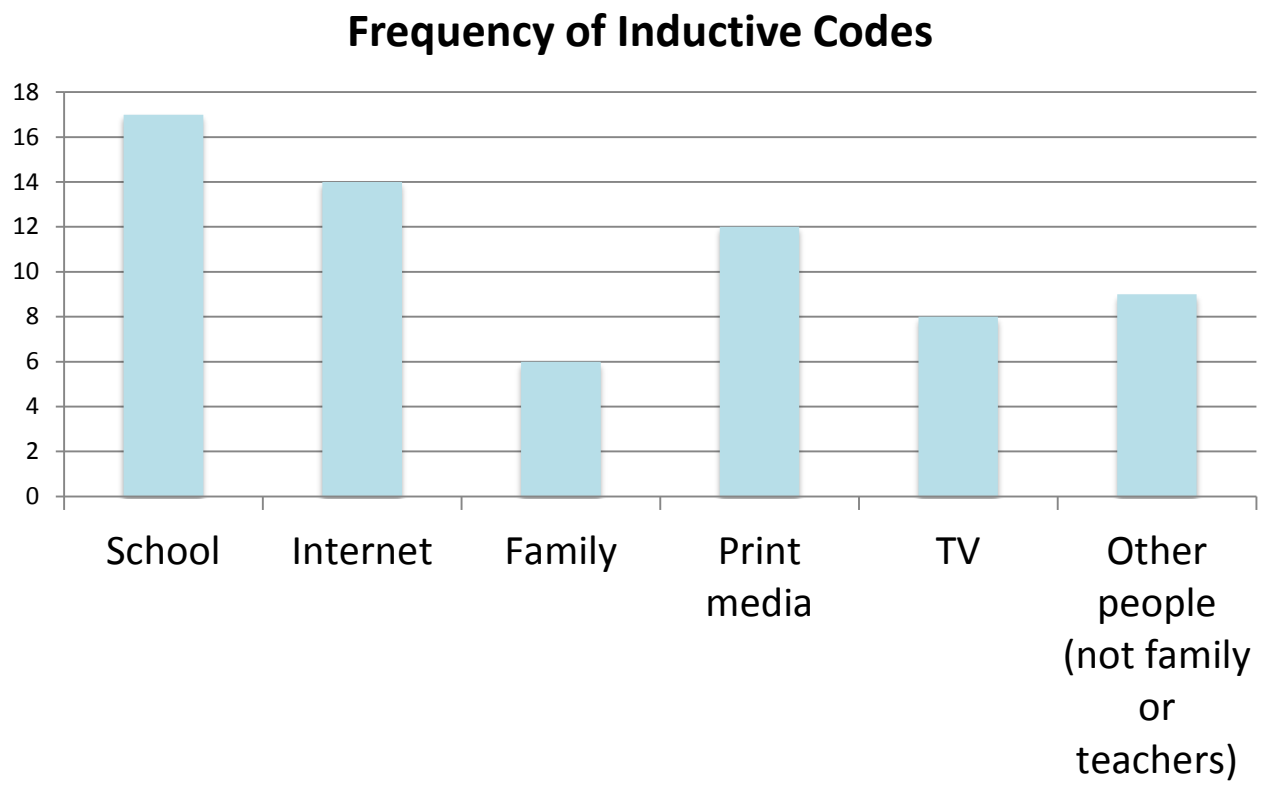
Flooding (physical impacts); focus on damage to houses, beaches, disruption to recreation

Heat waves (physical impacts); focus on personal experiences of hotter temps

Research Question Two

Investigation Three: Preliminary Findings

Inductive approach – Information sources



Top codes:

School: Hearing about climate change in school; also informal conversations, language arts, projects for enrichment classes

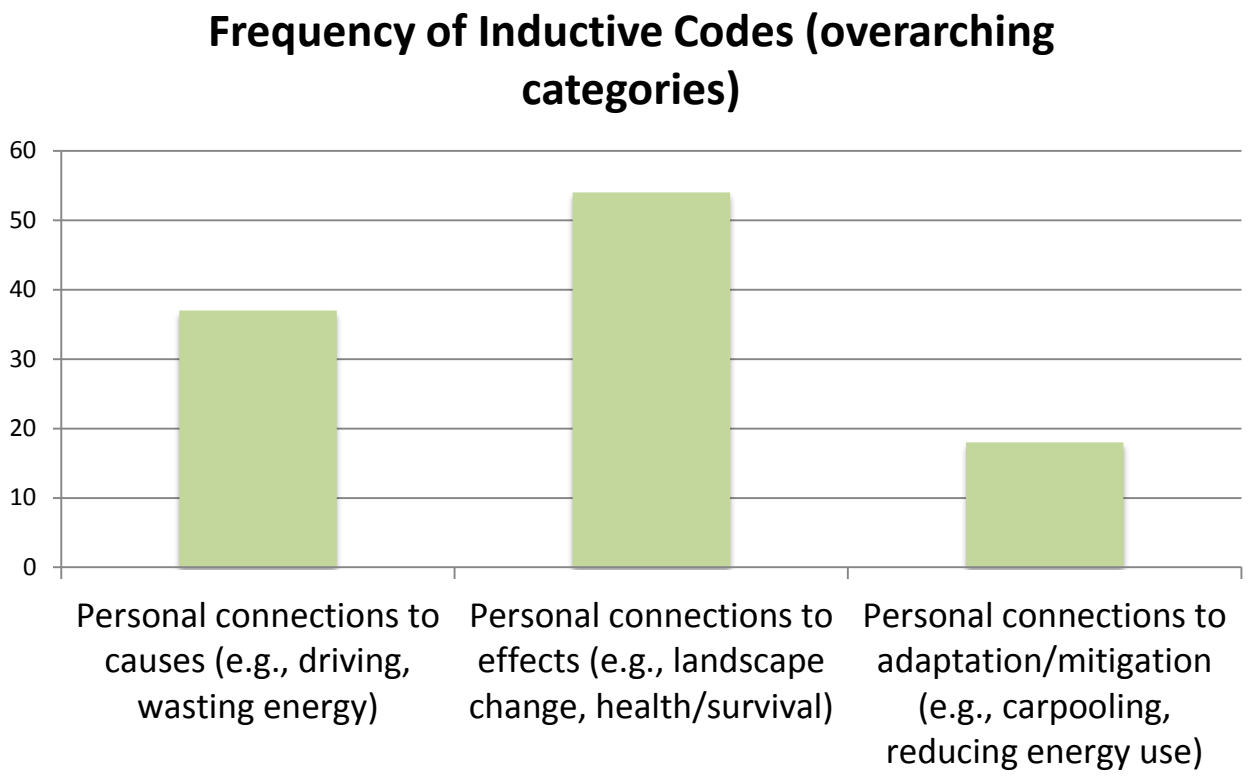
Internet: Internet mentioned often as a source, but distrust of Internet also mentioned

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



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

Research Question Two

Investigation Three: Status and Next Steps

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

SIP 3.2

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

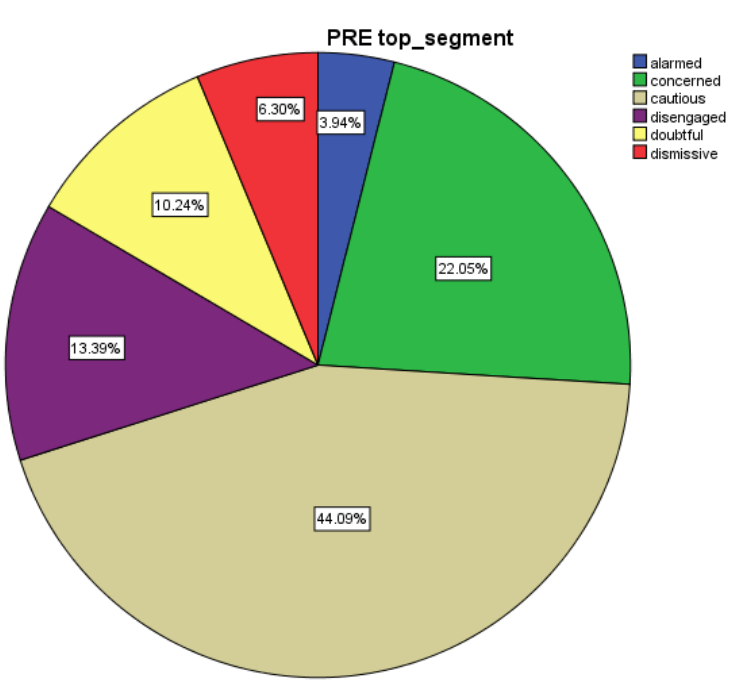
Investigations One and Two

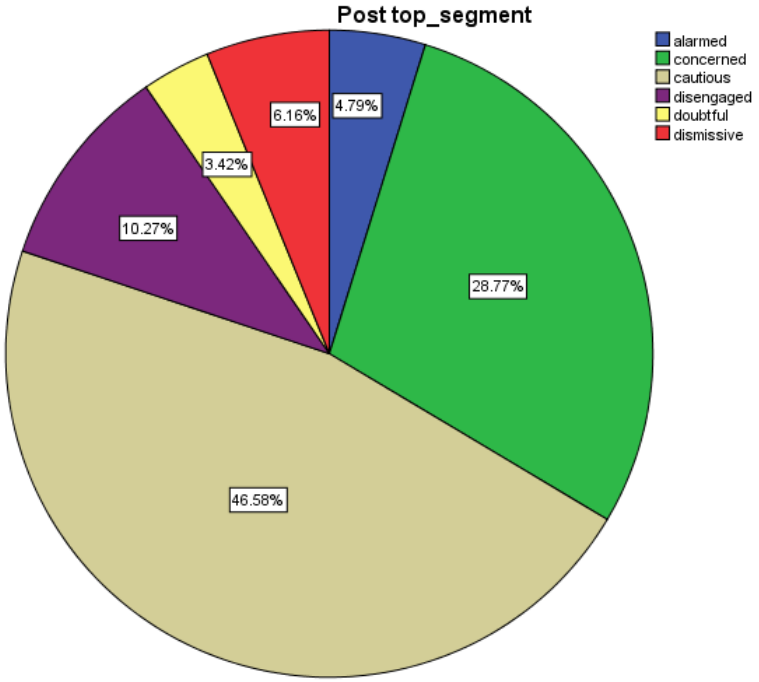
- Focal Case Study Context (teacher in 7th and 8th grades)
  - Sub-urban middle school
  - Teacher attended all professional development events
- Participants
  - Middle School teacher (N=1) and Students (N=150)
- Data
  - Classroom observations (N=12)
  - Teacher interviews (pre and post)
  - Student 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_2changes 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

McGinnis, J.R., McDonald, R.C., Hestness, E., & Breslyn, W. (2015). An investigation of science educators' views of role and responsibility for climate change education. Manuscript submitted for publication.

Breslyn, W., McGinnis, J.R., McDonald, R.C., & Hestness, E. (2015). Examining a process for developing a learning progression for sea level rise. Manuscript submitted for publication.

Hestness, E., McGinnis, J.R., Breslyn, W., McDonald, R.C., & Mouza, C. (2015). Science educators' conceptions of climate change and learning progressions in a professional development academy on climate science education. Manuscript submitted for publication.

Shea, N., Mouza, C., & Drewes, A. (2015). Climate Change Professional Development in the Context of NGSS: Design, Implementation and Initial Outcomes. Manuscript submitted for publication.

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.

Publications – Book Chapters

Hestness, E., McGinnis, J.R., & Breslyn, W. (2015). Integrating sustainability into science teacher education through a focus on climate change. In Stratton, S., Hagevik, R., Feldman, A., & Bloom, M. (Eds.), *Educating science teachers for sustainability*. Association for Science Teacher Education.

McGinnis, J.R., & Hestness, E. (in press). Using drawings to examine prospective elementary teachers' moral reasoning about climate change. In P. Katz (Ed.) *Drawings as data in science education.* Boston: Sense Publishers

Brickhouse, N., McGinnis, J.R., Shea, N., Drewes, A., Hestness, E., & Breslyn, W. (in press). NGSS

Online products and publications

Breslyn, W., Hestness, E., & McGinnis, J.R. (2014). Sea level rise online research tool (preservice). Available at: http://www.climateedresearch.org/science-methods/sea-level-rise/index.html

Hestness, E., Breslyn, W., & McGinnis, J.R. (2014). Climate change education resource materials for science teacher educators. Available at: http://www.climateedresearch.org/science-methods/index.html

McDonald, R.C., Breslyn, W., Hestness, E., & McGinnis, J.R. (2014). Conditional learning progression for sea level rise. http://www.climateedresearch.org/publications/2012/SLR-LP.pdf

McDonald, R.C., Breslyn, W., Hestness, E., McGinnis, J.R. (2013). Draft sea level rise teaching progression based on NGSS. Available at: http://www.climateedresearch.org/publications/2013/SLRTeachingProgression.pdf

McGinnis, J.R., Breslyn, W., McDonald, R.C., & Hestness, E. (2013). Climate change in the Next Generation Science Standards (K-12). Available at: http://www.climateedresearch.org/publications/2013/Climate-Change-NGSS.pdf

McGinnis, J.R., Breslyn, W., McDonald, R.C., & Hestness, E. (2013). Climate change education teacher professional development in MADE CLEAR: A research brief. Available at: http://www.climateedresearch.org/publications/2013/PDResearchBrief-MADECLEAR-3-5-13.pdf

McDonald, R.C., Breslyn, W., Hestness, E., & McGinnis, J.R. (2013). Hypothetical learning progression: Urban Heat Effect and Extreme Weather. Available at: http://www.climateedresearch.org/publications/2012/UHE-Nov28-2012-Draft.pdf http://www.climateedresearch.org/publications/2012/EW-Nov28-2012-Draft.pdf

Presentations

McDonald, R.C., McGinnis, J.R., Breslyn, W., & Hestness, E. (2015). Examining middle school learners' scientific explanations about sea level rise. Conference paper presentation proposal under review.

Breslyn, W., McGinnis, J.R., & Hestness, E. (2015). "It's happening now" – Middle school students' thinking about climate change. Conference paper presentation proposal under review.

Hestness, E., McGinnis, J.R., & Breslyn, W. (2015). Examining teacher candidates' moral and ethical perspectives on climate change. Conference paper presentation proposal under review.

Drewes, A. & Mouza, C. (2015). Examining middle school students' thinking on climate change: An earth history perspective from a MADE CLEAR classroom. Conference paper presentation proposal under review.

Drewes, A., Mouza, C., & Henderson, J. (2015). Climate science professional development: Curriculum design considerations and student learning outcomes. Conference paper presentation proposal under review.

Breslyn, W., McGinnis, J.R., & Hestness, E. (2015). Investigating the development of a learning progression for sea level rise, a climate change impact. Paper presentation at the annual international conference of NARST: A Worldwide Organization for Improving Science Teaching through Research. Chicago, IL, April 2015.

McGinnis, J.R., McDonald, R.C., Hestness, E., & Breslyn, W. (2015). Science educators' images of responsibility and actions concerning climate change education: diverse voices in a professional development academy. Paper presentation at the annual international conference of NARST: A Worldwide Organization for Improving Science Teaching through

Presentations (continued)

Hestness, E. (2014). Integrating global perspectives on climate change into science teaching and learning. Poster presented at the Maryland Statewide Colloquium on Internationalization of Education. College Park, MD. February, 2014.

Drewes, A. (2014). Three dimensional science learning and assessment design: Assessing climate change knowledge in the context of NGSS. Steele Symposium, University of Delaware, May 2014.

Hestness, E., McGinnis, J.R., Breslyn, W., & McDonald, R.C. (2013). Reconceptualizing teacher professional development for climate literacy using learning progressions and a regional observations approach. Presentation at the North American Association for Environmental Education 2013 Research Symposium. Baltimore, MD, October, 2013.

Breslyn, W., McDonald, R.C., Hestness, E., & McGinnis, J.R. (2013). Climate change education: Teaching, learning, and assessment. Presentation at the National Association for Research in Science Teaching annual international conference. Rio Grande, Puerto Rico, April, 2013.

McDonald, R.C., Breslyn, W., Hestness, E., & McGinnis, J.R. (2013). Climate change education: Policies and implications. Symposium presented at the National Association for Research in Science Teaching annual international conference. Rio Grande, Puerto Rico, April, 2013.

Hestness, E., Breslyn, W., McDonald, R.C., & McGinnis, J.R. (2013). The policy, practice, and research nexus of climate change education. Symposium presented at the National Association for Research in Science Teaching annual international conference. Rio Grande, Puerto Rico, April, 2013.

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