Climate Education PATHWAYS

Localizing Climate Change Education: Impacts on Student Knowledge and Agency in High School Science Classrooms

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BSCS SCIENCE LEARNING

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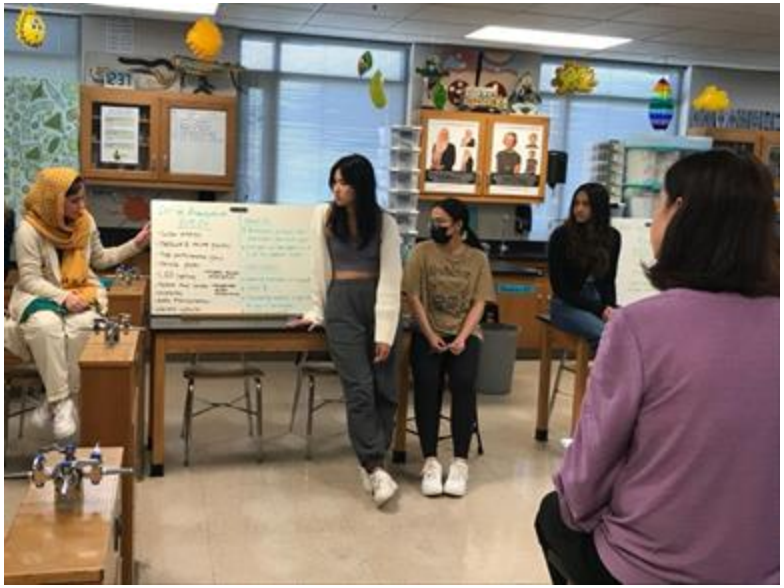
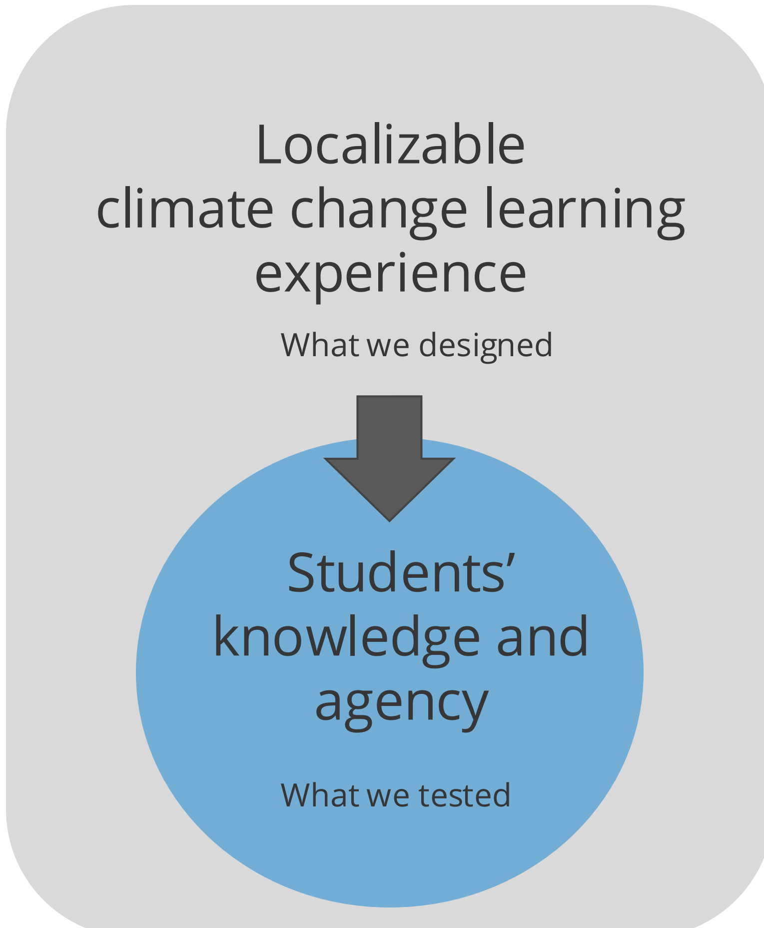
The Knowledge-Action Gap: A Critical Challenge



Design to support both knowledge and action



Localization

Addressing the Knowledge - Action Gap in Climate Change Education

- Available materials tend to focus on causal explanations for global warming and general consequences of a warming planet (Monroe et al., 2019)
- Climate change is a global phenomenon but its impacts vary across local regions and communities (IPCC, 2023; Knutti, 2019)
- Focusing on general consequences can lead to psychological distancing and does not translate into action (Busch & Chavez, 2022, (e.g., Allen & Crowley, 2017; Busch et al., 2019; Fahey et al., 2014)
- Situating climate education in local and/or personally meaningful contexts offers a promising approach to bridge this gap (Anderson, 2012; Buxton, 2010; Frick et al., 2021).
- Locally consequential climate education materials to draw attention to **actions students can take** and that can **support agency** and hope (e.g, Lee & Grapin, 2022; Monroe et al., 2019)

Purpose of our study

- Design and test an approach to climate change curriculum that is:
  - Widely usable
  - Support students in building climate science knowledge and foster environmental science agency (Ballard et al., 2017)
  - Includes two key features:
    - Phenomenon-driven storylines
    - Supports teachers to adapt to incorporate local climate change problems and solutions

Phenomenon-driven storylines

Anchor Phenomenon Lesson	Investigation lessons that support iterative sensemaking	Synthesis / Transfer task lesson

Key Features of Storyline Units:

- Phenomenon-driven (Edelson et al., 2021; Reiser et al., 2021; Penuel et al., 2022)
- Coherent from perspective of students (Reiser et al., 2021)
- Support students' epistemic agency (Cherbow, 2023)

Localizing storyline units

Local phenomenon lesson set	Base Unit Global carbon cycling & drawdown solutions	Local culminating task

Local Phenomenon Lesson Set

- 2-5 lessons
  - Local anchoring phenomenon
  - Investigation lesson(s)
  - Synthesis
- Teacher designed

Teacher Designed Unit Launch

Local phenomenon lesson set

Why are salmon and orca populations declining?

Why does Salt Lake City have such bad air quality?

Why are peaches becoming harder to grow in the Peach State of Georgia?

Localizing storyline units

Local phenomenon lesson set	**Base Unit Global carbon cycling & drawdown solutions**	Local culminating task

Base Unit

- Supports iterative sensemaking in a typical phenomenon-driven storyline
- Re-anchor around global average temperature rise
- 10 fully developed with global data, animations, and interactives

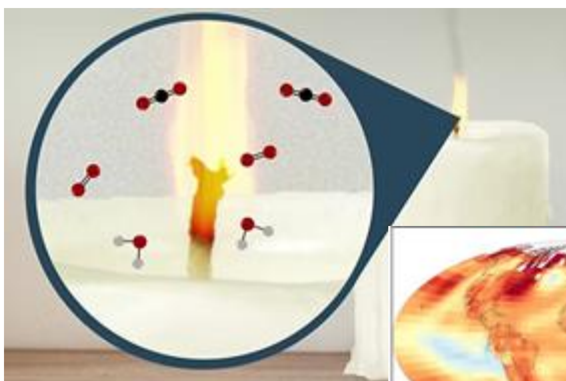
Base Unit

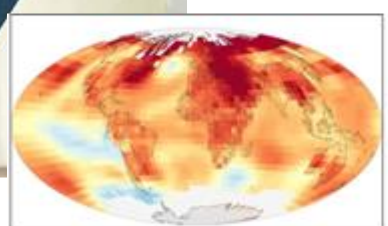
Local phenomenon lesson set

Base Unit
Global carbon cycling & drawdown solutions

Local culminating task

Why are temperatures rising?

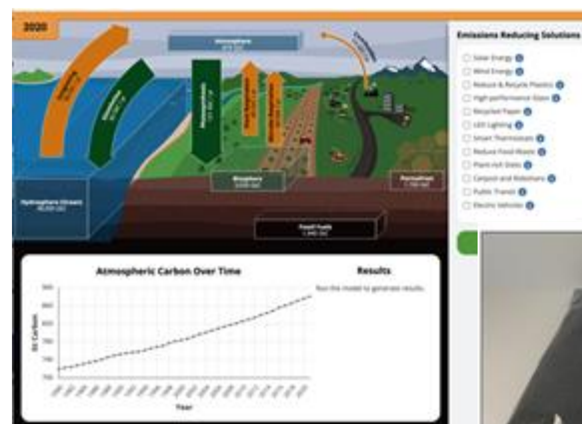




Comparing Temperature Graphs

Examine the ways scientists represent temperature data. Compare how data can be used to show short-term fluctuations and long-term trends.

What can we do to rebalance our carbon cycle system?



Soil and Carbon Lab

View a lab to investigate how carbon is released from the soil and what could be giving off the carbon.

Localizing storyline units

Local phenomenon lesson set	Base Unit Global carbon cycling & drawdown solutions	**Local culminating task**

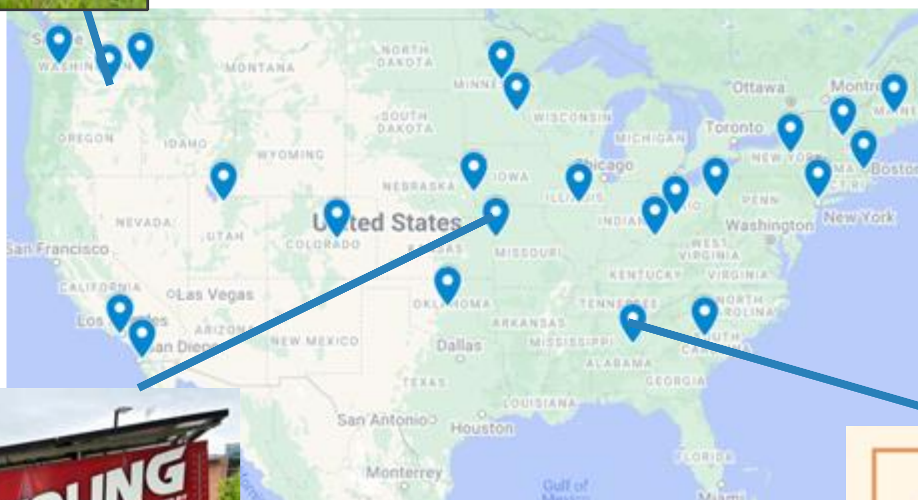
Culminating Task

- Length varies
- Teacher-designed or co-designed with students
- Focused on community action

Teacher Designed Culminating Task

Local culminating task

Restoration project in local riparian area near school.



Student produced solar powered community concert.

Educational cookbook to share family peach recipes with climate change explanations.

Localized storyline units

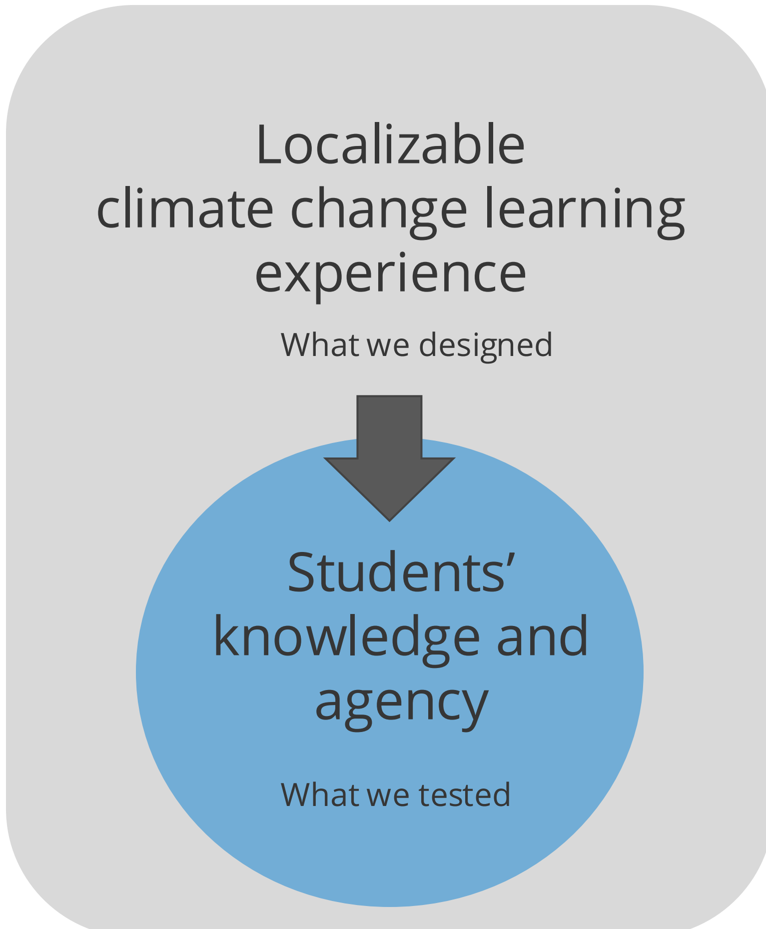
Local phenomenon lesson set	Base Unit Global carbon cycling & drawdown solutions	Local culminating task
• 2-5 lessons • Teacher designed • Local anchoring phenomenon & investigations	• 10 lessons • Fully developed with global data, animations, and interactives	• Length varies • Teacher-designed or co-designed with students • Focused on community action

Locally consequential climate education materials that draw attention to **actions students can take** and that can **support agency to take action** (Lee & Grapin, 2022; Monroe et al., 2019)

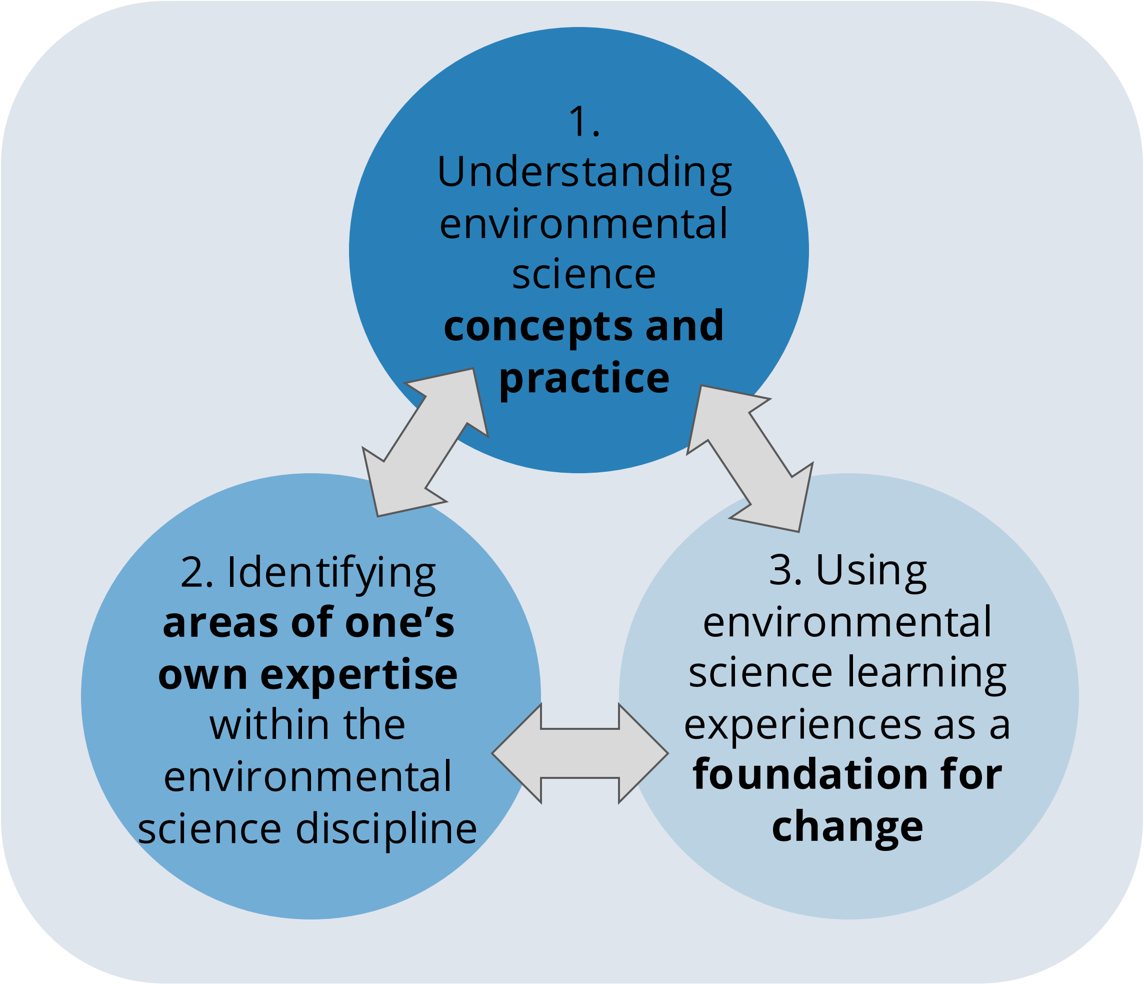
Quasi-Experiment:

Measuring Student Knowledge and Agency

Student Outcome: Environmental Science Agency

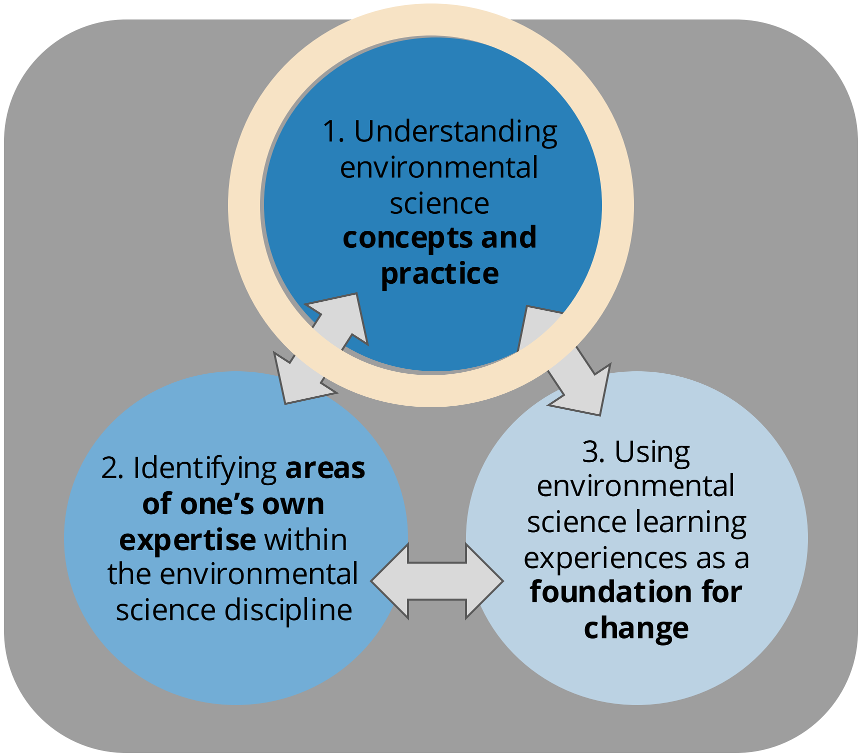


Student Outcome: Environmental Science Agency



Adapted from Ballard et al., 2017

1. Content and practice



Young people learn about environmental science concepts and practices that are powerful for understanding or acting in the world.

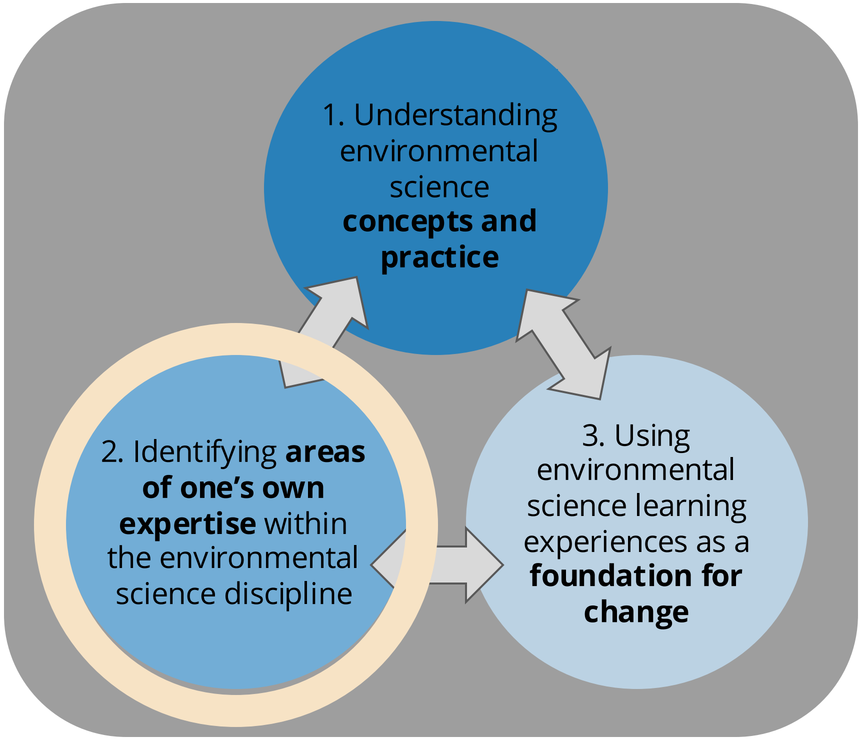
Concepts:

- Scientific disciplinary core ideas and crosscutting concepts
- Models for how the world works

Practices:

- Questioning practices
- Evidence gathering practices
- Sensemaking practices
- Technological practices for measuring or representing the world

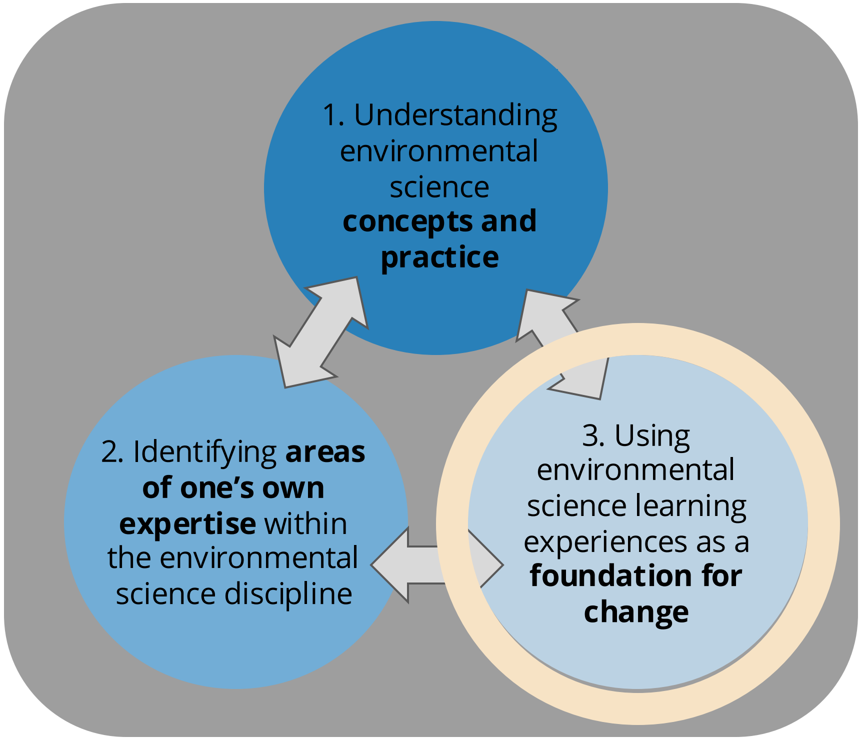
2. Roles and expertise



Young people take the lead on different aspects of work *within* the classroom using the expertise they bring and/or trying out new roles.

- **Differentiated roles**:
  - Investigative and information gathering roles
  - Analysis and evaluation roles
  - Reasoning and sensemaking roles
  - Communicating roles
  - Social roles

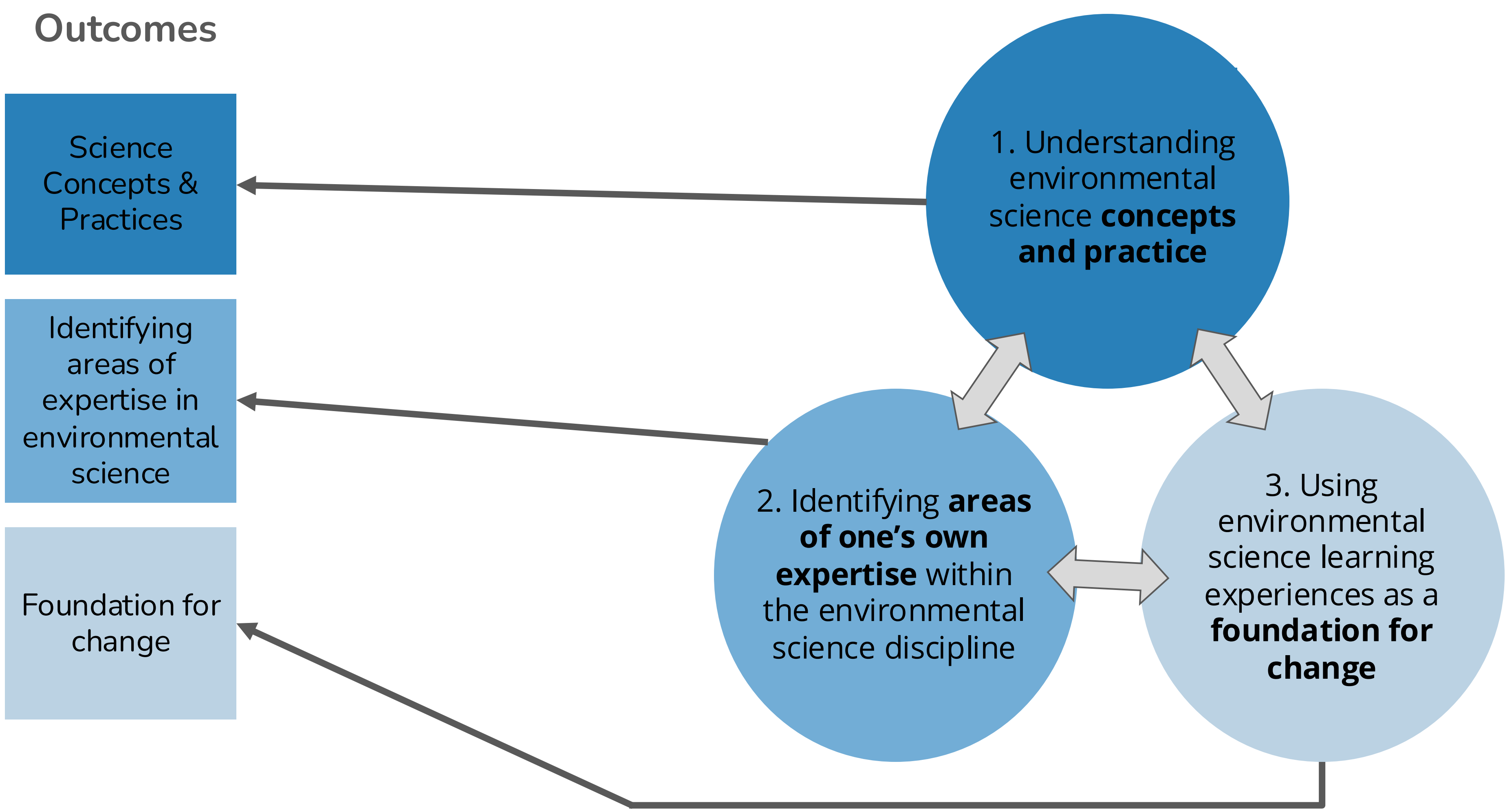
3. Foundation for change



Young people develop new ways of identifying, perceiving and acting in the world that become a foundation for action beyond the classroom.

- **Concepts, practices, and action**: Carrying experiences into their lives
- **Identities**: Developing new identities and being recognized by authentic audiences in new ways
- **Networks**: Expanding networks for learning or action

Developing a Measurement Framework for ESA



Developing a Measurement Framework for ESA

Outcomes	Instruments
Science Concepts & Practices	Knowledge
Identifying areas of expertise in environmental science	Roles Identity
Foundation for change	Transformative Experience Questionnaire

(Littrell et. al, 2022)

Developing a Measurement Framework for ESA

Outcomes	Instruments
Science Concepts & Practices	Knowledge
Identifying areas of expertise in environmental science	Roles
	Identity
Foundation for change	Transformative Experience Questionnaire

Research Questions

1. Does **knowledge of climate change** differ after high school students learn with a localized storyline unit versus a business-as-usual unit?

2. Does a **sense of roles and expertise in science** differ after high school students learn with a localized storyline unit versus a business-as-usual climate change unit?

3. Does **science identity** differ after high school students learn with a localized storyline unit versus a business-as-usual climate change unit?

4. Does **foundation for change** differ after high school students learn with a localized storyline unit versus a business-as-usual climate change unit?

Study Design

- Cohort controlled quasi-experiment, business-as-usual versus localized storyline
  - 25 teachers
  - 2,062 students
  - Students in each conditions took all instruments prior to and after their climate unit

- 60 hour PL to support teachers in designing a localized storyline

Study Design

Descriptive Statistics of the Sample: Sample Sizes by Treatment Group.

Variables	Total sample (N = 2,062)	Treatment (N = 942)	Comparison (N = 1,120)
FRL	32%	37%	29%
Gender			
Male	45%	43%	47%
Female	49%	51%	47%
Other	6%	6%	6%
Grade			
9th	42%	42%	41%
10th	24%	22%	26%
11th	14%	13%	16%
12th	20%	23%	17%
Comfort reading and writing in English			
English first language	90%	91%	90%
English not first, comfortable reading, writing & speaking	9%	8%	9%
English not first, not comfortable reading, writing & speaking	1%	1%	1%

Knowledge, Roles & Identity Instruments

Outcomes	Instruments
Science Concepts & Practices	Knowledge
Identifying areas of expertise in environmental science	Roles Identity
Foundation for change	Transformative Experience Questionnaire

- **Knowledge:** Measures students' understanding of climate change science concepts and practices.
- **Roles:** Measures student's science identity within environmental science
- **Identity:** Measures students' sense of roles and expertise in science, and their.

Transformative Experience Questionnaire

Outcomes	Instruments
Science Concepts & Practices	Knowledge
Identifying areas of expertise in environmental science	Roles
	Identity
Foundation for change	Transformative Experience Questionnaire

Foundations for Change: The extent to which students learning experiences extend beyond the classroom into their daily lives, providing them with a foundation for the current or future ability to act on environmental sustainability issues in their life or community.

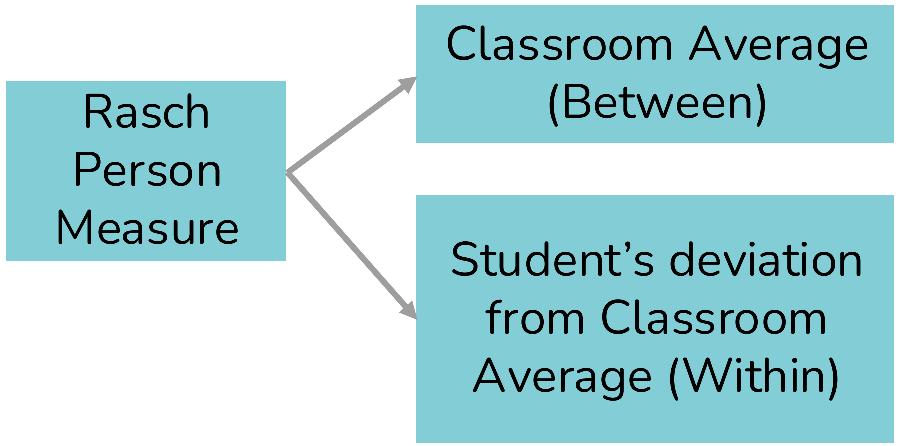
(Littrell et. al, 2022)

Results

Instrument Psychometric Properties

Instrument	Person Rel (Sep)	Item Rel (Sep)	Cronbach's Alpha	1st Contrast Eigenvalue
ESA-Roles	0.90 (2.94)	0.99 (9.03)	0.88	2.88
ESA-Identity	0.85 (2.35)	0.98 (6.98)	0.83	2.31
Knowledge	0.79 (1.94)	1.00 (21.1)	0.74	1.89
TEQ	0.89 (2.86)	0.99 (12.6)	0.95	1.75

Two-Level Random-Intercept Models



$$Post\_Knowledge_{ij} = \beta_0 + \beta_1 class\_mean\_knowledge_j + \beta_2 class\_dev\_knowledge_{ij} + \beta_3 class\_mean\_roles_j + \beta_4 class\_dev\_roles_{ij} + \beta_5 class\_mean\_identity_j + \beta_6 class\_dev\_identity_{ij} + \beta_7 class\_mean\_foundation_j + \beta_8 class\_dev\_foundation_{ij} + \beta_9 SASSY\_Cat_{ij} + \beta_{10} PeriodOrder_j + \beta_{11} FRL_{ij} + \beta_{12} ENG_{ij} + \beta_{13} Race_{ij} + \beta_{14} GEN_{ij} + \beta_{15} Grade_{ij} + \beta_{16} TID_j + \beta_{17} Treatment_j + u_j + \varepsilon_{ij}$$

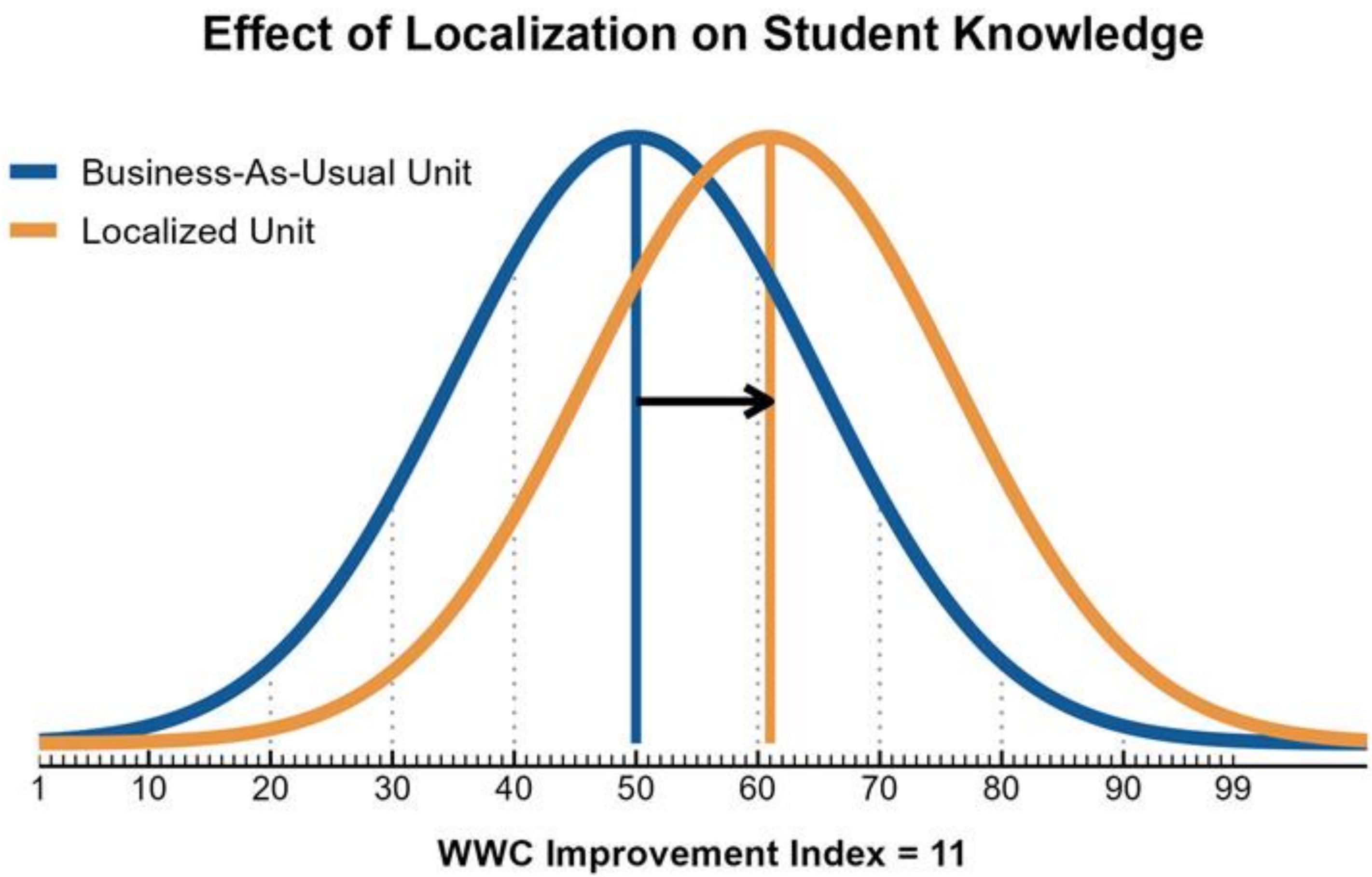
Research Question 1

Does **knowledge of climate change** differ after high school students learn with a localized unit versus a business-as-usual unit?

Predictor	**Coefficient (β)**	**Std. Err.**	**p-value**	**95% C.I.**
Pre-test Knowledge (Within-Classroom)	0.345	0.001	<0.001	[0.284, 0.405]
Average Pre-test Knowledge (Classroom Mean)	0.683	0.099	<0.001	[0.486, 0.879]
Localized Curriculum (Treatment)	**0.232**	0.051	**<0.001**	[0.133, 0.332]
Constant (Intercept)	-.054	0.167	0.745	[-0.268, 0.591]
Random Effects				
Classroom-Level Variance ($\sigma^2[u]$)	0.149	0.033		[0.096, 0.231]
Residual Variance ($\sigma^2[\varepsilon]$)	0.781	0.016		[0.750, 0.815]

Statistically significant positive treatment effect, indicating that, after controlling for a wide range of student-level, classroom-level, and teacher-level factors, students in the localized curriculum group **scored, on average, 0.232 logits higher** on the post-test knowledge assessment than students in the business-as-usual group.

Research Question 1



Hedges' g = 0.251

Research Question 2

Does a s**ense of roles and expertise in science** differ after high school students learn with a localized unit versus a business-as-usual climate change unit?

Predictor	**Coefficient (β)**	**Std. Err.**	**p-value**	**95% C.I.**
Pre-test Roles (Within-Classroom)	0.093	0.063	0.138	[-0.030, 0.217]
Average Pre-test Roles (Classroom Mean)	0.415	0.134	0.002	[0.149, 0.679]
Localized Curriculum (Treatment)	**0.081**	0.054	**0.139**	[-0.027, 0.188]
Constant (Intercept)	-0.044	0.226	0.847	[-0.495, 0.407]
Random Effects				
Classroom-Level Variance ($\sigma^2[u]$)	<0.001	<0.001		[<0.001, >100]
Residual Variance ($\sigma^2[\varepsilon]$)	1.053	0.045		[0.967, 1.146]

No statistically significant difference in post-test Roles & Expertise scores between students in the localized curriculum group and students in the business-as-usual group.

Research Question 3

Does **science identity** differ after high school students learn with a localized unit versus a business-as-usual climate change unit?

Predictor	**Coefficient (β)**	**Std. Err.**	**p-value**	**95% C.I.**
Pre-test Identity (Within-Classroom)	0.207	0.044	<0.001	[0.120, 0.294]
Average Pre-test Identity (Classroom Mean)	0.371	0.138	0.010	[0.094, 0.648]
Localized Curriculum (Treatment)	**0.071**	0.066	**0.285**	[-0.059, 0.201]
Constant (Intercept)	0.005	0.262	0.985	[-0.511, 0.521]
Random Effects				
Classroom-Level Variance ($\sigma^2[u]$)	<0.001	0.002		[<0.001, >100]
Residual Variance ($\sigma^2[\varepsilon]$)	1.354	0.113		[1.150 1.159]

No statistically significant difference in post-test science identity scores between students in the localized curriculum group and students in the business-as-usual group.

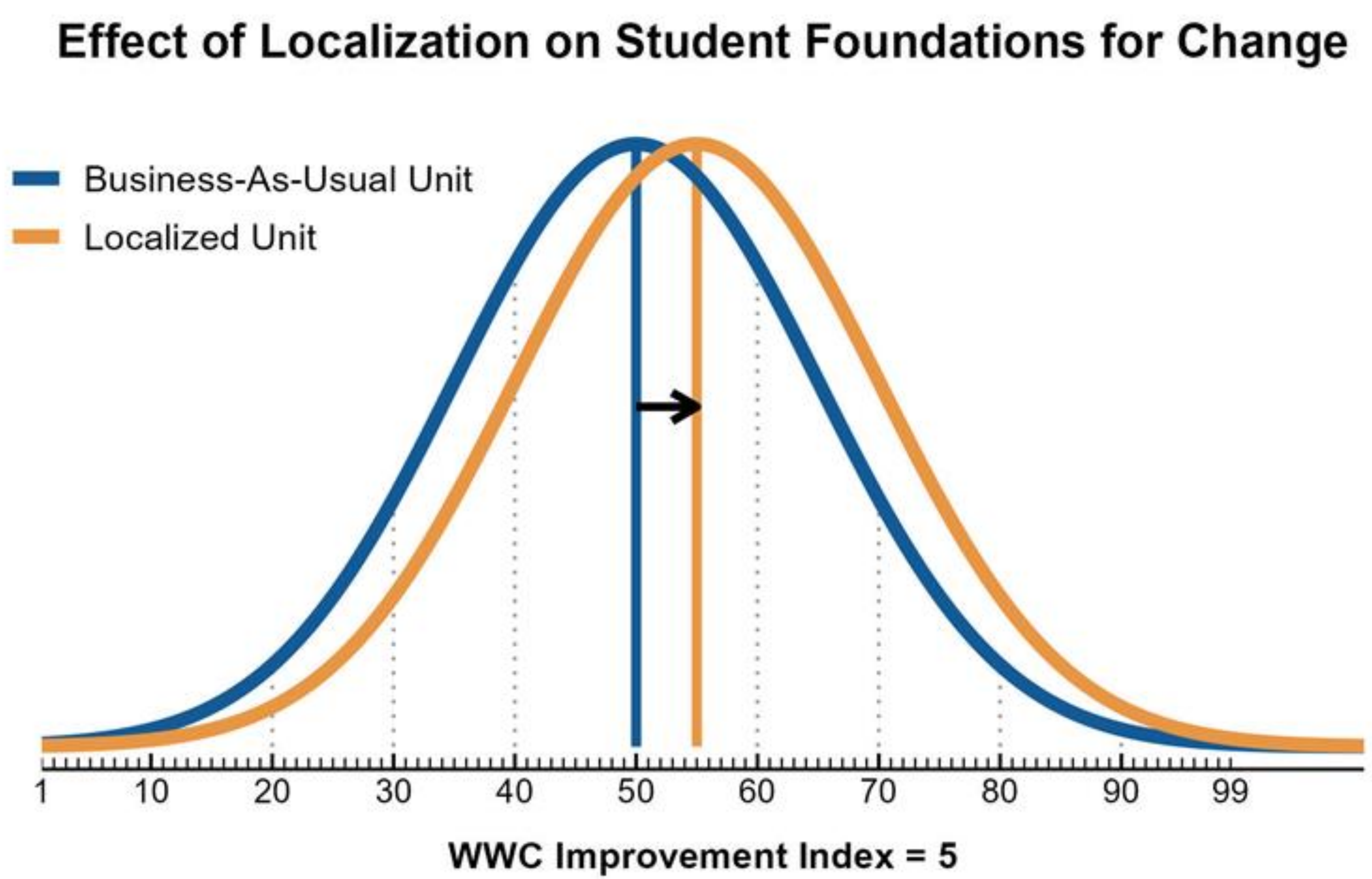
Research Question 4

Does **foundation for change** differ after high school students learn with a localized unit versus a business-as-usual climate change unit?

Predictor	**Coefficient (β)**	**Std. Err.**	**p-value**	**95% C.I.**
Pre-test Knowledge (Within-Classroom)	0.467	0.024	<0.001	[0.420, 0.514]
Average Pre-test Knowledge (Classroom Mean)	0.518	0.109	<0.001	[0.303, 0.732]
Localized Curriculum (Treatment)	**0.207**	0.076	**0.007**	[0.056, 0.358]
Constant (Intercept)	-0.659	0.314	0.037	[-1.27, -0.040]
Random Effects				
Classroom-Level Variance ($\sigma^2[u]$)	<0.001	<0.001		[<0.001, >100]
Residual Variance ($\sigma^2[\varepsilon]$)	1.617	0.046		[1.529, 1.711]

Statistically significant positive treatment effect, indicating that, after controlling for a wide range of student-level, classroom-level, and teacher-level factors, students in the localized curriculum group **scored, on average, 0.207 logits higher** on the post-test foundations for change instrument than students in the business-as-usual group.

Research Question 4



Hedges' g = 0.148

Key Findings

Localized curriculum shows potential to **bridge the knowledge-action gap** in climate change education.

a. Localized curriculum significantly improved student climate change knowledge (**addressing the 'knowledge' side of the gap**) (Hedges' $g = 0.251$, $p < .001$).

b. Students in the localized group showed significantly greater readiness to apply their learning and engage in climate solutions (**addressing the 'action' side of the gap**) (Hedges' $g = 0.148$, $p < .001$).

c. No significant impacts were found for science identity or roles and expertise.

Teacher Voices

- *“Students are wondering if there is 'hope'. And then, they look at the combination of changing lifestyles (vegan, electric cars etc) and the agricultural solutions.* ***Now they are wondering what else they can do.****”*

- *“Utilizing a local phenomenon to anchor my educational content has significantly enriched the level of engagement I experience with my students.* ***When students can personally relate to the subject matter, their understanding of scientific concepts deepens, moving beyond abstraction.*** *Despite the challenges posed by the contentious nature of teaching topics like climate change, integrating a narrative around a local phenomenon empowers students to explore, form independent opinions based on evidence, and break away from simply parroting parental views.”*

Implications & Future Directions

Promising Educational Approach

- Localized curriculum adaptation shows significant promise for climate change education
- Partial localization offers efficient balance of standardization and relevance
- Localized units particularly effective for knowledge acquisition and action orientation
- Professional learning critical for supporting teacher adaptation

Future Research Directions

- **Longer-term impacts on action:** Investigate longer-term impacts of localized climate education on *actual* student environmental action.
- **Local phenomena for action:** Investigation of most effective local anchoring phenomena to *maximize impact on both knowledge and action*.
- **Scaling for action:** Research scalable models for professional learning and curriculum implementation to *broadly bridge the knowledge-action gap*.

Presentation Materials

bscs.org/climate