

Article

Tracing Paths from Research to Practice in Climate Change Education

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Received: 5 May 2020; Accepted: 7 June 2020; Published: 11 June 2020



Abstract: The purpose of this qualitative study was to investigate the incorporation of climate change social science research into climate change education practice. Semi-structured interviews with 19 educators from five climate change related professional development programs and networks revealed a high level of awareness of climate change social science research. Educators accessed research through a variety of means and reported both practice change and a sense of validation as a result of the research. They reported shifting toward programs that focused less on climate facts to programs that focused on solutions and that integrated their understanding of audiences' values and identities. They also reported feeling a conflict between their practice knowledge and the knowledge they gained through professional development and accessing research. This work begins to fill a gap both in our understanding of how nonformal educators communicate about climate change and in how they use research in their practice.

Keywords: climate change education; research translation; qualitative; climate change social sciences; framing

1. Introduction

Scholarly interest in climate change education (CCE) and communication have expanded recently in tandem with the growing interest in teaching climate change at the practitioner level. Just as climate change educators engage in diverse education initiatives [1], CCE scholars document a wide range of education program foci, including literacy [2], collective efficacy [3], resilience [4], and justice [5]. Further, efforts to bridge the divide between practitioners and scholarship have also ramped up. For example, the North American Association of Environmental Education launched eeResearch, an online database of environmental education research [6]. Yet there is a gap in our understanding of research translation processes in environmental education and the processes through which CCE practices seem to “take root, blossom, and/or wither” [7].

Scholars call for CCE research to be guided by the domains that inform climate change communication, such as communication theory and psychology [8–11]. They also recommend broadening epistemological and theoretical approaches to CCE research to produce integrative theory, and to move beyond research that seeks to understand which education elements lead to climate change literacy [12].

With these trends in mind, we asked the following research questions:

- (1) To what extent are nonformal educators aware of climate change social science research and how do they find out about the research?
- (2) To what extent are environmental educators applying climate change social science research in their practice?

- (3) How do educators report framing climate change in their practice, and to what extent does that framing reflect what might be considered “best practices” from the research?

We use the term nonformal broadly to refer to those educators who work outside of the formal K-12 school system. Interviewees in this study occupied different organizational roles and worked with a range of audiences, from children and youth to town planners. We chose to focus on educators in nonformal settings because they work in a broad array of institutions that play a crucial role in science literacy and, therefore, climate literacy, in the United States [13,14].

In this article, we first review the literature on research translation and then turn to a brief review of key trends in climate change social sciences research. We next present results from an exploratory qualitative study on how nonformal climate change educators who have participated in five programs—National Network for Ocean and Climate Change Interpretation (NNOCCI), Climate Urban Systems Partnership (CUSP), Project Learning Tree (PLT), Climate Literacy and Energy Awareness Network (CLEAN), and Community Climate Change Fellowship (CCCCF)—translate climate change social science research into CCE practice.

2. Literature Review

2.1. Research Translation

Research translation is a complex process involving researchers, practitioners, policy makers, and other organizations or individuals that span the boundaries between research and practice [15]. Studies of research translation, also referred to as “knowledge mobilization” [16], “diffusion of innovation” [17], and “knowledge transfer and exchange” [18], span multiple fields, including health [18], education [19], and conservation [20]. In health-related fields and education, the focus “audience” ranges from policy makers to non-profit organizations to individual practitioners. Below we draw from multiple fields to gain insights into how environmental educators might use research and why certain research is translated into practice.

Much of the scholarship on how research translates into practice and policy focuses on developing typologies of use [21] and is conceptual rather than empirical [15]. The most common typology of use comprises instrumental, conceptual, and tactical uses (Table 1). Educators may use research conceptually to shape how they think about problems and solutions, instrumentally by changing their practice as a result of the research, or tactically to change policy or make organizational level changes [22,23].

Empirical research demonstrates that nurses and teachers are more likely to use research conceptually than instrumentally [24]. Cain [25] assessed how teachers used educational research texts over a 12-month period and found that the dominant form of use was conceptual. He notes that reading research texts also offered teachers time to reflect on practice—something they often have little chance to do—and challenged their existing thinking. While instrumental use, or direct application, may seem most desirable, Cain and Allen [26] argue that conceptual use is *the most* desirable form of research use because it entails teachers thinking critically about the research and reinterpreting it in terms of other knowledge.

In addition to *what* knowledge is transferred and put into practice, scholars have considered *why* certain research influences practice. Schneider [19] presents four key factors that affect whether educators adopt research-based practices: visibility (research is accessible and its quality can be determined); acceptability (research understood as valuable, conforms with educator worldview); feasibility (applying research does not require an overhaul of practice); and transportability (research is easily shared across networks and with audience). Leko and colleagues [27] build on these notions of feasibility and acceptability in their decision matrix to guide educators in considering research, asking: (1) Is there a burden of evidence to support the practice? and (2) Will the practice work in the educator’s context given its cost, its complexity, and the audiences and organizations with which an educator works? In addition to these considerations, teachers may evaluate the validity of research

based on whether it aligns with their values, beliefs, and previous experiences [28]. Research may also be acceptable because teachers view it as a commodity, valued according to its usability and the prestige it confers to those who understand it, differentiating them from less knowledgeable colleagues [25].

The nature of how research is communicated also impacts research translation. Intermediaries, or knowledge brokers, such as colleagues, the media, and individuals who provide professional development opportunities [29], play a role in translating and disseminating research to education practitioners [30]. Research suggests that actively engaging users with researchers—rather than a one-way dissemination of information from researcher to user—results in a higher likelihood of knowledge translation [31]. Cain and Allen [26] critique efforts like those of a United Kingdom project in which intermediaries developed policies and curriculum tools informed by research but did not share the research itself with teachers, so that teachers were unable to comment on, critique, or engage with the research meaningfully.

Table 1. Common Typology of Research Uses.

Research Use Type	Definition
Conceptual	Educator gains new perspectives, attitudes, and understanding of a situation but does not necessarily transfer this to practice [32,33].
Instrumental	Educator modifies practices or creates new practices informed by research [32].
Tactical	Educator uses research as “instrument of persuasion” to legitimate courses of action [33].

Methods of professional development and research techniques also impact the application of research in practice. Teacher education courses that engage participants in peer-to-peer learning groups, encourage them to ask questions, and require them to present about how to apply theory in practice, better develop their conceptual understanding of research-practice connections than do more traditional, lecture-based courses about education theory [34]. Research conducted about the UK-based MESH Guides program—a translational research project developed by a network of teachers and researchers—suggests the web resource afforded collaborative planning among teachers but not regular implementation of research in practice [35].

The notion of research translation and, in particular, evidence-based practice, has drawn critiques from those who question its merits and political stance. Questions of what kind of and how much evidence is necessary for a practice to be “evidence-based” remain. The dominant theory of change for research-to-practice interventions is that providing an evidence-based product and implementation support will result in higher fidelity implementations, while allowing for some adaptation [36]. Yet a focus on “what works” in formal education restricts the type of research conducted and opportunities for democratic participation by teachers in research, because what works is decided by a central governing body [37].

2.2. Climate Change Social Science Research Applied to CCE

Given the increasing focus on climate change in environmental education [7], and the wealth of social sciences research on climate change [38–40], we focused this study on research translation in climate change education. In this section, we review key trends in the climate change social science literature that have either already informed or could in the future inform CCE research and that, together, apply to two basic processes of CCE practice: knowing one’s audience and choosing the right language and program strategy based on that knowledge.

2.2.1. Identity, Worldview, and Values

One way of understanding one's audience is by understanding their salient identities. Identity, "a way of defining, describing, and locating oneself" [41], influences how we perceive information, and thus what we perceive as "relevant." A personal identity defines us as unique in comparison to other members of our in-group [42]. Our identity is also derived from the groups to which we belong, as captured by social identity: the process of defining, describing, and locating oneself within a particular group (or groups) [43]. Social identities encompass the general expectations, including the beliefs and attitudes, of social groups and thereby influence behavior as well as cognition. Identity protective cognition is a form of motivated reasoning, or thought processes that lead people to use beliefs and strategies to arrive at a desired conclusion, that protects a sense of self or identity but does not necessarily reflect scientific knowledge [44–46]. If a report on climate change threatens free market values associated with a Republican identity, those holding that identity may discredit the information or come up with a counterargument as a means of identity-protection [47].

Climate change social sciences scholarship in the U.S. has focused on how political affiliations affect perceptions of climate change science and policy. A meta-analysis identified political party as the strongest predictor of climate change belief in the U.S. [48], and partisans are more likely to support climate policies formulated by members of their in-group [49]. Although Millennial Republicans are more likely to agree that climate change is anthropogenic than their older counterparts [50], political affiliation remained a predictor of climate change attitudes among younger Americans as recently as 2017 [51]. However, among American racial and ethnic minorities, climate change attitudes are less dependent on political identity than they are among Whites, perhaps because minorities contend with greater threats from climate change [52].

CCE research exploring social identity and climate change seeks to understand the state of climate change teaching and the interactions between identity and student learning. One study with North Carolina middle school students found that, as with adults, hierarchical-individualist worldviews were correlated with lower rates of acceptance of climate change [53]. However, this study also revealed that students' belief in climate change increased after receiving climate change information regardless of worldview, which contrasts with adults, who are more entrenched in their worldviews. In a second study, Stevenson and colleagues [54] found that wildlife science undergraduate students evaluated climate change risk to wildlife differently than they evaluated risk to humans. While they relied on affect-related heuristics, determined in part by political affiliation, to assess climate change risk to humans, they relied on their *knowledge* of climate change to assess risk to wildlife. Identity, therefore, does not necessarily influence audiences' perceptions of certain climate change risks. In other research, science teachers' political ideology determined their approach to climate change in the classroom; teachers who were more conservative were more likely to teach "both sides" of the climate issue rather than to focus on consensus [55,56].

Values help define social identities, serve as guiding principles in our lives, and have been linked to pro-environmental behavior [57–59]. Three value types are particularly relevant when explaining environmental behavior: altruistic values (focus on the welfare of other people), biospheric values (focus on the welfare of the environment), and egoistic values (focus on oneself). Some research identifies altruistic values (i.e., those related to social justice or ensuring the health of others) as stronger motivators of low-carbon behavior [60,61] and of climate policy support [62] than biospheric values. Work with forest landowners in the southeastern United States, however, demonstrated that stewardship frames (biospheric value) increased landowner feelings of efficacy in their ability to make forests resilient to climate change, which was in turn positively correlated with intention to take climate-adaptive forestry actions [63]. This finding suggests that forest landowners hold environmental values despite their conservatism and that communicators may be able to harness these values to promote climate change engagement.

2.2.2. Framing

Framing research informs our understanding of how climate change educators communicate about climate change, of the information context in which educators operate, and of how students interpret climate change information. Frames comprise both communicative acts and cognitive schemata through which audiences interpret information. “Frames in communication” are the frames used by communicators to “organize the central ideas of messages” [64] and promote an interpretation of an issue. “Frames in thought” represent the characteristics of an individual that shape interpretations of a frame [65]. In a linguistic analysis, Romàn and Busch [66] found that sixth grade science textbooks in California frame climate change and humans’ role in climate change as uncertain. Busch [67] analyzed climate change frames employed by California science teachers and discerned two distinct climate change classroom discourses: a science discourse comprising frames such as impacts on Earth’s systems and global scale, and a social discourse comprising frames such as local scale and impacts on people. Stapleton’s [5] work with students who visited Bangladesh suggests that framing climate change in terms of human stories, particularly those that highlight climate injustices, renders the problem less abstract. Stevenson and colleagues [68] tested the impact of news articles using the emphasis frames agriculture, health, environment, and community on North Carolina agriculture students’ affective responses (hope or worry), their support for mitigation or adaptation measures, and their intentions to engage in individual climate actions like reducing personal energy use. They found a significant, positive correlation between the environment, health and community frames with hope and worry, but only worry predicted support for mitigation, adaptation, and intentions for individual behaviors. One explanation might be that the news article appealed to both emotions and their more sensational aspects led to higher perceived risk and negative emotions [69].

2.2.3. Construal Level Theory of Psychological Distance

Climate change is a global phenomenon that affects local processes and requires local action, and so scholars investigate how framing at different distances—spatial, social, temporal, and hypotheticality—affect judgement and decision-making. Research suggests that people view climate change as distant in each of these dimensions [70–72]. The construal level theory of psychological distance posits that people construe distant phenomena as abstract and proximal phenomena as concrete, and a common suggested application of psychological distance research is to frame climate change as a local risk [73].

Studies examining the role of spatial and temporal proximity frames in shaping support for climate change policy and risk perception yield mixed results. In some studies, local framing results in higher levels of engagement with climate change [74], whereas work focusing on risk perceptions suggests that local framing might not be as effective as global framing in communicating the magnitude of the risk [75]. One explanation might be that local frames are not necessarily more relevant than global frames [76] and that proximizing climate change may “lead to defensive reactions such as increased scepticism about the reality and relevance of climate change” [77].

Although psychological distance literature has not conclusively demonstrated the supremacy of local framing, “make it local” is a common refrain in both academic [39] and gray communication literature concerning climate change [78,79]. Further, a focus on local issues suffuses environmental education practice and is a critical component of the popular practice of place-based education (PBE) [80]. It is hard to draw conclusions about place-based education practice based on construal level theory studies in part because PBE experiences are rich and encompass much more than place-based messaging. It is, however, also worth considering the mixed results of CLT studies as an opportunity to reflect critically on what it means for education to be “relevant” and whether that necessarily means being “local”.

2.2.4. Emotion and Affect

In addition to considering local or distal frames, educators can draw from surveys showing growing concern and worry regarding climate change [81] and choose frames and program strategies that influence emotions like worry and hope. Affect (“the faint whisper of emotion” [82]) and emotion can determine how people judge climate change as a risk [83], whether they support policy [84], and whether they decide to take climate change action [85]. Risk perception research demonstrates that people frequently evaluate risks based on their feelings rather than on the pros and cons of a situation [86,87] and emotions may elicit support for climate change policy differently among political groups [88].

Yet the relationship among fear, concern, and action is complex. One might infer that, because negative affect increases concern [86], messages that produce negative affect will increase the likelihood of climate change action. Further, fear appeals dominate media coverage of climate change [89]. However, consistent with terror management theory, fear may also lead to climate change inaction, or, even worse, actions that reduce fear but increase greenhouse gas emissions [90,91]. To complicate matters, fear may enhance information retention in students while at the same time leading to narrower and less thorough information-processing, which could, in turn, influence climate change understanding [69].

Environmental education researchers have also explored the role of hope in climate change action and attitudes. Hope is an emotion associated with goal setting, pathway thinking (how to reach goals), and agency thinking (a motivation to use pathways) [92], and it has been shown to motivate action [85]. Although recent work with adults suggests hope may function more as an emotional coping mechanism than as an action motivator [93], work with adolescents links feelings of hope with a willingness to engage in pro-environmental behaviors [85,94,95].

Self-efficacy may be an important pathway to hopefulness about combatting climate change. Swim and Fraser [96] write of the “emotional labor” and associated burn-out related to teaching about emotionally charged issues like climate change in their evaluation of NNOCCI, concluding that the training made educators more hopeful and more energized to teach about climate change by enhancing their climate change interpretation skills and connecting them to a network of concerned peers. Among high school students in the southeastern U.S., climate action self-efficacy correlated with hope related to climate change [97].

2.2.5. Summary

In sum, climate change social science research offers ways to understand audience perceptions and to, potentially, communicate more effectively based on that knowledge. In designing this study, we expected that these bodies of research might be used by climate change professional development organizations who would then inform climate change educators and, in turn, affect CCE practice. We also expected that climate change educators might seek out research information directly to inform their practice.

3. Materials and Methods

To gain insight into the extent to which educators were aware of and applying climate change social science research in their programs, we conducted semi-structured interviews with environmental education professionals involved in climate change education training programs and networks.

3.1. Sample

The first author used a mix of stratified purposeful [98] and snowball sampling [99] to first identify regional or national professional development programs or networks that displayed evidence of designing climate change education content and professional development based on empirical research (Table 2). We assessed research influence on program design by reading curriculum materials,

websites, and email communication from list-serves. After speaking with leaders from these programs over the phone, we used snowball sampling to identify 19 environmental education professionals (Table 2). Interviewees held mid- to upper-level positions in their organizations. We attempted to (1) maximize difference in organization type to develop a sense of how climate change communication strategies are applied across environmental education and (2) identify interviewees who had reflected on climate change education strategies prior to the study. Interviewees commonly worked with multiple audiences in their professional roles (e.g., a zoo education coordinator might train volunteers and interact with the public).

Altogether, the interviewees represented 19 organizations committed to CCE programs and reached audiences from cradle to gray in 5 Northeastern states, 7 Southeastern states, 2 West Coast states, 1 Western state, and 1 Midwest state. Educators worked in nonformal and informal settings, and in rural, suburban, and urban areas. In addition to working directly with audiences who attended their programs, each of the interviewees trained staff, trained volunteers, or led education workshops for formal or nonformal educators. Sixteen of the interviewees were female and 3 were male; 18 interviewees were White, while one was Latina.

Table 2. Interviewee Description.

Group Name	Program Description	Interviewee Summary	Interviewee Audiences
Project Learning Tree (PLT), Southeastern Forests and Climate Change facilitators	EE module developed in collaboration with University of Florida, PineMap, and Project Learning Tree. Module designs based on interdisciplinary research from forest-related fields and climate change social sciences	5 state Project Learning Tree coordinators who had led trainings in their state. 1 local facilitator who had co-led a training.	K-12 classroom teachers, nonformal educators forestry professionals and university-level forestry students
National Network for Ocean and Climate Change Interpretation (NNOCCI) trainees	National network of people and organizations involved in informal education, climate sciences, and social sciences; training and tools based heavily on research from The Frameworks Institute.	7 NNOCCI alumni from aquaria, museums, zoos and non-profits in 6 states	General public, school field trips, municipal leaders, and staff at their organizations
Climate Urban Systems Partnership (CUSP) Facilitator	Network of informal educators, learning scientists, climate scientists, and community organizations that creates informal learning experiences centered around local climate change impacts and solutions. Based at University of Pittsburgh, approaches to climate change education guided by principal investigators' research.	1 CUSP coordinator	General public and partner non-profit organizations

Table 2. Cont.

Group Name	Program Description	Interviewee Summary	Interviewee Audiences
Climate Literacy and Energy Awareness Network (CLEAN) members	National climate change education list-serve and climate change resource clearinghouse. Offers regular webinars presented by academic researchers as well as education professionals. Peer-reviewed articles, gray literature, and educational resources are shared on the list-serv.	3 members who themselves run statewide or regional education programs and participate regularly in the list-serve discussions. Using a snowball method, identified one additional educator from CLEAN	K-12 teachers, nonformal educators, K-12 students, and general public
EE Capacity Community Climate Change Fellowship (CCCCF) educators	National climate change education training program, facilitated by the North American Association of Environmental Education (NAAEE) and Cornell University. Received training in climate change and relevant environmental education research.	2 CCCC educators: a program director of a state-wide conservation organization and a founder of a city-based climate change education program	Adult environmentalists and the general public

3.2. Interviews

We developed a semi-structured interview guide (Appendix A) with open-ended primarily questions about the context in which educators were teaching about climate change, how educators were teaching about climate change (e.g., language, teaching strategies, and information sources), and whether they were actively aware of climate change social sciences research. The only frame type we asked about specifically was local vs. global due to emerging research on distance frames [72,100,101] and environmental education's focus on place-based approaches. The first author conducted interviews using Skype and recorded interviews using the software Evaer. Interviews lasted 25–60 minutes. The first author transcribed and began initial coding [102,103] of interviews shortly after each interview. This process enabled reflexivity [102], and the first author adjusted interview probes and questions as needed to address aspects of the research that had not emerged through previous interviews.

All interviewees gave their informed consent before their participation in the study, and this study was approved by Cornell University's Institutional Review Board as exempt from IRB review (Protocol Number: 1601006062) on February 25, 2016.

3.3. Data Analysis

The first author started analysis with a careful and close reading of interview transcripts, using Microsoft Word comments for initial codes and reflections to identify relevant concepts that emerged from the interview [102,104]. These codes and concepts were a blend of a priori codes defined by the literature and trends that emerged from the interviews. This process provided “rich data” and enhanced the descriptive validity of the research [105]. The first author next developed structural categories [103] drawn primarily from the a priori concepts reflected in the interview guide (Appendix A), and emergent codes defined by interviewee language. The second phase of coding [103] used NVivo and identified pertinent groupings of categories and codes to develop the themes presented in the findings.

To enhance validity and to gain a better understanding of educator programs, the first author familiarized herself with NNOCCI, PLT, and CLEAN climate change education materials, including

lesson plans, presentations, activity props, workshop agendas, community outreach campaigns, and exhibits. This “prolonged engagement” with the interviewees’ programs provided insight into the contexts within which they were operating [106].

4. Results

We first present from which sources educators reported accessing research. Next, we describe how NNOCCI, CUSP, CLEAN, and CCCF educators conceived of the effects of research on their practice and how PLT educators used the research foundations of their climate change module to build trust with their audiences. We highlight emergent themes, including educators’ sense of validation and the challenges they experienced applying what they learned from research into practice. Finally, we portray educators’ framing choices, focusing on distance, hope, and identity. While distance framing was an a priori theme for this study, framing for hope and framing to appeal to audience identities emerged through the coding process.

4.1. Awareness and Points of Access

Sixteen of 19 educators had heard about or reported reading climate change social science research. One PLT educator reported reading forestry research journals, while two other PLT educators reported not reading or accessing research materials, forestry or otherwise. Educators described multiple points of access to research, including trainings, news, social media, colleagues, popular nonfiction, and reading non-peer reviewed research reports from private research groups like the FrameWorks Institute and EcoAmerica (Table 3).

Table 3. Educator Descriptions of Research Access.

Point of Access	Example Quotes
Professional development	NNOCCI is the only thing I’ve found that gives very concrete recommendations that have been researched and tested (NNOCCI educator). We were briefed on it from the Pine Map people, but I didn’t do any [reading] of my own (PLT educator).
Colleagues	[My colleague’s] master’s thesis was on [state residents’] knowledge, attitudes, and behaviors on climate change, so she had some really interesting findings about what drives people’s beliefs in climate change, and it’s very much the popular media not the, not what they actually know to be a fact (PLT).
Popular nonfiction	I was reading, George Marshall–Don’t Even Think About It. His new book about climate change (CCCF educator).
Research report (gray literature)	EcoAmerica I think it is put out that guide to talking about climate change and they have the 13 key steps (CUSP educator).
Research presentation	We all attended Suzanne Moser’s workshop in the fall (CCCF educator). ¹
Social media	There’s probably about a dozen of us who are regularly sharing reports and articles and resources for understanding what’s going on in the world, and that’s incredibly powerful I think (CLEAN educator).

¹ Moser has edited volumes and published peer reviewed articles on climate change communication (e.g., [39]).

4.2. Research Use

NNOCCI educators described their practice in terms of the FrameWorks Institute’s research and how it changed their program language. One participant explained how she developed an activity for high school students that uses all four of the “research-tested metaphors.” Two other participants explained how their program language had changed:

I guess I was just talking about [climate change]. I wasn’t doing the heat-trapping blanket, I also wasn’t necessarily using connecting with people using a value at the very beginning of the conversation

... And what the research shows is you really want to connect with people right away early and often, actually with a value that resonates with most people. The research shows those values are protection and responsible management (NNOCCI educator).

(E)ver since I did the NNOCCI training, I was able to revamp that presentation and make sure I framed it in a way that was consistent with the NNOCCI recommendations and using the different elements like explanatory metaphors and things like that (NNOCCI educator).

The CUSP educator referenced a literature review that informed the project's logic model:

(C)limate science itself has not led to any increased concern or change in attitudes or behaviors on climate change. That allowed us to reject the idea that we needed to teach climate science itself with this project (CUSP educator).

CLEAN and CCCF educators stressed how accessing research led them to approach their programs from the perspective of audience identity and values rather than from a strict focus on presenting climate science and facts. A CCCF educator emphasized that “[i]t’s really ... the values that people have, and it’s appealing to those things and having conversations about those things and not being dogmatic about trying to win an argument.” A CLEAN educator described how “[i]t’s about understanding their worldview, their tribe.” The CCCF educator who worked for a bird-focused non-profit described how “the research seems to be pretty consistent. There’s the values and there’s the social pressure,” but that she was frustrated that that message “has been really slow to be heard and implemented in terms of an approach.” She planned to develop a training that focused on communication skills for her organization and partner organizations that helped staff integrate climate change into their programs:

We are going to do a bare bones climate change 101 in the beginning just to make sure we’re all in the same place with information. But then it’s going to be about communication skills, both listening and verbalizing (CCCF educator).

The other CCCF educator, who left a career in academia to work with adult environmentalists on climate action, discussed her work in translating research:

I’ve gone deep, deep, deep into cultural cognition with Dan Kahan [Yale Cultural Cognition Project researcher] because this is really important, and Kahan himself is disseminating it at one level, but it is not reaching the level that I’m working at all. I’m talking to folks who it would never cross their minds, and it needs to cross their minds. So, I took it upon myself to translate his stuff to try to create workable public education tools out of it (CCCF educator).

PLT educators spoke about the forestry and scientific research included in the module in the context of their audiences trusting in research. One educator discussed the importance of trust in forestry research for her audiences when she mentioned the PLT module’s “Changing Forest” activity:

[The module is] based a lot on you know current research that’s going on in the field. So again, it’s difficult especially with our foresters and professionals and our forestry students it’s difficult for them to discredit the research that the U.S. Forest Service is doing (PLT educator).

Another PLT educator recognized that his audience does not have implicit trust in research even as he emphasizes a fact and citation-based approach:

So, we really lay out the facts. And then still, you know the facts are questionable as well, but we try to, we just more or less lay out the facts and provide the citations that show where those numbers and facts came from (PLT educator).

4.3. Practice Validation

In addition to describing how their practice had changed because of research, educators discussed feeling that their practice had been validated by research. A NNOCCI educator described how research by the Climate Literacy Zoo Education Network helped her because it “validates what I do. I’m not like, why are you spending all of this time doing something that doesn’t matter?” Another NNOCCI educator framed the confidence she gained from NNOCCI in part around its research foundations:

I think now that we have these techniques and we were able to say these were research tested, we know that these will work, this isn’t just us thinking they will work, they’ve been proven to work. That was really kind of the ticket (NNOCCI educator).

A PLT educator described the impact of learning about environmental psychology research through a professional development course:

There were a couple things related to environmental psychology which really struck me . . . It was just the whole way of looking at it was very interesting to me. It was, it had a logic to it that I felt like verified my point of view of a lot of things, and also that I felt like would make it easier for me to communicate to other people the concepts I was trying to share (PLT educator).

4.4. Research-Based Knowledge vs. Practice Knowledge

Even as some educators felt validated by research, they also evinced a tension between trusting the research their programs were based in and drawing on their personal experience to complement, and in some cases, go against this research. On the one hand, NNOCCI educators explained why they do not create their own metaphors for programs:

No, because it’s actually recommended that you don’t create your own metaphors because a lot of research and testing went into the ones that were developed by FrameWorks Institute our partner in the NNOCCI project, so that’s why they’re so powerful because they’ve been researched and tested (NNOCCI educator).

In contrast, another educator described how other educators have developed their own metaphors or analogies as a response:

I’m not a big fan of the osteoporosis of the sea. But there’s other things that people have used, making connections to lemonade, and things like that and the ocean being like a sponge, that have worked as well. But that’s the sanctioned metaphor (NNOCCI educator).

In reference to a guide to climate change communication put out in partnership with EcoAmerica and Columbia University, the CUSP educator described how she applied the points she agreed with, while explaining further:

The one that I always have a little bit of an issue with is the ‘speak from the mountaintops, don’t fight in the trenches.’ So, they’re talking about focus on the big picture, and I guess what they’re saying is arguing details is a problem. But sometimes in this local space the details are what people really care about, and so that’s the one that maybe doesn’t work as well for us (CUSP educator).

A CLEAN educator reflected on the difficulties of adapting his practice as he explained his climate change education work:

And I’ll also note that I’m speaking in a very deficit-model and I slip into that too often. Of course, deficits are real, but a deficit approach is not generally the most effective way to communicate. I haven’t fully come over to certain aspects of what I academically know. I don’t viscerally know them, or something like that (CLEAN educator).

In summary, on a professional level, educators described changes in their practice related to framing addressing audience values and identity. On a personal level, some educators described feeling validated by research findings, yet some educators also experienced a tension between their research- and their practice-based knowledge.

4.5. Trends in Educator Framing

Exploring educators' framing of climate change offers another perspective on their incorporation of or alignment with climate change communication research implications.

4.5.1. Distance Frames

Guided by the emphasis in climate change communication research on psychological distance and distance frames, the first author asked educators whether they used global or local frames. Fifteen educators reported using local frames, three reported using a mix of distant and local, and only one educator reported using distance frames only (Table 4).

Table 4. Examples of Local, Combination Local–Global, and Global Frames.

Frames	Example Quotes
Local/Close	Then we turn around and address it in ways that they've actually seen, you know increased insects, the increased wildfire, and how they're managing forests. Then they kind of understand because it's framed in a way that relates directly to them (PLT educator).
Local and Global	There's been a real movement which I agree with that we have to make this relevant and local . . . When we make it too local and don't connect back to the global piece, I think we do the rest of the world a disservice (CLEAN educator).
Global	I look at it, and therefore tend to discuss it, in terms of a global problem (PLT educator).

Those who emphasized local frames did so as a means of connecting with their audience's previous experiences. A PLT educator who worked with foresters explained why she liked using the PLT activity called "Changing Forests":

We do the 'Changing Forests' one a lot because again that is talking about things that we have actually witnessed and things that we've seen (PLT educator).

4.5.2. Framing for identity and values

Educators reported employing a mix of identity-driven frames. For one CCCF educator, tying climate change into natural impacts aided her in keying into her audience's identity as bird lovers:

We need to connect that activity to this is really good for birds and beneficial to you know maybe absorbing more carbon you know for like planting something along those lines (CCCF educator).

One CLEAN educator mentioned connecting to his audience's social identity group ("I'm talking to a Rotary Club, I'll start with the economy") while another emphasized the importance of appealing to her audience's "worldview, their tribe."

For PLT educators, science frames functioned as a means of maintaining political neutrality. A PLT educator describes how one of the videos she uses from the curriculum "explains very well the science of climate change without talking about politics at all." Another PLT educator discussed how skepticism in the United States about climate change affects her program goals:

I think there's still a lot of skepticism in the United States that climate change is even happening, and so really we just want people to leave knowing that this is a real thing, and if we can show them some

very good scientific evidence, I think a lot of times our participants sit there and go, 'Wow, I had no idea' (PLT educator).

This educator first identifies an audience identity: skeptic. Based on this, she describes shaping her goal for the program as one of the first steps to climate literacy—accepting climate change is happening—by using scientific evidence or information. Motivated reasoning research suggests that simply providing information will not sway skeptics; however, this educator perceived her programs as successfully shifting the knowledge base of skeptics.

A PLT educator was the only one to employ religion as a major frame to appeal to his audience's Christian identity. He had developed a skit about taking care of the forest as "God's directive" and reported asking his workshop attendees, "Doesn't the Bible say to take care of the forest?"

4.5.3. Framing for Hope

Consistent with research that suggests using positive frames promotes efficacy, educators reported employing solutions frames to maintain hope and to inspire action among their audiences. Their decisions to use solutions frames were based both on their professional development experiences and an intuition that it would be more effective than doom and gloom framing. Notably, solutions frames were used by 15 of the 19 educators. A NNOCCI educator talked about how energized the teachers in her teacher workshops get when they realize climate change as a classroom topic is "a really cool teachable moment in terms of it being interdisciplinary and totally relevant and focused on solutions." A CLEAN educator described giving audiences examples of climate-related action happening:

... particularly in the state or in their neighborhood is very powerful, and that's the hope part. Once they can see that these things are happening, they can be done, and they can participate. That's where it becomes hopeful (CLEAN educator).

Another CLEAN educator discussed how difficult it is for her to:

... not come across as all gloom and doom and how to give [children] some sense of hope ... I point out things that are going on right now that people are doing, so locally for instance in our county there are a lot of businesses and organizations which are working and actually have been very successful to promote renewable energy (CLEAN educator).

A PLT educator described how she needed to provide "good news" and she wants educators in her workshops to "realize that there are things you can do to address this." In her case, she introduces educators to PLT's Green Schools Initiative, a program that encourages schools to improve energy use, waste and recycling, water consumption, school site, and environmental quality.

5. Discussion

Several trends emerged from this research: educators used research to improve and validate practice, and educator framing choices reflected long-standing trends in environmental education (i.e., place-based education) as well as efforts to inspire hope in audiences, to appeal to particular audience identities, and, in the case of PLT educators, to appear politically neutral. We discuss these below and then consider how the phenomena of feeling validated by research illustrate both challenges and opportunities in the research translation process.

As might be expected, professional development and professional networks played a crucial role in educators' access to research, although educators interviewed here also accessed research through other means as well. The high level of reported research use and access contrasts with studies in formal education, which suggest that formal teachers rely more on practice knowledge even after participating in professional development [23,107]. In this study, interviewees occupied mid-to-high level positions in their organizations, a factor correlated with a higher likelihood of applying research to practice after attending professional development trainings [108]. Additionally,

this sample comprised a self-selected group of educators who were motivated to seek research-based resources to inform their programs and who viewed themselves as mediators between research and their audiences [109]. Fear of divisive climate conversations and the complexity of the climate issue may also drive educators to seek additional resources. The types of organizations in which several of the educators worked—in particular, zoos and aquariums—may also have facilitated research translation, as they served audiences who were open to learning about climate change [14,110,111].

Educators' framing decisions both illustrate instrumental research use and the role of professional contexts in determining language choices and program approaches. Research-based language choices, such as the NNOCCI metaphors, transferred easily to practice and were used beyond the NNOCCI group by other educators; NNOCCI educators also created non-NNOCCI approved metaphors for their particular contexts. Both NNOCCI and CCCF educators described changing their practice to highlight values, reflecting research on the role values play in climate change policy preferences [86] and intentions to change behavior [63]. In contrast, PLT leaders were from Southeastern states that trend conservative, and they emphasized climate change as scientific fact; they described a fact-based approach as appropriate given audience political identities and the need to depoliticize and present climate from a perceived neutral, non-threatening standpoint [112,113]. While one of the PLT leaders worked more with forestry professionals and students, other PLT educators interviewed for this research worked with self-selecting teachers who chose to attend workshops and so may also have viewed science as a neutral arbiter.

Educators integrated their audience assessments with their choice of distance frames, with most choosing local frames and a few choosing global or a mix of global and local frames. Environmental education has long had a place-based thrust, and personal relevance is a hallmark of environmental education and environmental interpretation best practice [114]. Climate change research that validates linking climate change to local impacts corroborates pedagogical approaches educators already held. Educators' use of mixed global and local frames reflects a tension in the framing research itself, which suggests that while local frames are more psychologically close and may increase the likelihood of policy support or action, global frames have been shown to increase study participants' level of concern about the issue [75]. Additionally, local frames combined with sensational frames may lead to negative feelings towards climate change action [69], which a PLT educator sought to avoid by using global frames.

Participating in research-oriented professional development also validated educators' sense that they were engaging in best-practices. Furman and Yarden [34] identified two types of overarching categories of questions teachers ask in connection with research and practice—questions about how theory might contribute to teachers' practice and questions about how teachers' practices could confirm theory. In our interviews, however, we find that educators viewed theory as confirming *their practice*, rather than the other way around. Similar to the findings of a study with teachers [25], educators in this study had a tendency to view novel research findings as familiar and validating. In light of this finding, providing the support structures for local adaptation and ownership of materials may be a more realistic goal [115] for professional development organizations than seeking to have their evidence-based materials translated into practice with as much fidelity as possible [36]. Taking the NNOCCI metaphors as an example, we can see how, even as some educators rejected certain metaphors in favor of ones they had developed themselves, they still employed the program's techniques—using figurative language to aid audience understanding.

6. Limitations

One limitation of this research is that it describes how educators *report* discussing climate change rather than observing them to assess how they discuss climate change in active practice. While this study maximized difference among participants by interviewing educators from multiple programs and states who worked with a wide range of audience types, most educators were leaders in their organizations, and their perspectives may not match those of colleagues who do more direct delivery of

program content. Additionally, the sample design and scope of research limited the sample to a group of mostly white women. This sample may typify what are traditionally considered environmental education organizations, in which white women occupy mid-level management positions [116] but it does not represent the breadth or diversity of educators in organizations that may deal with CCE but not do not define themselves as environmental organizations [4]. Future research might broaden the scope of organization types to ensure a more diverse sample, which would elucidate research-to-practice trends across a wider range of climate change education professionals.

7. Conclusions

Bridging the gap between research and practice represents a challenge that multiple academic fields continue to grapple with. Lemos and colleagues [117] describe how the path from information that is “useful” to information that is actually “usable” and “used” depends on interaction between the end-user (educators, in our case) and the information producer. The present study provides a view of how educators who have participated in a variety of research-based professional development programs and professional networks consider their practice and which pieces of those research-based tools (such as NNOCCI’s metaphors) are most salient to their practice. Educators interviewed in this study employed research information—and the fact that they had participated in research-oriented professional development—to shape their program language, staff trainings, and approach to audiences. For many of the educators interviewed here, the information that went from “useful” to “used,” or, in the language of Reid [7], the practices that “took root” involved shifts away from programs focused primarily on transmitting climate change facts to programs that integrated understanding of audiences’ values and identities and used place-based program language to resonate with audiences. Additional research should be devoted to understanding how education leaders like those interviewed for this study transfer their knowledge to their staff, on an organization-wide level, and into tangible education materials and outcomes.

The process of practice validation raises questions about the role of research in CCE practice, as it may limit educators’ application of research findings. One of the clearest takeaways from our interviews, however, is that the climate change educators in this study value highly the research they accessed, either through professional development or on their own. Moving forward, CCE professional development organizations may seek to further highlight the research underpinnings of their work. This may both build confidence in educators attending trainings and allow for additional critical reflection on what it means to apply that research in practice.

Author Contributions: Conceptualization, A.K.A. and M.E.K.; methodology, A.K.A. and M.E.K.; investigation, A.K.A.; formal analysis, A.K.A.; original draft preparation, A.K.A.; review and editing, A.K.A. and M.E.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: We thank Dr. Jonathon Schuldt for his input in this study as a member of the first author’s M.S. committee, Dr. Lee Humphreys for qualitative methods mentorship, the Civic Ecology Lab and Cornell Center for Conservation Social Sciences for their feedback, and to all the program leaders and interviewees whose participation made this study possible.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Semi-structured interview guide.

Interview Questions and Prompts
<ol style="list-style-type: none"> 1. Tell me about your center. <ol style="list-style-type: none"> a. Where is it located? b. How would you describe your region? c. What is the local community like? d. What do you think your local community knows about climate change? e. Who is the main audience at your center? 2. What is your role in this organization? 3. What kinds of climate change resources for planning programs would be helpful for you? 4. Tell me about how you came to teach climate change. 5. Describe a climate change program from your center. <ol style="list-style-type: none"> a. How is the program structured? (e.g., is it a half-day program? A whole-day program? Do people come to you, or do you go to schools or other community locations?) b. How would you describe your typical audience for this program? What kinds of activities do you run within the program? c. What do you want participants to know, think, or do after they leave your program? 6. Could you give me an example of how you describe climate change to your participants? <ol style="list-style-type: none"> a. How do you frame climate change? b. What kind of language do you use to talk about climate change? c. Do you talk about climate change as a local problem? As a global problem? 7. How would you describe your approach to teaching climate change? Do you use any particular teaching strategies? 8. What information did you use to create your climate change programs? 9. How would you rate the success of your climate change programs? <ol style="list-style-type: none"> a. What is working well? b. What isn't working well? c. What would you like to change? 10. Have you read any research about climate change communication? If so, what? 11. Have you read any research about climate change education? If so, what? 12. What kinds of climate change resources for planning programs do you have at your center? 13. What kind of change have you seen in your organization's approach to climate change education over the last 5 years? 14. Would you be willing to send a copy of your climate change lesson plans or other educational materials that you use? If you have run climate change related professional development workshops, would you be willing to send your advertising materials and a workshop agenda?

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