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Polar Bears or People? Exploring Ways in Which Teachers Frame Climate Change in the Classroom

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Not only will young adults bear the brunt of the effects of climate change, but they are also the ones who will be required to take action—to mitigate and to adapt. Framing, as both a theory and an analytic method, has been used to understand how language in the media can affect the audience's concern and intention to act. The theory and the analytic methods of framing were adapted and applied to answer the research question: How do teachers frame climate change in the classroom? Twenty-five lessons from seven teachers were analyzed using semiotic discourse analysis methods. Teachers' frames overlapped to form two distinct discourses: a Science Discourse and a Social Discourse. The dominant Science Discourse can be summarized as follows: *Climate change is a current scientific problem that will have profound global effects on the Earth's physical systems.* The Social Discourse, used much less often, can be summarized as follows: *Climate change is a future social issue because it will have negative impacts on people at the local level.* While it is not surprising that the Science Discourse was heard most often in these science classrooms, framing research suggests it is problematic. The research literature on framing indicates that the frames found in the Science Discourse—global scale, scientific statistics and facts, and impact on the Earth's systems—are not likely to inspire action. In contrast, the frames found within the Social Discourse—local scale, impact on humans, and connections to social, economic, and political processes—are more likely to inspire action. The implications for the classroom are discussed.

Keywords: *Climate change; Language; Framing; Media; Science communication*

Introduction

'Polar bears are being forced to swim longer distances as sea ice decreases', reads the caption under a picture of a seemingly distressed polar bear struggling in a stormy gray

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ocean (World Wildlife Fund [WWF], 2014a). Another page titled 'People at risk' shows an image of an Indian mother holding a malnourished child in front of a dilapidated straw house. The caption: 'I have lost my crops almost five times in the last few years' (World Wildlife Fund, 2014b). These two contrasting cases are an illustration of how mass media can serve as a messenger of climate change and how its messages can be presented or 'framed' in a variety of ways. The first example uses a *wildlife frame* with a wild animal as the main character. In contrast, the second example uses a *human frame*, which emphasizes the direct effects of climate change on people (Manzo, 2010). Why might the framing of climate change be of interest?

Frames are 'interpretive storylines that communicate what is at stake in a societal debate and why the issue matters' (Nisbet & Scheufele, 2009, p. 1770). Framing is of particular concern because numerous communication studies have shown how the presentation of different frames affects a person's sense of responsibility and motivation to act to resolve environmental problems (Gifford & Comeau, 2011; Jang, 2013; Otieno et al., 2014; Spence & Pidgeon, 2010). For example, as 'the face of climate change', polar bears and stories of their struggle inspire action. Polar bears are the second most popular animal to be adopted through monetary gifts to the WWF (Manzo, 2010). However, other studies have shown that unless a person considers him/herself a 'wildlife lover', the polar bear is not motivating (Hulme, 2009). For this person, the human framing incites greater concern.

For the general public, mass media is the main source of information for learning about climate change (Leiserowitz, Smith, & Marlon, 2010). Using the theory of framing and frame analysis methods, a great deal of research has been done to characterize the media's role in the public's understanding of and attitudes toward climate change. In contrast, for youth, the science classroom is an important source of information about climate change (Dupigny-Giroux, 2010; Jeffries, Stanisstreet, & Boyes, 2001; Leiserowitz, Smith, & Marlon, 2011). Analogous to journalists, teachers make choices in the language they use to teach about climate change, and their language frames the issue of climate change for their students. However, we know very little about how teachers talk about climate change in their classrooms. Consequently, the aim of this research is to answer the question: How do teachers frame climate change when teaching climate science in the classroom?

The following section provides a brief overview of the theory of framing. I then review empirical work that has been done to understand the framing of climate change in mass media as well as the effects of those frames on individuals' attitudes. Finally, I review the research on climate change education, to show how using framing as a theory and analytic method can provide a fresh perspective on climate change education in the classroom.

Framing as a Theoretical and Analytic Lens

In his 1974 book, *Frame Analysis: An Essay on the Organization of Experience*, Erving Goffman defined frames as 'definitions of a situation [that are] built up in accordance with principles of organization which govern events—at least social ones—and our

subjective involvement in them' (p. 10–11). He regarded 'frame analysis' as 'a slogan to refer to the examination in these terms of the organization of experience' (p. 11). In other words, Goffman saw frame analysis as a way to identify an individual's social constructions (or 'frames') of common situations and experiences. Since 1974, Goffman's concept of framing has influenced theory and research methodologies in the study of mass media, social movements, and politics (Scheufele & Tewksbury, 2007).

Theoretically, framing links macro-level and micro-level processes between society, the media, and individuals in the audience (Scheufele, 1999). Scheufele identified three such processes: (1) frame building, (2) frame setting, and (3) the individual-level effects of framing. At the macro level, journalists draw upon ideologies, attitudes, and organizational pressures to craft their messages. By doing so, the media is building the frames for a particular topic. During the frame setting process, the frames are fixed and presented to the audience, making them available to individuals. At the micro level, individuals in the audience use frames to filter the incoming messages, using 'mentally stored clusters of ideas that guide individuals' processing of information' (Entman, 1993, p. 53). As a result, individuals will develop attitudes, understand attribution of responsibility, and take actions based on how the issue was framed. These three theoretical processes are supported by empirical work on climate change and media communication.

Climate Change in the Media

Media's frame building and frame setting of climate change. Frames are not accidental. Journalists draw upon ideologies, attitudes, and organizational pressures to make conscious choices as to what they will present to their audience. By doing so, the media builds and sets frames for individuals in their audience. There has been much research examining how mass media—the main source of information for the public—has framed climate change.

Through examination of television news segments from 1995 to 2006, Boykoff and Boykoff (2007) found that anthropogenic climate change was framed as uncertain and controversial (even among scientists). The researchers sampled from 286 television segments, chosen from network shows with high viewership and influence. The segments were analyzed for their framing of uncertainty and lack of scientific consensus about human-caused climate change. They claimed that the US public's view of climate change as controversial is a result of that framing's prevalence in television news coverage. Specifically, the journalistic norm of balance—presenting all sides of an issue equally—has been applied to the coverage of anthropogenic climate change. Therefore, through the frame-building process, the media drew upon an ideological stance of balance, which resulted in the framing of climate change as controversial.

Organizational pressures have also been found to influence framings of climate change within print media. In a study of popular magazines from 1997 to 2004, Sonnett (2010) found that journalists framed climate change in a way that was consistent with their audience's ideologies. The researcher compared the representation

of risk due to climate change in US magazines sampled from 14 leading publications in 4 areas of interest: politics, science, business, and environment. Using content analysis, Sonnett found that political magazines emphasized *dread*; science magazines emphasized *adaption*; business magazines stressed *caution*; and environmental magazines called for *protection*. The study demonstrates that different media sources portray climate change risk in different ways. Journalists at each of the magazines were creating content for a certain audience and were making choices as to how to present information.

Studies also show how the media can influence the salience of an issue. Boykoff (2007) compared the quantity of coverage about anthropogenic climate change in newspapers from 1988 to 2004. Over those years, the quantity of coverage has ebbed and flowed, but there are notable spikes coinciding with political events. For example, the first spike in 1990 coincides with the publication of the Intergovernmental Panel on Climate Change's (IPCC) First Assessment Report. In 1997, there was another sharp increase in coverage when the Kyoto Protocol was being introduced and debated. These increases in the quantity of coverage indicate when those in the media have deemed climate change as being a 'newsworthy' topic. Through the quantity of coverage, therefore, the media is indicating whether or not climate change is an important topic for the public.

Taken together, studies such as these three suggest how the media are building and setting frames about climate change in line with their ideologies and journalistic norms for the public, influencing both the nature and the quantity of the content. In particular, the journalistic norm of balance is influential in producing an impression that the topic is controversial within the scientific community. As well, the public are getting different views of the risk involved with climate change depending on the type of media they choose to read. These frames may partially explain the results of public polling, which indicate a decreasing belief and concern about climate change among US citizens (Pew Research Center, 2013). Thus, it is the audience's responses to these frames that make this issue so important and interesting.

Audience's responses to framings of climate change. Framing also affects how a message is interpreted. Individuals draw upon 'personal experience, partisanship, ideology, social identity ... [and] conversations with others' (Nisbet, 2009, p. 18) to make sense of the world. Many experiments have been conducted to test how different frames affect individuals' feelings of concern about climate change. The results of these studies are often not in agreement. This section highlights a few of these studies and is organized into groups to facilitate making comparisons.

Attribution frames. Attribution frames assign responsibility. In the case of climate change, they assign 'blame'—for who or what is responsible for climate change. If people are to take mitigating action, they need to understand that humans are to blame for climate change. After all, if climate change were a natural phenomenon, then our action would be unnecessary. And indeed, survey research indicated that if people believe that humans are causing climate change, then they are more concerned about climate change (Bord, O'Connor, & Fisher, 2000; Malka, Krosnick,

& Langer, 2009). However, not all research studies substantiate this common-sense interpretation. In a study conducted by Otieno et al. (2014), the attribution of responsibility—human or natural—did not influence the perception of risk, emotions, or learning outcomes. Likewise, Jang (2013) surveyed Americans under experimental conditions. One treatment group read a text that attributed climate change to America's excessive use of fossil fuels, and the other treatment group's text attributed it to China's fossil fuel use. If participants read that climate change was America's fault, then there was a higher chance they would agree that climate change was a natural phenomenon. This group also exhibited less concern about the effects of climate change and less policy support for climate change mitigation.

Valence frames. Valence frames are used to portray climate change in either a negative or a positive manner, playing on the emotions of the message recipient. The Oteino et al. (2014) study discussed previously also studied a sensational (emotional) versus a neutral framing. They found that the sensational frame was correlated with an increased perception of risk, more negative emotional responses (for example, fear), and higher scores on the content portion of the survey. However, too much fear can also be counterproductive. Feinberg and Willer (2011) conducted an experimental study measuring the effect of a dire (negative) or hopeful (positive) framing of climate change on participants' level of skepticism and their willingness to take action to reduce their carbon footprint. The participants who read the negative message had increased skepticism about the future, while the participants who read the positive message had decreased skepticism. Through an additional experiment, the researchers found that feelings of skepticism mediate individuals' willingness to take action to reduce their carbon footprint. That is, those with increased skepticism were less likely to take action.

Spatial frames. Spatial frames compare how distant (or close) the effects of climate change will be. The typical spatial frames used for climate change are global or local. Experimental research suggests that the local framing may lead to more positive attitudes toward mitigating actions; however, other mediating factors were evident. Scannell and Gifford (2012) found that the effectiveness of the local framing was most strongly mediated by the degree of local place attachment. In their study, a strong attachment to place was correlated with a greater willingness to engage in mitigation actions. This study's results slightly conflict with another recent study of the local versus global frame. Spence and Pidgeon (2010) tested the spatial frame with citizens of the UK. Their findings agree with the Scannell and Gifford study in that the framing of climate change impacts as a local issue led to more positive attitudes toward mitigation actions. However, contrary to that, the framing of impacts as a distant threat resulted in increased perception of those impacts being more severe.

Temporal frames. Temporal frames represent climate change as a current issue or as an issue that will occur in the future. To inspire action *now*, it would make sense that we would need to understand that climate change is happening *now*. However, climate change is often portrayed as a future event, as something that will affect our children or grandchildren. Because people tend to discount future events, a future framing likely leads to inaction or a wait-and-see approach (Center for Research on

Environmental Decisions, 2009). However, the framing research does not support this prediction. Dickinson, Crain, Yalowitz, and Cherry (2013) surveyed birdwatchers after they read a statement framed in one of two ways. The current-framed statement read 'Studies have shown that if a large number of people in North America would reduce their energy consumption a small amount, this would have a large impact on the U.S. carbon footprint' (Dickinson et al., 2013, p. 149). The future-framed statement read: 'Studies have shown that if a large number of people in North America would reduce their energy consumption a small amount, this would have a large impact on the U.S. carbon footprint and its effects *on future generations*' (Dickinson et al., 2013, p. 149). The results of a survey indicated that the participants were slightly more willing to take action if the issue was framed as a benefit to future generations. In another experimental study, Rabinovich, Morton, and Postmes (2010) compared the effect of time on intention to take pro-environmental action. They gave UK university students a web page to read that presented the effects on the environment in a near-term situation of 1 month or a long-term situation of 10 years. Participants were more likely to take positive action if they had been in the long-term condition. The researchers concluded that the placing of benefits in the distant future was more motivating than the placing of benefits in the short term.

Impact frames. Impact frames define who or what will be affected by climate change, such as polar bears or people. When comparing the wildlife frame and the human frame, Dickinson et al. (2013) found a wildlife frame to be more effective. The human-framed statement read: 'Climate change is dangerous for *people*, especially those living in low-lying coastal areas' (Dickinson et al., 2013, p. 149). The wildlife-framed statement read: 'Climate change is dangerous for *birds*, especially those already suffering from loss of habitat' (Dickinson et al., 2013, p. 149). The participants in their study were more willing to take action when mentioning the danger to birds, but the sample was birdwatchers so it is likely they found that statement personally motivating. In contrast, O'Neill and Nicholson-Cole (2009) concluded that participants in their study found images of starving children more relevant than polar bears. They conducted a multi-method qualitative study in Norwich, UK, measuring the impact of visual images on a person's sense of salience and efficacy. Using interviews and focus groups, they found that participants did not find images of polar bears personally relevant, but the participants did find images of starving children highly relevant. However, both of these images decreased the participants' feelings of efficacy. Efficacy was the greatest when participants were shown images of common household objects such as energy-efficient light bulbs and thermostats. Because impact frames are highly relative, messages about climate change should offer many impact frames to appeal to a wider audience (Center for Research on Environmental Decisions, 2009). The introductory WWF example used a multiple framing technique—both human and wildlife—on their webpages about climate change, likely with the goal to appeal to a broader audience.

In summary, experimental studies show that the way a message is framed affects how a person will perceive climate change, particularly how that person may be

inspired to take personal mitigating action. However, they do not all concur as to what those responses may be. Despite this disagreement, recommendations have been made on how to communicate more effectively about climate change with the public. If messages about climate change are to be effective, they should establish human causation, balance negative and positive emotions, portray climate change as an issue that is both here and now, and be tailored to an audience's orientation (Center for Research on Environmental Decisions, 2009). So, how are teachers talking about climate change? Are teachers framing their messages in the way that has been recommended for effective communication?

Climate Change in the Classroom

Studies which catalog student misunderstandings are typical of the research that has been done to date about climate change education (Jakobsson, Makitalo, & Saljo, 2009). Current research shows that students have many naïve conceptions. And, despite increased attention to climate change education, these conceptions have remained stable over the past two decades. In a synthesis of the literature, Shepardson, Niyogi, Choi, and Charusombat (2011) identified many of these common naïve conceptions that students hold. For example, students often confuse global warming with the deterioration of the ozone hole, mistakenly thinking that the ozone hole allows more sunlight to enter through our atmosphere, which is causing temperatures to rise. Students also confuse the greenhouse effect (needed for life to exist on Earth) and global warming (detrimental exaggerated greenhouse effect).

While these studies do provide a snapshot of what students know at a certain point in time, they only provide a partial understanding of how climate change is taught and learned in classrooms. First, these studies place an emphasis on 'knowledge', which only partially explains why people engage with and act upon environmental problems. Other significant factors in predicting pro-environmental behavior include attitudes, social norms, locus of control, and situational factors (Kollmuss & Agyeman, 2002). Second, these studies say nothing of how 'the knowing' comes to be. What happens in the classroom? What does the teacher say or do? How do the students make sense of what is said or happening? To understand *why* students may have these alternative conceptions, we must look *inside* the classroom. The sociocultural theory of learning provides that 'knowledge is distributed in the world among the individuals, the tools, artifacts ... and the communities and practices in which they participate' (Greeno, Collins, & Resnick, 1997). Language is the essential tool used within the classroom, and teachers serve a key role in mediating knowledge for their students through their use of language (Lemke, 1990; Wells, 1999). Because of the importance of language and the social setting for meaning-making by students, this study will be looking at the *language* teachers choose when teaching about climate change *in the classroom*. Framing can be used to deepen our understanding of how climate change is being taught and learned within the classroom.

The theoretical framework for the media also applies to the classroom (Figure 1). At the macro level, teachers likely make choices when *frame building* based on their

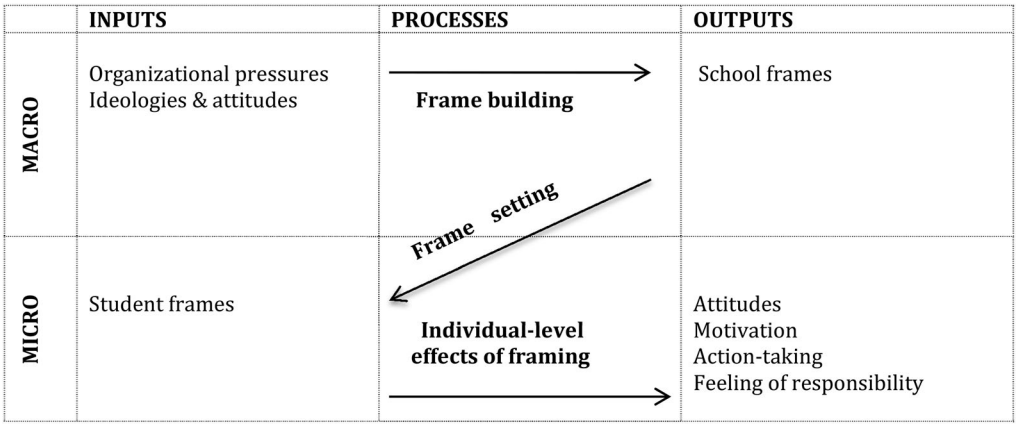

Figure 1. The theoretical framing processes between the teacher and the students. Image adapted from Scheufele (1999)

available curricular materials, their own personal beliefs and attitudes, the school context, and other community influences. For example, if the curriculum or textbook presents climate change as a natural phenomenon, the teacher may also frame climate change as being largely attributable to natural (rather than human) causes. A teacher may also not feel comfortable teaching controversial or interdisciplinary subjects (Gayford, 2002) and, therefore, restrict the frames used when teaching about climate change. A teacher may insist on balance (Oulton, Day, Dillon, & Grace, 2004) and, much like the journalistic norm of balance, inadvertently frame climate change as a scientific debate. During the *frame setting* process, the frames are then presented to the students. Frames are enacted as teachers talk about climate change in their lectures. Frame setting may also occur as students engage with the materials that are presented during the lesson, such as readings or videos chosen by the teacher.

At the micro level, the students will employ their own *individual frames* to define what they see as the issue. Students bring with them their own sets of personal experiences and attitudes, which they will use when engaging with climate change in the classroom. For instance, research has found that teenagers' perception of risk is highly influenced by their parents, and this in turn mediates the youths' responsiveness to new information about climate change (Mead et al., 2012). Although framing experiments have mostly been conducted with adults, one study of teens found that hopeful messaging about climate change was more motivating, whereas fear-based messages were disempowering (Ojala, 2012).

Research Question

This brief review of the literature indicates that framing has provided some explanation as to how the media shapes public understanding and concern about climate change. In the classroom, teachers have a similar role as the media, framing climate change for their students. Teachers are acting as the frame setters within the

classroom, and these frames are made apparent through their choice of language while teaching about climate change. However, we have little understanding of what teachers say while teaching about climate change. Such understanding is important because the way a teacher frames climate change affects how a student perceives the risk and his or her role in taking action. Therefore, this study seeks an answer to the question: How do teachers frame climate change when teaching climate science in the classroom?

Study Context and Participants

The data for this study come from a three-year collaboration between a private university's School of Education and School of Natural Sciences to create a climate science curriculum (Table 1) and professional development program for the use of that curriculum. The curriculum progresses from an opening 'hook' activity about how the climate and humans are connected. Then, the next two lessons establish the physical science concepts: the energy budget and the function of greenhouse gases. In Lessons 4 and 5, the effects of a changing climate are investigated; students learn about the impacts of climate change on the physical and biological Earth systems. Lastly, the unit culminates in comparing possible solutions, using a mitigation wedge activity in which students select a suite of solutions to mitigate carbon emissions. Overall, the curricular materials stress the role of human activity in climate change.

Table 1. Climate change curriculum outline (Stanford Climate Change Education Project, 2014)

Lesson # and name	Student learning objectives
1. Introduction to climate change	Students will be able to identify the relevance of studying climate change and differentiate between elements of weather and climate
2. Energy budget	Students will be able to apply the concepts of energy and light to create an input/output model of energy budget for the Earth
3. Greenhouse gases	Students will be able to identify greenhouse gases and their sources and apply the properties of these gases and radiative forcing to model Earth's energy budget
4. Impacts of climate change on physical systems	Students will analyze the sources for climate data and will analyze these data to identify the impact of climate change on physical systems
5. Consequences on biological systems and adaptation	Students will analyze data to determine the consequences of climate change on environmental, biological, human, and social systems and identify adaptation strategies for these consequences
6. Climate change mitigation	Students will be able to compare and contrast climate change mitigation strategies (macro and micro) in light of environmental, economic, political, and ethical impact

The data source for this study comprised over 15 hours of videotaped classroom observations of 7 teachers who participated in the professional development program and used the curriculum. These seven teachers volunteered to have their classrooms videotaped, and thus are a convenience sample. Three of the teachers were in middle schools: Gary, Hask, and Marrow. The other four teachers were in high schools: Holden, James, Luft, and Tindle. (Please note the teachers' names are pseudonyms.) All of the teachers were female, except for Mr Marrow. Five are public school teachers, one is a public charter teacher, and one is a private school teacher. The teachers ranged in experience from being in their first year of teaching to those who had eight years of teaching experience. All of the teachers had reported that they have taught climate change in their classrooms before, and they also claimed to have confidence in their understanding of climate science. Provided with a scale (1— very, 2—somewhat, and 3—none), four teachers said they were very confident and three teachers said they were somewhat confident in their understanding of climate change.

Methods

This qualitative research was an exploratory, multiple case study. Because of the focus on language, semiotic discourse analysis methods were used, with particular attention given to individual words and phrases and their possible meanings (Lemke, 1990).

Data Preparation

Table 2 shows the composition of the video data used for this study. The class sessions represent three lessons from the curriculum: Energy Budget, Causes and Effects of Climate Change, and Mitigation Plans. These were the three lessons for which

Table 2. Description of video data by lesson number and teacher

	Lesson 2: Energy budget	Lessons 4/5: Causes and effects	Lesson 6: Mitigation plan	
Middle school				
Ms Gary	2 classes	2		
Ms Hask	2	2	2	
Mr Marrow	1			
High school				
Ms Holden	1	1	2	
Ms James	1	1	1	
Ms Luft		4		
Ms Tindle	2		1	
Total MS	5	4	2	**11**
Total HS	4	6	4	**14**
Total	**9**	**10**	**6**	**25**

classrooms were observed. Most of these lessons were approximately 30–45 minutes long, totaling over 15 hours of classroom instruction time for analysis. Eleven of the 25 class sessions were from middle-school classrooms, and 14 were from high school. They were unevenly distributed among teachers: Hask, Holden, and James taught all three lessons, Gary and Tindle taught two of the lessons, and Marrow and Luft taught only one of the lessons. The data were prepared for analysis by watching the video and creating a time-stamped transcription of teacher dialogue.

Data Coding

To identify the frames teachers used in their talk, the transcripts were coded with NVivo software, using a combination of an a priori and an in vivo coding scheme devised by the author (see the appendix). The a priori codes were developed using existing literature in the field of media and communication about climate change, such as the frames presented in the Introduction. The a priori frame groups were attribution frames (climate change cause as natural or human), impact frames (who or what—people or wildlife—will be affected), spatial frames (global scale or local scale), temporal frames (a current or future event), and valence frames (conjuring either positive or negative emotions).

A few additions were made to the in vivo coding scheme, when the a priori codes were insufficient to capture frame-use worth noting. Three frame groups were added: agreement frames (consensus or controversy), problem sphere frames (science or social), and solution frames (adaptation or mitigation). In addition, two frames were added to a priori groups: the regional/national code was added to the spatial frame group in order to distinguish local as just the Bay Area and the state of California. The Earth's physical systems code was added to the impact frame group in order to capture the use of this frame by teachers.

The transcripts were coded at the level of an 'idea unit', which is a segment of transcript that conveys a singular idea (Chi, 1997; Miles & Huberman, 1994). The idea unit may consist of a few sentences, but the smallest segment was a full sentence. For an example see Table 3, where line 1 is not coded as it is the context for the teacher talk, showing the topic of the slide projected at the front of the room. The teacher starts talking in Line 2, and this sentence is coded as *affect people* because it relates to how the decreasing snowpack will affect humans. In Lines 3 and 4, the text is coded as both *science sphere* and *human-caused* because the teacher is referring to data on a graph (science) and carbon dioxide emissions (human-created). In Line 5, the text is coded as *negative valence* because the teacher makes an explicit comment about how this is 'bad'. In Line 6, the text is coded as a *local issue*, because the teacher is relating how less snow in the Sierra Mountains will actually affect many Californians because it is a source of drinking water. Lines 7–9 are coded as both *social sphere* and *adaptation* because the teacher speaks to 'water issues' (social), which will require our conservation action (adaptation).

An iterative process was used to code the transcripts using the constant comparative method (Glaser, 1964). When the coding process had reached a point of stability and

Table 3. Example of coded transcript excerpt

Line #	Transcript text	Code assigned
1	Slide p. 8—Diminishing Sierra snowpack	
2	This is responsible for a lot of our drinking water and irrigation water for farming	Affect people
3	So, here if we have lower emissions, we have 74% remaining but with	Science sphere
4	higher emissions only 60% by 2049	Human-caused
5	Those people who like to snowboard, that is bad news	Negative valence
6	So, this is half of California's water storage	Local issue
7	We already face a lot of water issues in California. So if our main source of	Social sphere
8	storage location goes away, we're going to have to build a lot more	Adaptation
9	reservoirs, be a lot more conservation minded with our water	

saturation, a coding reliability check was conducted and calculated as follows: reliability = number of agreements/total number of agreements + disagreements (Miles & Huberman, 1994). The coding reliability was very favorable; agreement with two colleagues was 85.3% and 88.3%. These reliability scores indicated that the coding scheme was verifiable and ready to analyze for patterns.

Identifying Patterns

To analyze the coding trends, the data were quantified to answer these analytic questions (Chi, 1997):

(1) Which frames are used more often across all cases (lessons and teachers)?
(2) How do the frames overlap?

To answer Question 1, a cross-case analysis of frequencies of codes was generated. To answer Questions 2, a matrix of coding was created to calculate the correlation (Pearson's *r*) of when codes were co-occurring (Miles & Huberman, 1994). The results of these analyses are synthesized in the next section.

Findings

Same Graph, Different Stories

Visualize two classrooms. Both are darkened; the lights are off. In both, two graphs are projected onto the screen: one showing sea level rise and the other showing temperature rise (Figure 2). The students are quietly seated, and the teacher is speaking to the students. Consider the different ways these two teachers are discussing the same content.

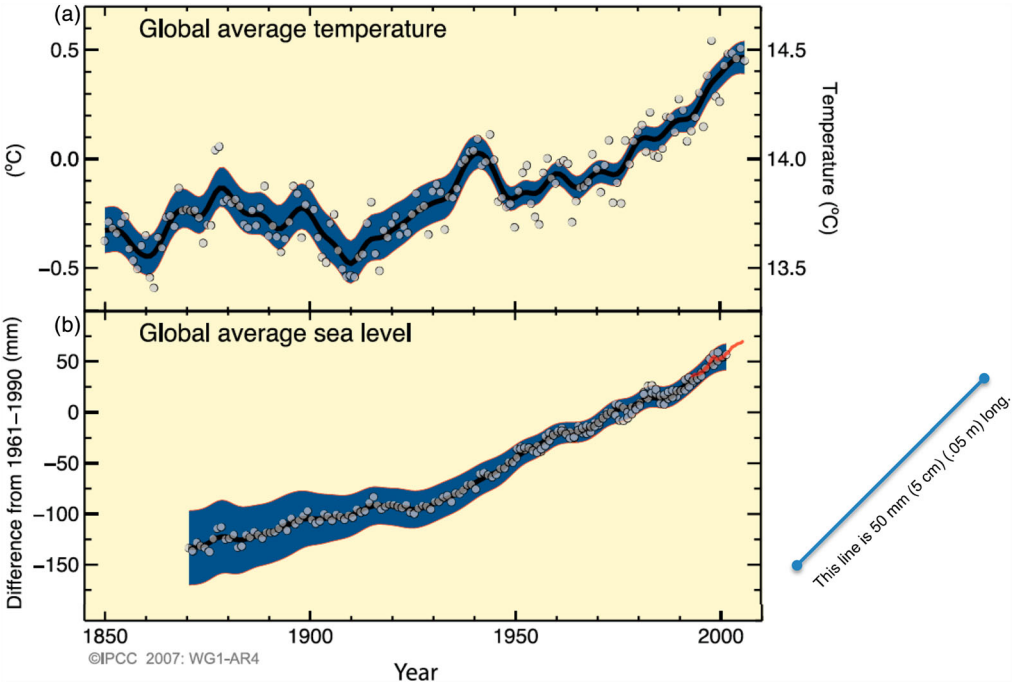

Figure 2. Global average temperature and sea level rise graphs. Image from IPCC (2007)

Ms Gary, a young female with dark curly hair is sitting at the back of the classroom. Her students are looking quietly at the screen. She is saying to her students:

Teacher transcript	Frames
*Some of the **things that can happen**, some of the impacts. Sea level rise is what we are going to focus on today. Temperature, obviously. More precipitation. All of these things are related. In terms of how that **affects you** because maybe you're like 'whatever' maybe we're here at **[city]** and we looked and saw that . . . how high did we raise the water level and we were still safe **right here on campus?** We went pretty high. We are up on a hill and we are far away from the coast right now. We were pretty much safe, so you might think 'ok' that doesn't really matter to me. But, ultimately, you think about **health, agriculture**. We looked at that in terms of the Central Valley, which is where what happens? Farming. If that floods, **then boohoo for us**. Water resources. All of the stuff . . . all has an impact on us just by a change in the climate.*	Future time scale Impact on humans Local scale Social sphere Negative emotion

In another classroom across the city, Ms Luft is standing at the front of the room. She is tall with long brown hair. She is presenting the same graph and is saying to her students:

Teacher transcript	Frames
*The next 2 graphs were about **sea level and sea level rise**. So, what is the purpose of these graphs? What are we looking at? So, we are comparing temperature and **global** average sea level and we see they are both **trending** upward. So, that looks like a **correlation**. Ok. What else? What are these shaded areas around these lines? Did you read the fine print? **Uncertainty**, yeah. This is a confidence range we feel around that number. What do you notice as we get closer to present? The shaded area gets small, and that's because we have better methods. How is this related to climate change?*	Impact on Earth physical systems Global scale Science sphere
***Warmer temperatures are correlated to rising sea level**. Warmer temperatures more water. We don't get that from this graph, but you are inferring that from other stuff we have looked at. So, from 3,000 years ago to **present**, sea level was mostly constant, rising .1 to .2 millimeters per year. That's really small so now we are looking at 1–2 mm per year. That is 10X different. And since 1992, we have risen 3 mm per year.*	Natural causes Current time scale

While Ms Gary and Ms Luft are both presenting the same content—literally the same graph of sea level over time is displayed in both classrooms—they are framing the graph in entirely different ways. In the first vignette, Ms Gary frames the issue as a *social problem* as it will impact people and societal structures such as our agricultural system. She also uses a *local framing* by providing geographical examples from the state—the Central Valley—as well as projecting the effects of sea level rise on the students' own school campus. Her message has a *negative valence frame* as she says 'boohoo for us' about the loss of food production capacity, but she tempers that by using a *future frame* because these effects are possibilities in the future but are not occurring yet.

In contrast, in the second vignette, Ms Luft is framing the issue as a *science problem* by focusing on the data and statistics of sea level rise, using scientific terms such as trending upward, correlation, uncertainty bands around the data trend line, 0.1 to 0.2 millimeters, 10× times, and 3 mm per year. Her framing presents climate change as a *current issue* that is happening now: sea levels are currently rising. But these impacts are *globally framed*—it is happening at a global scale and is affecting only Earth systems. These two teachers illustrate a common pattern across all of the teachers' talk. The frames clustered to form two distinct discourses: a Science Discourse and a Social Discourse.

Frames Overlap to Form Two Discourses

Frames co-occurred to form two distinct discourses: a Science Discourse and a Social Discourse. The results of a correlational analysis are shown in Table 4. The Science Discourse consists of five frames that were highly correlated (defined as a Pearson's r of 0.7 or higher) to each other: science problem sphere, global scale, current issue, and impact on physical Earth systems and natural causes. The Social Discourse

Table 4. Correlation (Pearson's r) of co-occurrence of frames

	Consensus	Contro-versy	Human-caused	Natural causes	Impact people	Impact plants and animals	Impacts on physical Earth	Science issue	Social issue	Adap-tation	Mitiga-tion	Global	Local	Regional or national	Current issue	Future issue	Negative or fearful	Positive or hopeful
Consensus	1.00																	
Controversy	0.51*	1.00																
Human-caused	0.39	−0.12	1.00															
Natural causes	−0.02	−0.19	0.43	1.00														
Impact people	−0.03	−0.27	−0.17	−0.22	1.00													
Impact plants and animals	−0.08	−0.30	0.21	−0.07	0.21	1.00												
Impacts on physical Earth	0.13	−0.23	0.48	0.43	−0.19	0.25	1.00											
Science issue	0.16	−0.20	0.66**	0.83***	−0.15	0.14	0.74	1.00										
Social issue	0.00	−0.26	−0.30	−0.36	0.88***	0.03	−0.32	−0.33	1.00									
Adaptation	0.22	−0.04	−0.23	−0.23	0.16	0.20	−0.23	−0.18	0.20	1.00								
Mitigation	0.07	−0.19	−0.17	−0.28	0.22	−0.26	−0.30	−0.26	0.63	0.26	1.00							
Global	0.17	−0.20	0.63	0.84***	−0.05	0.11	0.66	0.99***	−0.23	−0.14	−0.23	1.00						
Local	−0.12	−0.29	−0.19	−0.19	0.92***	0.33	−0.09	−0.12	0.79	0.11	0.16	−0.06	1.00					
Regional or national	−0.11	−0.30	0.20	0.18	−0.02	0.13	0.69	0.39	−0.13	−0.32	−0.21	0.32	−0.02	1.00				
Current issue	0.23	−0.21	0.46	0.43	−0.16	0.10	0.82	0.75**	−0.16	−0.24	0.00	0.70	−0.14	0.54	1.00			
Future issue	−0.09	−0.33	−0.10	−0.20	0.85***	0.23	0.02	−0.10	0.79	−0.11	0.21	−0.04	0.86	0.12	0.00	1.00		
Negative or fearful	−0.12	−0.34	−0.05	−0.12	0.90***	0.26	−0.08	−0.01	0.81	0.04	0.27	0.08	0.86	0.05	−0.02	0.86	1.00	
Positive or hopeful	0.01	−0.23	−0.22	0.04	0.24	−0.29	−0.21	−0.07	0.55	0.13	0.72	−0.02	0.25	−0.24	−0.06	0.22	0.21	1.00

*$p < .05$.
**$p < .01$.
***$p < .001$.

Table 5. Side-by-side comparison of discourses

Science Discourse	Social Discourse
Facts, statistics, and science concepts	Economics, society, and politics
Global scale	Local scale
Current time frame	Future time frame
Impacts of physical Earth systems	Impacts on people
Natural causes	Negative valence

consists of five frames that were highly correlated to each other: social sphere frame, future issue, local scale, negative valence, and impacts on people.

Returning to the first vignette, Ms Gary was engaging in the *Social Discourse* (shown bolded in Table 5). There are five frames associated with the Social Discourse: social problem sphere, local scale, future time frame, negative valence, and impacts on people. The Social Discourse, then, is characterizing climate change as a social issue because it will have negative impacts at the local level on people. And, these impacts will more than likely be felt in the future. Across all of the teacher cases, this discourse was less prevalent. Taken together, the Social Discourse accounted for 25.1% of the teacher talk.

In the second vignette, Ms Luft provides an example of the *Science Discourse* (shown bolded in Table 5). There are five frames associated with the Science Discourse: science problem sphere, natural causes, global scale, current issue, and impacts on physical Earth systems. This discourse treats climate change as a scientific issue because it is focused on the physical processes involved, including the causes and the effects on Earth systems. It presents climate change as currently happening. This discourse was more prevalent as four of these frames—science sphere, global scale, current issue, and impact on physical Earth system—were the most predominant in the cross-case analysis. Taken together, the Science Discourse accounted for 55.3% of the teachers' talk.

Science Is the Dominant Discourse

Four frames dominated the teacher's talk—science sphere, global scale, current issue, and impact on Earth's physical systems—and comprised 51.5% of the total frames used (Table 6). All of the other 14 frames played minor roles in teacher talk, with each frame accounting for less than 6% of the total framings used. Therefore, the main storyline teachers are telling can be summarized as follows: *Climate change is a current scientific problem that will have profound global effects on the Earth's physical systems*.

Across cases, teachers mostly framed climate change as an issue of *science* on a *global* scale. The science sphere frame and the global scale frame comprised 37.6% of the framing instances (20.1% and 17.5%, respectively). In addition, teachers talked about climate change as something that is *currently* happening and that will have

Table 6. Framing comparison totals and between teachers across all lessons

Teacher	Consensus	Contro-versy	Human-caused	Natural causes	Impact people	Impact plants and animals	Impacts on physical Earth	Science issue	Social issue	Adap-tation	Mitiga-tion	Global	Local	Regional or national	Current issue	Future issue	Negative or fearful	Positive or hopeful	Total
Gary	2	0	4	6	8	0	1	17	9	0	0	20	7	3	3	7	10	4	**101**
Hask	3	0	5	0	1	2	4	9	4	0	4	4	2	0	3	0	2	3	**46**
Holden	1	0	0	2	2	1	1	5	4	1	4	4	1	0	3	2	5	6	**42**
James	2	1	0	3	2	3	2	2	2	0	1	2	2	0	1	3	1	2	**29**
Luft	6	0	7	5	6	5	24	52	9	3	5	44	9	8	23	10	9	2	**227**
Marrow	0	0	0	2	0	0	0	3	0	0	0	3	0	0	0	0	0	0	**8**
Tindle	0	0	4	0	0	0	0	6	0	0	0	5	0	0	0	0	0	0	**15**
Total instances	**14**	**1**	**20**	**18**	**19**	**11**	**32**	**94**	**28**	**4**	**14**	**82**	**21**	**11**	**33**	**22**	**27**	**17**	**468**
Relative percent	**3.0**	**0.2**	**4.3**	**3.8**	**4.1**	**2.4**	**6.8**	**20.1**	**6.0**	**0.9**	**3.0**	**17.5**	**4.5**	**2.4**	**7.1**	**4.7**	**5.8**	**3.6**	**100.0**

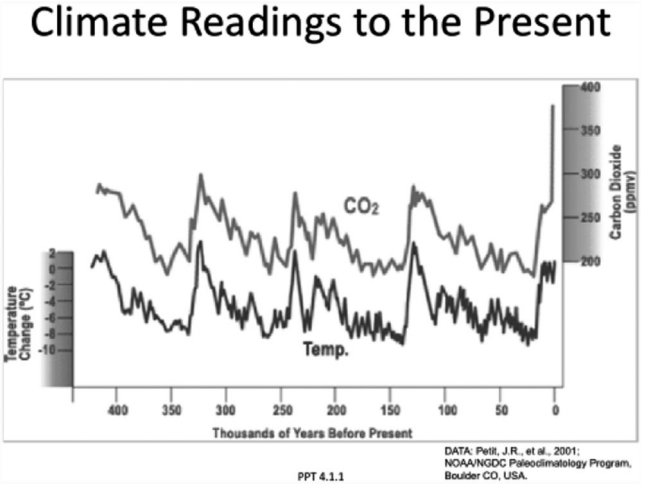

Figure 3. Vostok Ice Core data of CO_2 and Temperature. Image from Petit et al. (2001)

impacts on the *Earth's physical systems*. The current issue frame and the impact on Earth's physical systems frame accounted for 13.9% of the total frames used (7.1% and 6.8%, respectively). These frames form the core of the Science Discourse.

In the next example, consider how the teacher is using these frames: science, global scale, current issue, and impacts on Earth's systems. The teacher, Ms Hask, has an iconic graph of global temperature and atmospheric carbon dioxide levels over time (see Figure 3) projected on the screen, and she is saying:

> This one is taking into account the atmospheric direct measurements we have. What is it? 375 give or take. What is interesting about this graph? The first thing is the correlation between temperature and carbon dioxide. And the second is ... what is frightening about this graph? CO_2 [levels] are unprecedentedly high. What does unprecedented mean? Never before happened ... or at least in the last 422,000 years. So, that is something that has scientists very concerned. There is a lag here [between carbon dioxide and temperature]. All predictions indicate that the temperature line will follow suit very quickly. And very quickly in geologic time scales is over the course of a couple of decades. So, based on your answers what do you think will happen in the near future? [Temperatures] will rise, given this relationship. That is what we would expect. So, do you think this part of a natural cycle? Why not? Yeah, it's rising really fast. There are periods where it has risen very fast, just not quite as high as where we are now. That's what really has people worried.

Ms Hask is asserting that climate change, and temperature change in particular, is happening based on the scientific data from the Vostok Ice Cores. She is modeling how to interpret the data in the graph, by drawing attention to the correlation between temperature and carbon dioxide levels. The scientific discourse relies on data in the forms of graphs and charts. The last peak, shown in the far right-hand side of the graph, is current day. This graph perhaps became iconic when, in *An Inconvenient Truth*, Al Gore theatrically used a cherry-picker to raise himself to the present-day temperature

and carbon dioxide levels. This graph of increasing temperature and carbon dioxide is often shown to incite concern. And, yet, it often fails to do exactly that (Center for Research on Environmental Decisions, 2009). How might the frames found in the Social Discourse help connect the science to students' personal lives?

Including the Social Discourse as a Bridge to Student's Lives

The Social Discourse can be summarized as follows: *Climate change is a future social issue because it will have negative impacts at the local level on people.* Across all of the teacher cases, the Social Discourse frames accounted for 25.1% of the teacher talk (Table 6): social sphere frame (6%), local frame (4.5%), future time frame (4.7%), impact on people frame (4.1%), and negative valence frame (5.8%).

There were few instances of the Science and Social Discourses overlapping. One in particular, however, may provide insight as to how including frames found within the Social Discourse can be used to make the scientific facts more relevant to students. Again, we return to Ms Luft's classroom, where she is showing map-like images (Figure 4) projecting the amount of snowpack on the Sierra Mountains from 2020 to 2049 and 2070 to 2099 using two emissions scenarios (low emissions and high emissions). Ms Luft bookends the science by framing the issue of snowpack as one that is important to people:

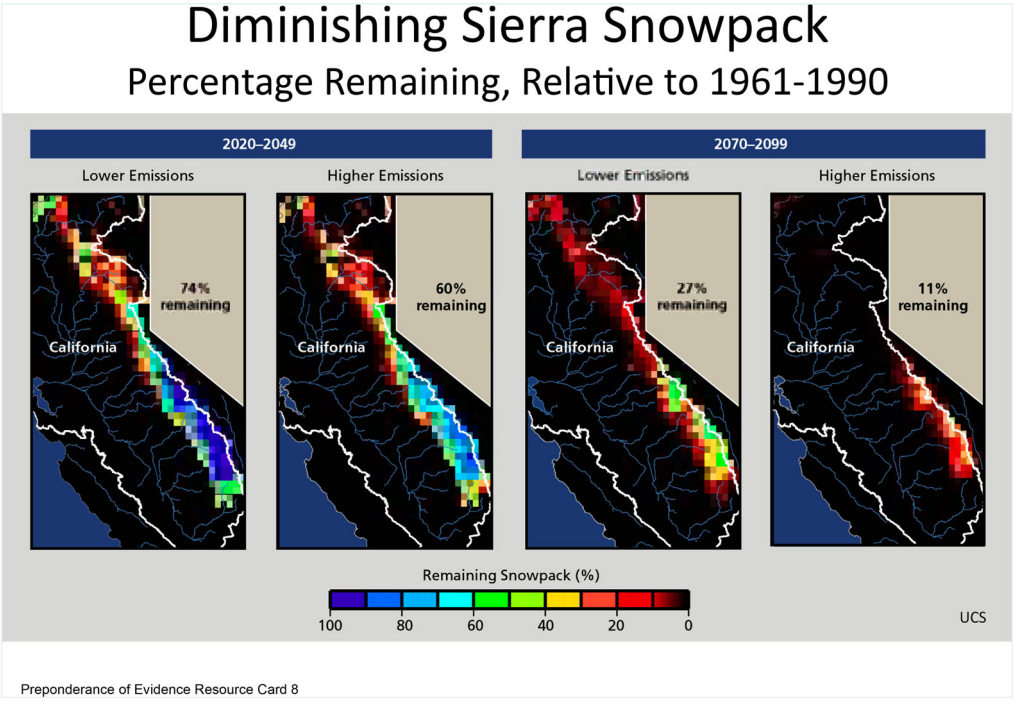

Figure 4. Diminishing Sierra snowpack map projections. Image from California Climate Change Center (2006)

> This is responsible for a lot of our drinking water and irrigation water for farming. The percentage remaining, relative to the 1961 to 1990 average. So, here if we have lower emissions, we have 74% remaining but with higher emissions only 60% by 2049. But by, 2099, we are looking at only 27% remaining at low emissions and 11% with high. Those people who like to snowboard, that is bad news. So, this is half of California's water storage. We already face a lot of water issues in California. So, if our main source of storage location goes away, we're going to have to build a lot more reservoirs, be a lot more conservation-minded with our water. We're going to have fiercer battles between fisherman and farmers and all that.

The teacher begins by modeling interpretation of the visual data for her students, clearly framing the issue within the scientific realm. The snowpack projections are bleak even under the low emissions scenario: 74% remaining by 2049 and 27% remaining by 2099. Ms Luft relates this loss first to a common recreational activity for students—snowboarding. But then, perhaps more seriously, she relates this loss to the effect it will have on fresh water supply for the state—fresh water used by students, by fisherman, and by farmers. By focusing on people, she connects all of these stakeholders together through their shared need of a fresh water supply. She also connects to possible individual-level and infrastructure-level adaptations that will be necessary: conservation of water and creation of more reservoirs. The complex storyline created by the framings Ms Luft used—impact on people, connections to the social sphere, and a local scale—is more likely to engage student concern because it connects to their personal lives in time and scale. Students are seeking personal relevance in their science classrooms (Osborne & Collins, 2001) and these framings offer such an opportunity to connect.

So, Was it Polar Bears or People?

Although the polar bear did not make an appearance in any of the classroom lessons observed, another iconic and endangered animal did stand in the polar bear's place—the California Mountain Pika. Ms Luft has been speaking about a graph showing projections for changes to future summer California temperatures (Figure 5). The students are quiet and subdued, but erupt suddenly when a photo of a Pika comes onto the screen. Ms. Luft says:

> What about this cute little guy? [Students: Aww.] There is a cute little Pika that runs around. They are kind of like a mouse and a rabbit. They are just little things [said in 'baby' voice] and they pick up plants and drag them back to their little ledge. So, species that are sensitive to temperature conditions can only move up the mountainside. In the Sierras, Pika were seen at 7,800 and above in 1900. By 2004, they were not seen below 9,500. They are moving up. But how high are the Sierras? Not that much higher than that. So where do the Pikas go? You can see them in Yosemite. We are looking at a possible extinction of a very cute animal.

Across all teacher cases, the impact on plants and animals frame was used the least (2.4% of framings). Research indicates that empathy with creatures—such as the Pika—could possibly be a motivating factor in taking personal mitigation actions

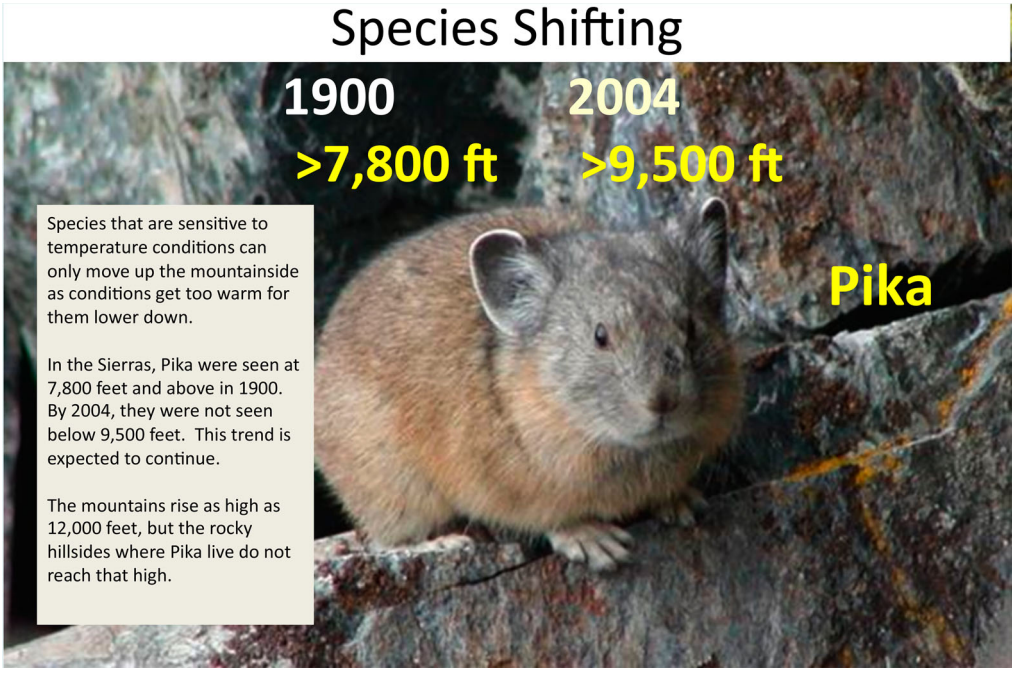

Figure 5. California Mountain Pika image and statistics. Image from Stanford Climate Change Education Project (2014)

(Myers & Saunders, 2002). The impact on people frame was heard slightly more (4.1% of framings), while the impact on physical Earth systems frame was used the most (6.8% of framings). The recommendation emerging from research is to use a variety of framings to appeal to a wider audience (Center for Research on Environmental Decisions & EcoAmerica, 2014). It appears then that although the impacts on the Earth's physical systems frame was used the most, teachers did use other impact frames and thus may be reaching a larger segment of their students.

Discussion

The goal of this exploratory research was to characterize the ways in which teachers are framing climate change when teaching it in the classroom. These are the main conclusions one can draw:

(1) Frames overlapped to form two distinct discourses: a Science Discourse and a Social Discourse.
(2) The Science Discourse was more prevalent and comprises five frames: science problem sphere, global scale, current issue, impact on Earth's physical systems, and natural causes.
(3) The Social Discourse was less prevalent and comprises five frames: social problem sphere, local scale, future issue, impact on people, and negative emotion.

These findings have pedagogical and research implications for climate change education. First, existing research in communication indicates that certain frames are more effective in creating feelings of concern and willingness to take action. The discourses developed in this study can be useful to consider the power of teachers' language choices. Second, using framing as a theoretical and analytic lens provided insight into how climate change is being portrayed in classrooms through teacher framings. The theoretical framework proposed in the Introduction, therefore, suggests avenues for further research.

Pedagogical Implications

The two discourses developed through analysis of the frames used by teachers are distinctly different from each other. While it is certainly outside the scope of this study to determine the effects the teachers' language choices had on their students' perception of climate change, it is possible to hypothesize what those might be from the existing literature.

The Science Discourse tells this story: *Climate change is a current scientific problem that will have profound global effects on the Earth's physical systems*. It is not surprising that the *Science Discourse* was more prevalent in these *science* classrooms. However, the frames that are associated with the Science Discourse (science facts and figures, global scale, current issue, impact on Earth's physical systems, and natural causes) are problematic in that they do not align with research-based recommendations for effective communication about climate change.

Inference and extrapolation from the research on framing in the media can help us to understand what effect the Science Discourse may have on students' perception of climate change. First, lack of concern in the face of dire statistics can be explained as resulting from a two-part cognitive system: reasoning and intuition (Kahneman, 2003). The reasoning system is deliberative and analytic, requiring extended effort. The reasoning system deals best with numerical statistics and graphs. In contrast, the intuitive system is driven by emotion and runs quickly because it operates automatically, without thought. The intuitive system responds best to emotive images and narratives. The problem with solely relying on the reasoning system is that action-taking is primarily driven by emotion (Slovic, Finucane, Peters, & MacGregor, 2007). The consequence, then, of using only statistics and facts is that it may fail to create concern and a desire to take action for students.

Second, research on the individual-level effects of framing also indicates that a global framing will decrease feelings of concern. This is largely a psychological response to the scale of a global framing, in which individuals have difficulty perceiving such vastness as the 'Earth' as it is outside of our everyday experience (Markowitz & Shariff, 2012; Scannell & Gifford, 2012; Spence & Pidgeon, 2010). In addition, people have difficulty 'connecting' with inanimate objects such as Earth systems (like oceans, temperature, and atmosphere). If the predominant frames (scientific and global scale) are likely to be ineffective, then this leads us to the question: How can climate change be presented in the classroom in a way that connects to the students?

The Social Discourse tells this story: *Climate change is a future social issue because it will have negative impacts on people at the local level.* Again, we can infer from the research on framing in the media to understand what effect the Social Discourse may have on students' perception of climate change. First, the Social Discourse emphasizes how climate change will impact people. Rather than focusing on a wildlife/nature *versus* human frame, an interconnected frame is recommended for effective communication about climate change. By changing behavior, individuals can have positive consequences for both wildlife/nature *and* humans. In this way, the frame is likely to appeal to a wider range of audience members. 'Communicators sometimes frame climate change as if it is only an environmental problem, which enables some people to shrug it off as something only environmentalists need to worry about' (Center for Research on Environmental Decisions, 2009, p. 17). Instead, by including human health, economic prosperity, and national security in the messaging, it makes climate change a problem about which *everyone* should be concerned.

Second, the local framing is considered more effective because it appeals to a person's 'sense of place', which considers how people connect with places and the influence of those connections on engagement with the environment (Ardoin, Schuh, & Gould, 2012). In other words, it is the connection a person has to his or her local environment that may serve as a mediator to feelings of agency. Communication studies have indicated that sense of place is highly correlated to a greater willingness to engage in mitigating actions (Scannell & Gifford, 2012).

Third, emotional responses to climate change can be used to promote action instead of creating a sense of hopelessness. As stated previously, the presentation of charts and graphs and even scientific data can be less motivating than vivid images and compelling stories. These latter methods appeal to emotions, the primary driver of action-taking. However, overuse of emotional appeals (specifically messages of doom) could be detrimental, leading to 'numbing'. Instead, teachers would do better to balance factual information with emotional visuals and narrative. In this way, the negative emotion frames in the Social Discourse could be beneficial, but only up to a point.

Most teachers do not see teaching the social aspects as part of their responsibility as a science teacher, mainly because the social aspects can sometimes be considered controversial (Gayford, 2002). However, the need for effective climate change education is paramount. Climate change is an issue that will pervade through our students' lifetimes and well beyond the school walls. The core concern of this research's findings is the availability of a variety of frames for students. For example, if a teacher is only using a Science Discourse, then students may not see relevance to their own personal lives. This type of language may also further contribute to student perceptions of 'school science' as being separate from the real world or the students' lived experience. Likewise, an overemphasis on the Social Discourse may not arm students with the proper scientific understanding of the issue, making them vulnerable to misrepresentation of climate change such as is often seen in the media. The recommendation of this author is to seek a combination of the two discourses in the classroom.

These two discourses can be used to help teachers evaluate the language they are using when teaching about climate change, and even more broadly, other socioscientific issues

such as genetic engineering and stem cell research. The discourses can also be used to teach students how to interpret text in their science books or online resources. By differentiating between the science side and the social side of issues, students can more critically judge current debates. For instance, while the science of climate change is robust and there is no longer a scientific debate about whether climate change is happening, there is still much debate about what actions we should take as a society.

Research Implications

Because this study is a small, multiple case study, the patterns presented are likely not generalizable. However, these descriptive patterns offer an opportunity to think deeply about how language may be used by teachers when teaching about climate change. As such, this study raises interesting questions that would benefit from additional research. Specifically, it would be useful to expand the research to include other parts of the theoretical framework (as presented in Figure 1).

To examine the process of frame building, one could consider the curriculum the teachers draw upon. All of the teachers in this study were using the same curriculum. The teachers' lectures were given using the PowerPoint presentations included in the curricular materials provided during the professional development program. Therefore, these materials are likely affecting the frames teachers build. However, as was shown in the opening vignettes, even when talking about the very same graph, teachers still have choices as to how they talk about climate change. There were teacher-level differences that suggest that other factors are influencing the way teachers are presenting climate change to their students. These other factors could be a line of future research.

To examine the actual individual-level effects of different framings (instead of extrapolating from the literature as was done here), one would be able to experimentally test different framings on student's sense of concern and intention to take action. This is an area of needed research because most framing experiments are conducted with adults, not school-aged children. It is possible that adolescents would react differently than adults when confronted with evaluation of risk due to climate change.

The purpose of this research was to fill a gap in our understanding of climate change education in the classroom. While we know much about students' naive conceptions, we know little about how climate change is presented to students, particularly through teacher discourse. Framing—as a theoretical model and an analytic method—provided a novel and fruitful approach to exploring teachers' use of language when teaching about climate change. It also provides a bridge to move beyond 'what students don't know' to understanding 'how students come to know'. In that way, we can work toward improving climate change education.

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Appendix

Table A1. Frame analysis codes, definitions, and transcript text examples

Frame codes	Definitions	Transcript text examples
Agreement frames		
Consensus	Emphasizing scientific or societal agreement	*We know that humans are responsible for significant increased carbon emissions that have an impact on physical and biological systems of earth. We know that. We have learned that*
Controversy	Emphasizing scientific or societal disagreements	*The debate was not about whether climate change was happening, but about whether it was humans causing it. That was the debate*
Attribution frames		
Humans	Human-caused climate change	*What we agree upon is that humans are responsible for significant increased carbon emissions that have an impact on physical and biological systems*
Natural	Naturally occurring climate change	*It is good to recognize that we have that normal cycling, increasing and decreasing the levels of CO_2 in the atmosphere*
Impact frames		
People	Stressing effect on humans	*A lot of people get their water from glacial melt in Asia from the Himalaya. A lot of loss, a lot of thinning. Billions of people get their drinking water from glacier melting in spring*
Wildlife	Using animals or plants as icons	*They are moving up, but how high are the Sierras? Not that much higher than that. So where do the Pikas go? You can see them in Yosemite. We are looking at a possible extinction of a very cute animal*
Earth's physical systems	Using examples of impact on the physical systems of Earth	*The last set here . . . we have severe weather. What does this graph actually tell us? Increase in days with very heavy precipitation*
Problem sphere frames		
Scientific issue	Consideration of climate change as an issue of science	*This is a picture of how surface temperatures have changed since . . . This is the 2000 to 2005 mean surface temperature difference from the records of 1951 to 1980. We use 1951 to 1980. That is a 30-year span for climate. We average that*
Social issue	Consideration of the economic, political, and societal aspects of climate change	*It made you wonder why you don't do some of these things. I wonder, too. I think it has to do with the dollar signs. Because doing nothing is pretty cheap. People, like the President, he is trying to fund some types of energy—solar energy*

Solution frames		
Adaptation	Decreasing the effects/consequences of climate change	*How do we adapt our lifestyle in order to deal with that warming? The wine growing people in Napa valley and Sonoma valley might decide that they need to plant different varietals of grapes in order to keep their wine businesses going in California*
Mitigation	Decreasing the causes of climate change	*There is so much resistance to stopping burning fossil fuels, but we need to bring emissions significantly lower than they are now to stabilize concentrations of CO_2.*
Spatial frames		
Global	Using global examples or perspectives	*How many [glaciers] are thinning? A lot. This is New Zealand. The snows of Kilimanjaro disappearing rapidly. What do you notice about the number of spots in the Northern and Southern hemispheres?*
Local	Using local (Bay Area or California) examples or perspectives	*What about the Bay Area? Remember we talked about this. They are saying this is the future coastline. This is South Bay. Am I going to have water front property here?*
National/regional	Using US examples or perspectives	*The Muir Glacier in Alaska in 1941. It was completely frozen, and in 2004, it was completely melted*
Temporal frames		
Current issue	Emphasizing short-term time scale; mostly a result of present verb tense	*We are going to look at why that is happening because, yes, it is happening*
Future issue	Emphasizing long-term time scale; mostly a result of future verb tense	*What they are saying is that maybe this is our future line if we have a 1-meter sea level rise*
Valence frames		
Fear/negative	Appealing to negative emotions	*We looked at that in terms of the Central Valley. Which is where what happens? Farming. If that floods, then boohoo for us*
Hope/positive	Appealing to positive emotions	*In the middle of this, some of you were scared. I got all kinds of reactions to this. So at the end, we are going to talk about what we can do*