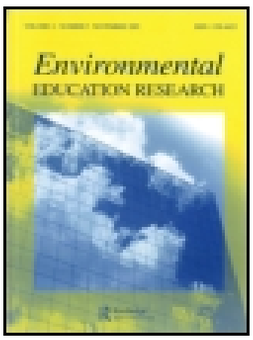

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Climate change education in the humanities classroom: a case study of the Lowell school curriculum pilot

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ABSTRACT

Climate change as an instructional topic in K-12 schools is most frequently taught in the science classroom. However, it is a human issue requiring social as well as technological and scientific solutions. This study analyzes and evaluates a climate change curriculum implemented via an integrated social studies and language arts framework in a middle school classroom. The curriculum reflects collaboration between a private school, a climate education non-profit, and a government agency (NOAA). Following the first year of implementation, student surveys, teacher interviews, and classroom observations comprise the primary tools of data collection and evaluation. Based off these data, students demonstrate high levels of climate literacy, improvements in reading comprehension, and overall engagement with the topic. Teachers report successes and challenges of teaching the curriculum, and administrators offer opportunities for scaling and implementing the curriculum in other schools and contexts (including public schools). Findings from this study are relevant to climate change curriculum developers, researchers, and educators seeking to incorporate an interdisciplinary, socio-scientific approach to climate change education in their work.

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Climate change education; climate literacy; humanities framework

1. Introduction

The realities of climate change, both already experienced and forecast for the future, make teaching young people about the causes, consequences, and solutions to climate change a national imperative for public and private education. Many organizations and research institutions are already committed to this mission, and are producing curriculum, resources, articles, and evaluations to strengthen the movement behind youth climate education (e.g. Western Washington University Facing the Future; North Carolina State University Environmental Education lab; Climate Literacy and Energy Awareness Network- CLEAN; NOAA Climate Education Office; Climate Generation: A Will Steger Legacy; Maryland and Delaware Climate Change Education Assessment and Research- MADE CLEAR; Arizona State University School of Sustainability). However, evidence suggests that climate education in the United States is still a work in progress, and that education in K-12 schools has not been successful on a national scale in clearly communicating the scientific consensus around anthropogenic climate change (Plutzer

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et al. 2016; Kuppa 2018). Plutzer's et al. (2016) national study is titled 'Mixed Messages', highlighting the problem that many science teachers are presenting 'two sides' to a problem that is already resolved in the scientific community.

While science education has thus far been the most common channel through which to deliver and research climate change education (CCE), much scholarship emphasizes that CCE should be holistic and included in cross-curricular projects (see Schreiner, Henriksen, and Hansen 2005; Climate Generation: A Will Steger Legacy 2018). However, evidence of extended practice of holistic CCE remains lacking. This study takes a 'research into practice' approach, examining a yearlong effort to teach climate change through a humanities framework with integration between the humanities and science curricula. Humanities is the study of the strengths and challenges of human society through literature, art, history, geography, civics, and economics. The term 'humanities' is used at the school of study to refer to the integrated social studies-language arts curriculum. Applying the humanities framework to climate education builds on recommendations to bring a human face to climate education via storytelling, narrative, and other strategies in order to increase engagement and hope rather than provoke negative, detached emotional reactions (Moser 2007; Nisbet 2009; Somerville and Hassol 2011; Wolf and Moser 2011; Westerhoff and Robinson 2013).

We present and evaluate a case study of humanities-focused CCE for middle school students, investigating the curriculum pilot in the sixth grade of a small independent school located in NW Washington, DC. We seek to answer the research questions:

1. What are the impacts on sixth grade students and teachers of implementing a CCE curriculum over the course of an entire academic year focused in the Humanities classroom?
2. What administrative school structures are conducive to adopting an integrated, holistic climate change curriculum?

2. Literature review

2.1. Effective CCE strategies

2.1.1. Incorporate more than knowledge

According to a recently published literature review on effective CCE strategies, it is important to equip students with knowledge that is personally relevant and meaningful (Monroe et al. 2017). Approaching climate education through social studies and language arts promotes student engagement, climate literacy, and action, and highlights the human connection to climate change (Climate Generation: A Will Steger Legacy 2018). According to a recent review of the climate communications literature by Susanne Moser, transitioning from awareness and concern into action remains a persistent challenge for the U.S. population as a whole (Moser 2016). The information-deficit model, which presumes that merely providing information will lead to desired behavior changes, has been debunked and critiqued by several CCE scholars (Wolf and Moser 2011; Wynes and Nicholas 2017) who argue that narrative frames, trusted messengers, and experiential learning pedagogy are required to motivate effective climate action, more than effective retention of climate science information (Nisbet 2009; Siegner 2018).

2.1.2. Use real world contexts

Within the existing literature, integrating local and global 'real world contexts' emerges as an important CCE strategy. A recent study highlights the use of the World Climate Simulation tool developed by Climate Interactive as effective in mobilizing engagement and intentions to action. Participants simulate real UN climate negotiations[1] by representing a particular country, observing how their intended emissions reduction pledges affect global temperature, and negotiating

with other 'countries' to achieve temperature stabilization below 2 °C. Gains in knowledge, engagement, and desire to learn and do more about climate change were statistically significant, across the political spectrum (Rooney-Varga et al. 2018).

2.1.3. Incorporate other best practices from emerging CCE literature

As this is a rapidly evolving field, there is a need for coordination and partnership between CCE researchers and practitioners, such that research can be more easily translated and adopted in the classroom. Further study at the intersection of research and practice is needed to investigate the efficacy of various climate education strategies as a vehicle for translating knowledge into action. For example, upon learning the results of the paper cited above regarding the World Climate Simulation activity (Rooney-Varga et al. 2018), one of the coauthors of this study shared with the curriculum coordinator, who then adopted a simulation lesson into the Lowell humanities curriculum. Upon subsequent curriculum evaluation, the continued evolution of this simulation learning strategy is made possible. Regarding consistency of evaluation approaches, prior research establishes working measures and principles of climate 'literacy', comprising knowledge, attitude, and engagement dimensions, to both qualitatively and quantitatively describe student outcomes (CLEAN) (NOAA 2006; Siegner 2018) which further studies can adopt for ease of comparison.

2.1.4. Incorporate practices into curriculum as well as associated PD

Findings from Valdez, Peterson, and Stevenson (2018), Stevenson et al. (2018), and Stevenson (2016) demonstrate the importance of effective messengers in relaying climate information, suggesting the importance of better preparing teachers for climate instruction through PD opportunities. There remains a lag in implementing findings from climate communications into the educational context of K-12 schools via teacher professional development (PD). Drewes, Henderson, and Mouza (2018) report on the effects of a yearlong climate education PD for science teachers (the 'Climate Academy'), tracing effects of participation into teaching practice in one particular classroom and suggesting room for improvements in CCE PDs (Drewes, Henderson, and Mouza 2018). Effective PD, and thus effective CCE, draws on content knowledge, proximity to practice, and context conceptualization, incorporating local examples, student/teacher emotional responses, and opportunities for positive impact in the local community (Ojala 2012; Luft and Hewson 2014; Busch 2016; Drewes, Henderson, and Mouza 2018).

Given that most of the literature focuses on PD opportunities for science educators, it is a unique application to consider CCE and PD opportunities for social studies and humanities educators. Approaching CCE from a purely science educational framework risks overlooking the necessary economic, social, and behavioral adaptation and mitigation strategies human societies could choose to adopt. Lowell's vision of a humanities-focused climate change curriculum, building up to a middle school-wide focus on climate change, is 'truly groundbreaking' in the K-12 education world (NOAA Climate Education Program Manager F. Niepold, personal communication, November 2016). Based on curriculum evaluation data reported here, the school plans to host a CCE PD for humanities educators nationwide in August 2019, creating an opportunity for further research into CCE PD offerings.

2.2. The promise of the humanities curriculum

The humanities context allows for the full exploration of the anthropocentric nature of climate change, from information to human actors. What conditions in our history, politics, and economies led to the climate changes that people currently experience? How might these challenges be addressed through current or future social systems? The social studies inquiry arc, advanced

by the National Council of Social Studies, provides a powerful tool for meaningfully engaging in these questions. In its document, *The C3 Framework for Social Studies State Standards*, it writes

> Now more than ever, students need the intellectual power to recognize societal problems; ask good questions and develop robust investigations into them; consider possible solutions and consequences; separate evidence-based claims from parochial opinions; and communicate and **act** upon what they learned. And most importantly, they must possess the capability and commitment to repeat the process as long as is necessary. (National Council of Social Studies 2017, emphasis added)

Humanities studies are central to creating an educated citizenry prepared for leadership in mitigating and reversing climate change. Humanities inherently incorporates real world contexts, social and political histories, and opportunities for human engagement between students and their surrounding community. Viewed through a CCE research lens, the humanities discipline furthermore offers a unique opportunity to understand and address the bifurcated public response to climate change. According to the Yale Project on Climate Change Communication (YPCCC)'s Six Americas study, the American public response to climate change can be classified into six groups along a spectrum ranging from 'Dismissive' to 'Alarmed'. As of December 2018, 9% of the public is 'dismissive', and 29% are 'alarmed', an 8-point increase since March (Leiserowitz et al. 2018). In order to channel the energies of this growing 'alarmed' population sector in a productive, effective direction, it is especially necessary to invest in improved youth education, communication and engagement, fostering a greater willingness to take action (Niepold, Scowcroft, and Gingras 2017). Several scholars have proposed research investigations into the Intergenerational Learning (IGL) that occurs as children bring home CCE topics learned in school to discuss with their parents, influencing climate literacy throughout the household and across generations. Humanities education holds promise due to inclusion of narratives for ease of information-sharing between students and families.

Despite this potential, thus far no article published in the *Journal of Social Studies Education Research* takes up the issue of integrating CCE within social studies instruction, and a Google Scholar search for climate change and social studies education yields no relevant results. There are a small, growing number of practitioner-focused climate change and social studies education instructional and informational documents, published through channels such as the Climate Generation non-profit, and the National Council of Social Studies journals (geared toward educators) (Kumler and Vosburg-Bluem 2014; Harris et al. 2016), but publications in the academic literature are extremely limited. Thus, our research study contributes an important and missing perspective to the academic body of CCE literature.

3. Methods and school context

3.1. School context and motivation

The Lowell School in Washington, DC is a small, progressive independent school that promotes active, collaborative learning with curricula that are 'integrated across subjects, draw on powerful, relevant content and student interests, and support the development of internal motivation and a strong voice' (Lowell school website). As members of the staff became aware of the education 'gap' in addressing climate change, based on participation in a workshop hosted by People's Curriculum for the Earth, interest in incorporating CCE arose alongside an opportunity to revise the middle school curriculum.

The curriculum development process began with the Director of the Middle School planning to revamp the middle school curriculum to focus more on global perspectives. He wanted the middle school experience to serve as a springboard for students to feel empowered to take action on global issues, both in middle school and later on in high school (K. Yee, personal communication, May 18, 2018).

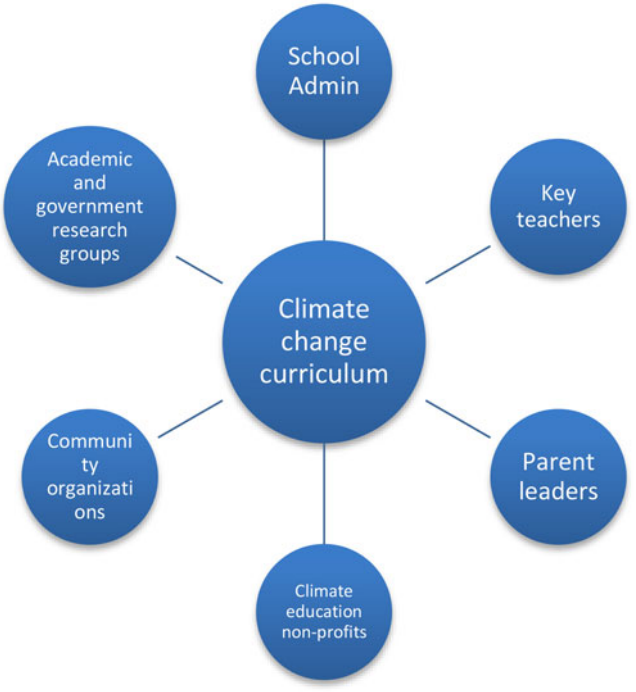

Figure 1. Climate curriculum web of support.

The curriculum developed for this pilot is the result of broad-based collaboration, involving internal as well as external partnerships. The Web of Support around the curriculum project is summarized in Figure 1. Each of the supporting elements played a crucial role in enabling the curriculum to come into being and serve as a platform for research, evaluation, and information-sharing.

The curriculum maps onto each trimester, with books, lessons, and topics falling within three themes: (1) Energy, (2) Movement, and (3) Collective Action (J. Totz, personal communication, June 1, 2018).

The Director of the Middle School acknowledges that Lowell's curriculum development process represents 'pretty fast change' for adopting a new sixth grade curriculum, and that the new ideas were a leap of faith that required buy-in from key individuals who were able to bring others on board. Partnership with outside groups helped make this one-year curriculum development turnaround possible, from idea to implementation (K. Yee, personal communication, May 18, 2018). There was a sense of urgency among the school leadership that climate change represents a crucial issue that the world is facing and, therefore, they should waste no time in delivering meaningful instruction on this topic to students. While a work-in-progress, a current set of curriculum documents and development materials can be found in Appendix A.

3.2. Methods

Our study employs a mixed-methods case study design. Mixed methods approaches are particularly valuable for uncovering causal processes and pathways in small-n, case study-based research (Ragin 1994). We collected data from all relevant stakeholders and from various stages of the curriculum deployment: planning phase, implementation phase, and assessment/revision phase. Taken together, these data points create a holistic picture of the curriculum pilot, incorporating a variety of perspectives (both student and adult) and a mix of quantitative and qualitative data. Our aim is to uncover replicable, scalable processes in CCE curriculum development

and implementation to guide other researchers and practitioners seeking to effectively develop student climate literacy.

Consent for student participation in this research study, a partnership between Lowell School and the University of California, Berkeley, was obtained through school documentation from parents who sign blanket consent waivers upon enrollment for students to participate in any research study the school undertakes while their child is enrolled, and from the Lowell School Communications Director.

3.2.1. Data collection

We evaluate the curriculum impact and enabling forces based off data from three main sources: student surveys, teacher/staff interviews, and classroom observations.

3.2.1.1. Student surveys. The student survey comprised questions on both climate change knowledge (nine multiple choice and two open response questions) and attitudes/engagement (six questions, four of which are based off of the shortened YPCCC Six Americas survey). The survey was distributed to the fifth, sixth, seventh, and eighth grades, representing 116 students. The sixth grade results represent the 'experimental' group in this semi-experimental design, while the fifth and seventh grade students represent 'control' groups who did not receive the climate change curriculum focus in their humanities classes. The eighth grade students are used for additional comparative analysis as they study climate change for 12 weeks in science class, and are, thus, a form of comparison between science and social studies-based climate curriculum.

Student surveys were anonymously collected without demographic information attached. The survey instrument is included in Appendix B.

3.2.1.2. Teacher/staff interviews. Interview subjects represented school staff (2), teachers (2), and the partner non-profit Climate Generation (1), for a total of five in-depth interviews of approximately 1 h in length. By the nature of this study as a participatory research partnership, one of the interview subjects is also a coauthor of this article. Rather than muddying the waters of analysis or representing a conflict of interest, it is our belief and intention that coauthorship provides necessary clarity and depth of perspective on the curriculum pilot by partnering a climate education researcher with an educator interested in critically analyzing, improving, and disseminating a climate curriculum innovation.

Interviews were semistructured and focused on the following topics: (a) impacts of teaching climate change through humanities, (b) student and parent responses to curriculum, (c) process of developing curriculum and/or delivering instruction (strengths and challenges), and (d) advice and recommendations for other schools. The interview guide can be referenced in Appendix C.

3.2.1.3. Classroom observations. The classrooms observations took place toward the end of the school year, in April, and notes were recorded for analysis by one coauthor (Siegner). The other coauthor (Stapert) contributed insights from her observations and experience working in the school over the course of the year in her interview (detailed further in the Results/Discussion sections below). Observational research methods bring critical insights and context to inform interpretation of results. Ethnographic data reveal motivations and behaviors and uncover process, important data to capture through field notes and carry forward into analysis, following guidelines of prominent sociological researchers such as Bourdieu, Burawoy, and Geertz (Ragin 1994).

3.2.2. Data analysis

3.2.2.1. Survey analysis. Survey results were compared and analyzed using Google Forms data analysis as well as basic statistical analyses. Google Forms is a commonly used educational

Table 1. Climate knowledge by grade level.

	Fifth grade	Sixth grade	Seventh grade	Eighth grade
Average % correct	60.4	74.4	69.5	74.8
# of students	30	36	27	23

technology, and thus, using this method has the advantage of making the process easily replicable to teachers, schools, and education organizations seeking to gather their own data on similar interventions (or researcher-practitioner teams). Disentangling confounding variables and adjusting for student baseline academic performance and demographics are additional avenues for future research but were not the focus of this study.

3.2.2.2. Interview coding. Interviews were manually coded for themes related back to the research questions as a group, and analyzed by respondent type to understand differences in reaction between teachers versus other adults involved in curriculum development and piloting. Interview themes inform next steps for Lowell as well as other schools seeking to implement climate change curriculum through a humanities focus, and guide researchers studying effective strategies and evolving trends in climate education. They reveal strategic improvements possible for the curriculum, as well as hypotheses for testing in larger CCE research explorations, ideally across multiple school sites and in both public and private schools.

4. Results

4.1. Student climate literacy and engagement

The climate literacy survey was administered to 30 fifth graders, 36 sixth graders, 27 seventh graders, and 23 eighth graders, for a total of 116 students. The sixth graders averaged 74.4% correct response on the nine multiple choice questions, while the fifth graders averaged 60.4% correct, seventh graders 69.5% correct, and eighth graders 74.8% correct (see Table 1). The sixth graders had higher correct response rates for five out of the nine MC questions; in the remaining four, the seventh grade had the highest response rate on two questions, and the eighth grade had the highest response rate in the other two. Asked about the global temperature rise limit specified at the United Nations Conference of the Parties (COP21) talks in Paris, the sixth graders outperformed their peers by the greatest margin, perhaps due to the focus on UN climate conferences prior to a mock UN climate negotiations activity included in the curriculum (see Figure 2). In the open response questions regarding solutions for lowering CO_2 levels and mitigating climate change, the sixth grade students matched the eighth graders in terms of total number of responses across various categories (see Table 2), and were the only grade in which a student mentioned the single most impactful individual action to mitigate climate change: have fewer children (Wynes and Nicholas 2017). While the sample sizes are too small to merit statistical significance, there are other (nonstatistical) conclusions of significance to be drawn from these results (see Discussion below).

The attitude and engagement questions showed that the eighth graders had the highest levels of concern about climate change and its impacts on future generations, according to the first four questions, which were borrowed from the YPCCC shortened Six Americas Survey (SASSY) (Chryst et al. 2018). On the other two engagement questions, asking how often students had looked up information on climate change and talked to friends/family about it in the past year, the sixth grade students had the highest response rates. Responses to attitude and engagement questions are summarized in Table 3.

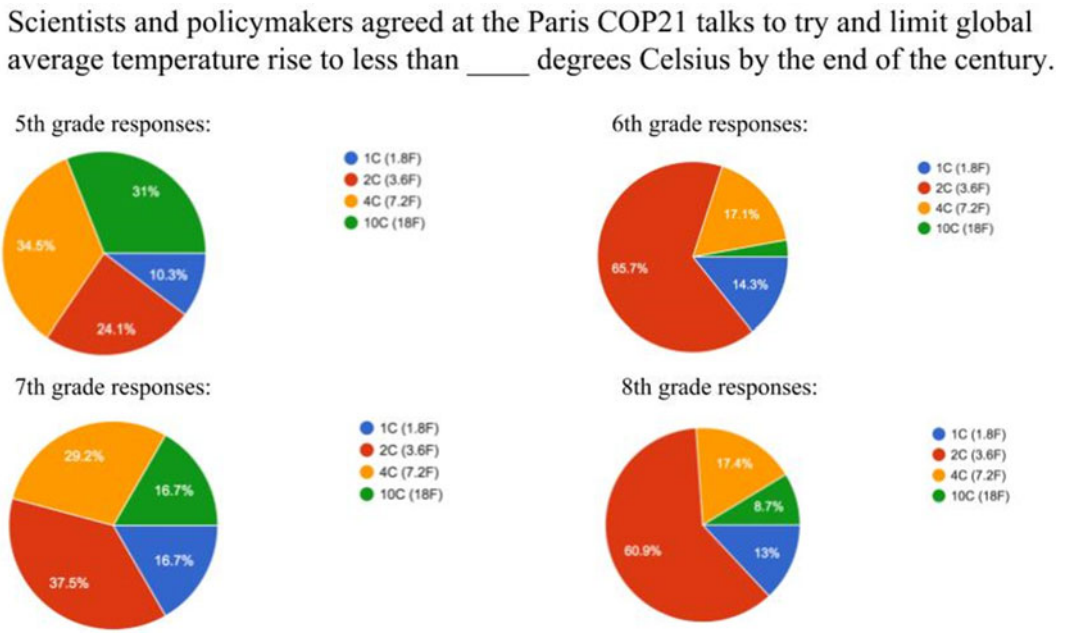

Figure 2. Responses to temperature rise limit question, by grade level.
Note: Correct response: less than 2C, sixth grade scored highest.

Table 2. Climate mitigation strategies identified.

	Fifth grade	Sixth grade	Seventh grade	Eighth grade
Have less children	0	1	0	0
Education	0	1	0	2
Solar/wind	12	19	8	17
Planting trees	7	14	14	14
EVs/transportation	12	19	16	23
Food/farming	2	9	4	8
Total # of responses	33	63	42	64

Note. Coding of student open responses.

4.2. Teacher/staff interview themes

Key themes from the interviews as a whole include middle school readiness for climate education, positive parental response, importance of partnerships, need for community action projects, developing a stronger solutions focus, further integration between science and humanities curriculum, and need for teacher preparation/professional development. Relating back to the research questions, they are presented here as they relate to student impacts and enabling structures for developing and implementing CCE through Humanities.

4.2.1. Administrative structure and enabling factors

The curriculum coordinator, who worked most closely on the development process along with Climate Generation staff, recognized the need from the beginning to build a wide platform of support for the idea from stakeholders both within and beyond the school. Several parents as well as staff, teachers, and external partners were present at the very first curriculum planning meetings.

According to school staff, the reaction from parents has been overwhelmingly positive, and there is reported evidence of students discussing climate change with their parents. In the Director's words, 'any pushback we were expecting has not happened,' (K. Yee, personal

Table 3. Responses to attitude/engagement questions by grade.

	Fifth grade	Sixth grade	Seventh grade	Eighth grade
How important is GW to you personally (Extremely/Very)*	65.5%	60%	56%	72.8%
How worried are you about GW personally (Very)	41.4%	44.4%	44%	50%
How much do you think GW will harm you personally (A great deal)	27.6%	16.7%	16.7%	13.6%
How much do you think GW will harm future generations (A great deal)	72.4%	77.1%	54.2%	81.8%
*Looked up info on CC** that you haven't learned in school in the past year (Weekly/monthly)*	17.2%	47.2%	16%	27.3%
Talked to friends/family about CC in the past year (Every day/weekly)	21.6%	38.9%	15.8%	18.1%

*GW = Global Warming
**CC = Climate Change.

communication, May 18, 2018). Parental support forms a key piece of the enabling environment for implementing CCE. The conversation has spread among parents at the whole school, who are aware of what's going on, and are motivated to keep their students at Lowell because of the new curriculum focus. It is additionally used as a recruitment tool to attract new families—2018/2019 sixth grade recruitment gains are related to the new curriculum, according to staff. This reinforces administrative support to devote the resources and time to continue and improve the curriculum (N. Stapert, personal communication, May 7, 2018).

One key growth point identified in several interviews was the need to expand and improve the solutions focus within the curriculum, and provide opportunities for students to take meaningful action locally on climate mitigation options. For example, when students read 'The Boy Who Harnessed the Wind', students build windmills in science class. During the focus on renewable energy, they could also do a community action project around solar incentive programs: Maryland has a program for homeowners to put solar on their roofs, and students could advocate for DC to adopt a similar program as the same publicly owned utility covers both jurisdictions. Another idea brought up by staff is to change the end-of-year field trip from New York City and go to an island in the Chesapeake Bay threatened with disappearance due to sea level rise. The solutions piece is the most complex part to develop, as the content must be laid down first and authentic solutions built on top of that. This is a clear area of focus for future years (N. Stapert, personal communication, May 7, 2018) that could build off of the collaborative partnerships already established during the curriculum development process.

4.2.2. Student outcomes

The curriculum coordinator summarized the first year implementation as follows: 'Students learned how climate change affects a variety of people around the world, and how different people are responding to it. They read fiction and non-fiction texts featuring climate change and studied the interaction of geography, civics, and economics with climate change. Next year we are hoping to add a substantial service learning aspect to the course, as well' (N. Stapert, personal communication, August 1, 2018).

When asked if middle schoolers are 'ready' to learn about climate change, addressing a common concern among educators about an age threshold for talking about a topic as overwhelming as climate change change, all respondents answered in the affirmative. In the words of one teacher, students learn about the Holocaust and slavery in middle school, so they're already

dealing with emotionally charged content. One sixth grade teacher initially felt inclined to avoid the topic due to 'gloom and doom' connotations and possible negative emotional responses, preferring to focus instead on developing a love of nature and the outdoors among students. However, he reports having his mind changed by the curriculum pilot experience, and notes that his skepticism about the climate fiction (or 'cli-fi') novel in particular proved unwarranted. The students had incredibly positive responses to the cli-fi novel chronicling a girl and her family's flight from their homeland as climate refugees and struggle to start a new life. Students felt catalyzed to take action: 'The Cli-fi novel was groundbreaking for me. The kids really enjoyed it. It's a weird way for doom and gloom to be exposed to them, but yet their reaction is incredibly surprising, I thought they'd turn off, but it almost seems motivating and inspiring them to learn more' (L. Kelly, personal communication, May 18, 2018).

The Director of the Middle School brought up several noteworthy outcomes from the first year not captured in the student climate surveys. From the school's internal standardized testing, he noticed a dramatic improvement in the sixth graders' reading comprehension scores. According to the director,

> Our kids know how to read and draw inferences from non-fiction texts. You see natural progress year to year, but don't often see close to 2 SDs in data year to year. I can't completely attribute that to new curriculum, I need more data, but it certainly prompts the hypothesis that it might be the curriculum. They are constantly discussing non-fiction texts in Dave's class this year. It's building skill in a more meaningful way because they are more engaged. This is something I'll be tracking closely in the coming years, and looking for improvements in writing skills as well in the seventh grade testing cycle (K. Yee, personal communication, May 18, 2018).

Box 1. Focusing on the teacher response themes brings up a mix of reactions to the curriculum, simultaneously categorizing the experience as fun/exciting and difficult/challenging. Both teachers highlighted the *Boy Who Harnessed the Wind* close reading and aligned windmill project as a key success of the year, as well as the Fossil Fuels Museum project on which they collaborated. In this futuristic museum simulation, students created and presented their exhibits to the Kindergarten class, explaining how society 'used to' source energy from fossil fuels but now procures energy from alternative clean sources. These two activities should ideally inspire further integration opportunities on other topics and throughout the school year.

In science, the teacher is considering a revision of the entire first unit to be about Energy and Environment, centering hands-on school greening projects. In humanities, the teacher repeatedly expressed the need for solutions and projects to be authentic and meaningful, rather than 'token' solutions that students can tell isn't really solving the problems they are learning about at the appropriate scale. This is admittedly difficult to achieve through school-based 'action' projects, but important when developing community-school partnerships that have potential to engage students in authentic solutions.

Speaking to student outcomes, the science teacher states, 'the humanities focus is great..When environmental science is cross-curricular, it's much more meaningful … Doing it through humanities connects [students] to it much more. And taking more time to do [climate education] in humanities makes science lessons even better' (L. Kelly, personal communication, May 18, 2018).

The Middle School Director concludes his interview with a call to action to other schools to 'be courageous and take risks … Why are we denying this? It's everywhere. [Climate change] needs to be addressed squarely in Middle School curriculum, giving students a chance to apply it in higher grades' (K. Yee, May 18, 2018). His recommended improvements, for Lowell and elsewhere, include carrying the curriculum theme forward into the later middle school grades, including seventh and eighth grade science classrooms, and making climate change a focus for the eighth grade independent projects. He envisions a capstone 'Model UN' simulation in eighth grade that includes climate change as a key theme, and seeks to incorporate climate change as a discussion point in all middle school field trips and projects to constantly build on the sixth grade foundation.

4.3. Classroom observations

Classroom observation notes were collected from visiting both sixth grade humanities classes in April 2018. During this visit, sixth grade students articulately expressed the difference between climate change and global warming, which they acknowledged they had not known previously. One student clearly explained the process of hydraulic fracturing in incredible detail, down to the underground wells with cement lining, injecting water at high velocity to release the oil stored in underground pores, producing a lot of wastewater and creating seismic activity (according to the teacher this was based on independent knowledge acquired at home; in this case, rather than teaching the student something new, the curriculum seemed to provide an opportunity to share her knowledge with the class in a relevant context). Students were generally excited to share what they had learned, and shared memorable topics and projects of particular interest to them. This included the 'CliMojis' art project, where they created personal Climate Emojis after reading a Washington Post article about a company designing climate change-based emojis, so that texters could communicate their frustrations and anxieties around climate change pictorially (Chiu 2018). The students read and discussed the article, and then designed their own climojis, synthesizing learning in a visual form. Other significant learning experiences reported were the Fossil Fuel Museum and learning about how bees will be impacted by climate change while reading a novel called *The Hour of the Bees*. When asked what students were hoping to do about climate change based on their newfound knowledge, students responded with ideas such as spreading awareness, creating more things from plant materials (biofuel, degradable plastics, food, etc.), farming in a way that supports the environment, and putting more plants in the ground. Many students seemed to have clear ideas around how to take action, and expressed feelings of hope and empowerment when describing their collective 'climate solutions'.

5. Discussion

As a whole, the Lowell middle school demonstrated much higher levels of knowledge and engagement around climate change than the average American teenager or adult. Based on a 2010 nationally representative survey of American teenagers, knowledge of climate science basic facts was found to be very low (below 50% correct for most questions asked) (Leiserowitz et al. 2018). 59% of American adults fall into the 'Alarmed' or 'Concerned' categories of the YPCCC Six Americas spectrum as of December 2018 (Leiserowitz et al. 2018) compared to 82% of Lowell middle school students. What remains a challenge both nationally and at Lowell is building optimism around our ability to solve climate change: only 8% of youth agreed that we can and will do something to mitigate climate change in a recent study (Feldman et al. 2010 cited in Busch, Henderson, and Stevenson 2018), and a mere 5% of Lowell students indicated they believe their generation will solve climate change.

While acknowledging the receptive audience for implementing the curriculum, the results relating to increased student engagement, increased literacy scores (for even the lowest-performing students) and favorable response to a humanities-focused climate curriculum are nevertheless significant and worth building on as an approach to middle school climate education. The time period between sixth and eighth grade is a significant youth development stage during which students develop capacity in knowledge retention and empathy and gain exposure to many new topics, and yet the sixth graders performed equal to or above the eighth graders on most climate knowledge and engagement questions. They shared information learned with families and friends more often than their eighth grade peers learning about climate change through science only, generating important hypotheses for CCE/IGL scholars.

In response to teacher interview themes and concerns with the pilot curriculum, updates to the curriculum will include greater emphasis on nonfiction reading assignments within the Humanities classroom accompanied by detailed reading guides that help students make

connections between climate science, real world events, and solution/action opportunities. Overall, the positive momentum expressed by teachers for science-humanities integration brings up another key takeaway from the pilot: the climate change theme provides exciting opportunities for integration between science and humanities that had not previously existed.

Results and best practices from this case study should be applied intentionally to other classrooms and school contexts. The web of support (extending from parents to teachers and staff) is a crucial enabling factor as well as the participation of key influencers. For example, the curriculum coordinator credits the role of one teacher bringing in her daughters' expertise on climate education and climate research as key to lending credibility to the curriculum from an early stage, allowing it to grow beyond the idea phase. Few studies in the existing literature report on the enabling factors that allow a CCE intervention to come into being, and yet it is important to consider the motivational, social, and structural pieces that should ideally be in place to allow a CCE curriculum to thrive in a given school environment.

In an age where researchers are worried about a decline in climate literacy and engagement in the millennial generation, effective CCE strategies are especially needed (Kuppa 2018). Millennials, defined as those born between 1981 and 2000, are often considered the hope for a more climate engaged society, leaders that address climate change head on and build climate resilient communities using best practices from today's climate science research. However, a recent paper seeking to update a 2010 national survey of American teens finds a decline in the belief that humans can reduce global warming effectively and 'similar or less engagement on global warming than other generations' (Kuppa 2018). If education is not successful in engaging and catalyzing action from this group, the prospects for averting catastrophic climate change may be bleak.

Based on our findings that humanities-focused climate education shows promise in engaging students through narrative, storytelling, and local community projects, and building upon climate communications research that similarly emphasizes a storytelling approach, humanities CCE should be further implemented and investigated through comparative analyses and case studies in other locations that employ a similar assessment methodology. This study will benefit greatly from replication particularly in public schools, which are more challenging environments in which to innovate on curriculum content, but more reflective of the U.S. student experience. The time for further study is ripe, with national polls indicating public opinion on climate change is entering the zone of widespread acceptance, rather than mixed feelings or controversy (Saad 2017). Public support is particularly high for climate education, at 79% nationally (Marlon et al. 2018).

5.1. Applying curriculum to other schools

The Lowell School curriculum coordinator suggests several vehicles for integrating similar curricula into more structured, state-mandated public school subject matter: through choice of reading materials in civics classes, suggested options for student independent research projects, and current events classes at the high school level. She outlines three specific opportunities for incorporating climate education into social studies classrooms through tweaks to what is already happening, rather than major curriculum overhauls: (1) in elementary school states and regions studies, where studying the climate of the state or region is already an explicit objective, (2) middle school global geography classes, and (3) in high school current events classes. She sees these as opportunities to 'lean into the climate change challenges and how people are addressing them in different contexts' (N. Stapert). The Director concurs, adding, 'for independent schools this change is very easy. But for public schools, there's so much you can do with this curriculum too. If you have to teach about government, geography, or history you can use pieces of this [integrated into pre-existing units and curriculum mandates]' (K. Yee, personal communication, May 18, 2018).

These suggestions for integrating CCE attempt to complement rather than supplant existing topics and curricula, in effort to minimize instructional tradeoffs that are often difficult and inflexible.

5.2. Scaling effective CCE strategies through teacher PD

Preparing teachers to be effective conduits of climate education is a crucial step in humanity's response to climate change, as 'teachers occupy a social role as cultural authority in traditional classroom contexts and are therefore differentially powerful actors in educational spaces' (Gore 1995 cited in Drewes, Henderson, and Mouza 2018). Teachers are important influencers of what 'comes to matter' in the classroom based on their ability to mobilize and communicate their own knowledge effectively (Ball, Maguire, and Braun 2012). A recent National Academies Board on Science Education report concludes that 'ultimately, the ability of the elementary and secondary school systems to provide comprehensive climate literacy education will depend on the systematic availability of quality curriculum resources, impact of curriculum mandates such as state standards and assessment, and, importantly, the **preparation of teachers**' (Simmons 2011, emphasis added). The Lowell curriculum coordinator is keen to put these recommendations into practice, through co-facilitating a Summer Institute for Climate Education with Climate Generation at Lowell School in Summer 2019. The 3-day institute will be geared toward Humanities educators.

To scale up and improve existing CCE PD offerings, policy support and funding will be necessary, as well as additional CCE research focused on evaluating PD opportunities and how they translate into classroom teaching actions and confidence levels. Washington State recently passed Senate Bill 6032, providing $4 million in funding for science teacher training in Next Generation Science Standards, which include climate science standards (Branch 2018). With this act of legislation, 'Washington advances to leading the nation in K-12 climate literacy, becoming the first state in the country to dedicate significant support for climate education' (Branch 2018). These funds will cover teachers attending Professional Development (PD) workshops offered by climate education groups such as Climate Generation (which hosts an annual Summer Institute for Climate Education). The opportunity to provide integrated Social Studies + STEM PD trainings around climate change is a key area for growth as more states consider adopting Climate Literacy policies.

6. Conclusions and recommendations

Working within a population group that is further toward the 'Alarmed' side of the political opinion spectrum, we explore the connection between information and action as part of our curriculum study. We report that (1) students receiving the humanities-focused climate curriculum exhibit academic gains in reading comprehension and enthusiasm for the curriculum content, and (2) the action/solutions focus can be strengthened by better incorporating authentic and meaningful student climate action projects in the local community. This will require additional partnerships and planning to implement, and may include field trips, hands-on schoolyard greening projects, contacting local elected officials, and developing community-school collaborations that allow for service learning projects to have meaningful impacts. The full impact of the curriculum on empowering student action may take several years in order to fully evaluate, but student self-reports and teacher interview data indicate promising trends and aspirations to action.

These preliminary results help shed light on the gains to be made through a humanities-focused climate change curriculum, and build momentum for expanding the focus on K-12 climate education outside the science classroom. They require further replication in both independent and public school settings to add confidence to student learning and engagement gains. The larger takeaways from this research investigation are that (1) the impetus for expanded CCE

in K-12 schools is abundantly clear, starting in the sixth grade or earlier (Schreiner, Henriksen, and Hansen 2005; UNESCO 2010; Plutzer et al. 2016; Niepold, Scowcroft, and Gingras 2017; National Wildlife Federation n.d.), (2) public opinion supports educating youth about climate change (Marlon et al. 2018), (3) a humanities-centered curriculum is a promising way to engage students in climate education in a way that promote dialogue with friends and family, and (4) the sixth grade students involved in this curriculum pilot demonstrated strong academic gains in reading comprehension on annual standardized tests, above and beyond performance improvements seen in previous years.

Taken together, these findings provide strong motivation for further study and implementation of climate education in the social studies classroom. In particular, future studies should focus on the student action elements of CCE, and how to most effectively build the education into action pathway, as the 'action' piece remains elusive and difficult to measure in many CCE curriculum studies and climate literacy assessments. Further study is also needed to investigate peer teaching opportunities between social studies/language arts and math/science teachers. While integration between the social sciences and STEM is becoming increasingly common in many school settings and is widely recognized as an educational best practice (Bogan, King-McKenzie, and Bantwini 2012), climate change as a focal topic of integration requires further investigation.

Additional recommendations based on this study include providing opportunities for educators and researchers to engage in discussion on climate education via humanities frameworks at professional meetings and conferences. Educators working on this socio-scientific topic are already discussing strategies at conferences for developing 'constructive hope' in their students, as opposed to hope based on denial or ignorance (i.e. 'I hope climate change won't be a problem') (Ojala 2012). Creating more conference themes or tracks around climate education will help elevate the opportunities for CCE beyond the science classroom. As a research team, we have disseminated preliminary findings of this investigation at several conferences in Fall 2018, including the National Council for the Social Studies annual conference and North American Association of Environmental Education (NAAEE). We look forward to expanding on the results of the first year, building off the feedback from students, teachers, and the broader CCE research community, in the second year curriculum implementation currently underway.

Notes

1. The climate change curriculum under investigation here incorporates a similar Model UN climate negotiation as an effective student learning opportunity.

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Appendix A. Lowell school curriculum planning documents

A.2: Curriculum influences

- **A People's Curriculum for the Earth**- 'a collection of articles, role plays, simulations, stories, poems, and graphics to help breathe life into teaching about the environmental crisis;' foregrounds issues of justice and includes articles on 'people who are working to make things better' (Bigelow and Swinehart 2014)
- **Next Generation Climate**- science curriculum for grades 6-8 from Climate Generation: A Will Steger Legacy, a nonprofit and national leader in climate education based in Minneapolis, Minnesota.
- **National Oceanic and Atmospheric Administration (NOAA) Climate Program**- The Senior Climate Education Program Manager educated staff on the importance of climate education, and provided resources developed by NOAA.
- For diagram of influences converging into curriculum planning process, see Figure A1.

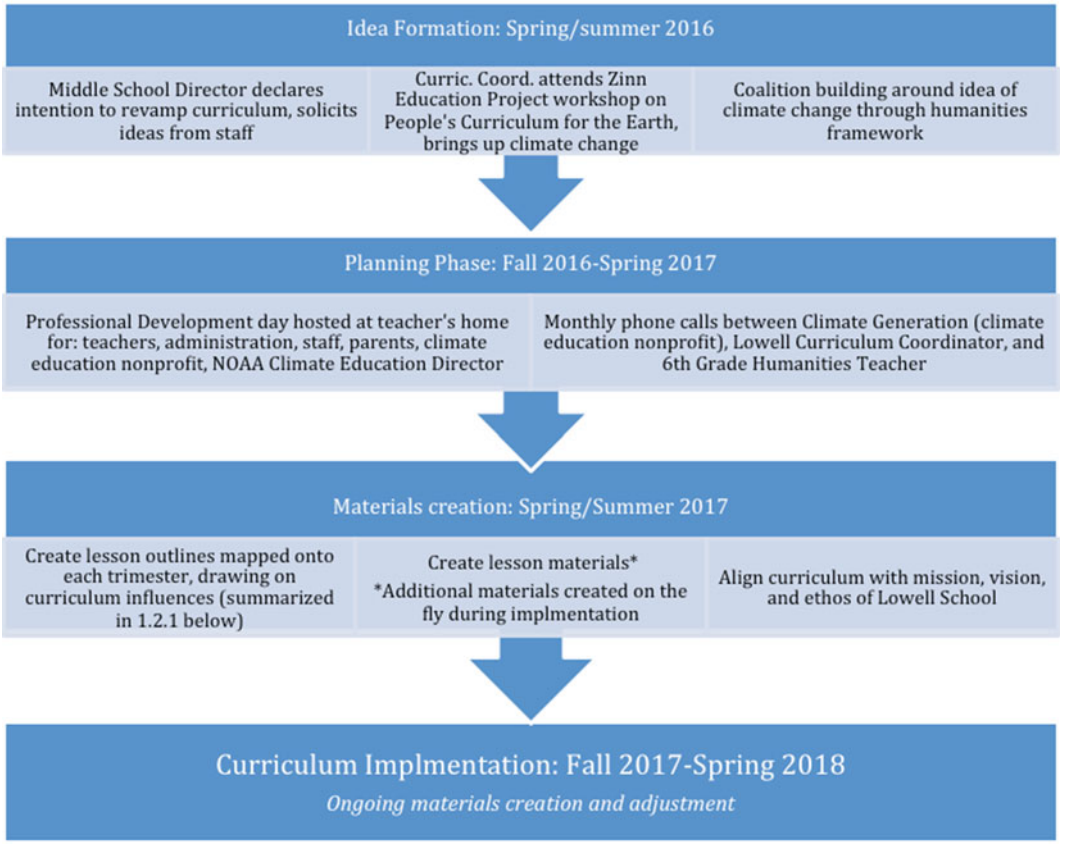

Figure A1. Curriculum design and development process diagram.

A.3: Climate solutions curriculum Map- Lowell school sixth grade

Trimester 1: Energy

Literacy	Summer Reading (6 lessons): Same Sun Here, Life As We Knew It
12 weeks	Narrative (10): Boy Who Harnessed the Wind
1. lessons/week	Expository (10): Climate Change for Beginners, Ch. 2 and 3
2. 25 lessons	Drama (10): Amrita's Tree
Social Studies	Civics (9): Environmental law (local, state)
12 weeks	Economics (9): Supply and demand (carbon)
2 lessons/week	Geography (9): Mapping carbon production and carbon use
25 lessons	History (9): Industrialization
Writing	Climate Solutions Research Paper
12 weeks	*Preassessment* (2)
2 lessons/week	*Gathering* (8): Study mentors, categorize, knowledge inventory, topic expansion
25 lessons	*Researching* (8): Balance weight of information, notetaking structures, facts and quotes, summarizing
	Drafting (8): Table of contents, organizing chapters, elaborating, expert voice
	Revising (8): Text features, text structure, engage with narrative voice, expert vocabulary and glossary
	Postassessment (2)
Service Learning Project	

Trimester 2: Movement

Literacy	Narrative (9): The Giver
12 weeks	Expository (9): Climate Change for Beginners, Ch. 6 and 7
3 lessons/week	Expository (9): Change Agents/Biographies
36 lessons	Media (9): Documentaries
Social Studies	Civics (9): Advocacy
12 weeks	Economics (9): Regulation and the marketplace
3 lessons/week	Geography (9): GIS mapping (extreme weather)
36 lessons	History (9):
Writing	Persuasive Essay
12 weeks	*Preassessment* (2)
3 lessons/week	*Gathering* (8): Study mentor evidence, distinguish reasons from examples, experiment with different sides
36 lessons	*Researching* (8): Develop a claim, developing strong reasons, considering audience perspective, using a variety of sources
	Drafting (8): Writing introductions, writing conclusions, organizing evidence, summarize evidence
	Revising (8): Eliminating and replacing weak evidence, using narratives in essays, using convincing language, counterargument
	Postassessment (2)
Service Learning Project	

Trimester 3: Collective Action

Literacy	Narrative (9): Exodus
12 weeks	Expository (9): Climate Change for Beginners, Ch. 4 and 5
3 lessons/week	Expository (9): Climate Migrants
36 lessons	Media (9): TED
Social Studies	Civics (9): Environmental law (national, international)
12 weeks	**World Climate Summit**
3 lessons/week	Economics (9): Cost/benefit analysis and risk management
36 lessons	Geography (9): Relief maps
	History (9): Indigenous peoples
Writing	Cli-Fi Short Story
12 weeks	*Preassessment* (2)
3 lessons/week	*Gathering* (10): Character descriptions, setting descriptions, evaluating problems, planning a message
36 lessons	*Drafting* (11): Story arc, balancing dialogue with action, managing transitions, blending fact and fiction
	Revising (11): Developing the heart of the story, slanting the writing, strengthening the ending, hooking the reader
	Postassesment (2)
Service Learning Project	

Appendix B. Student survey

Name:_____
Date: _____
Lowell School Climate Change Survey

Note to students: By completing this survey thoughtfully and truthfully, to the best of your ability, you are contributing to an important graduate student research project at the University of California, Berkeley. You are not only helping to improve the experience of other Lowell students who will participate in climate change curriculum, but your participation has the potential for national impact in the conversation around effective climate change education. Please answer the following questions, and keep in mind that this is a *survey* not a test. It is an opportunity to see where you're at with climate knowledge and engagement, and there are no consequences for wrong answers. The goal is that you will learn the answers to all these questions and more through climate education!

Knowledge

1. What is causing global warming?
   a. The sun moving closer to the Earth.
   b. Melting glaciers
   c. The added or extra greenhouse effect due to increased concentration of heat-trapping gases from human activities that prevent solar radiation from leaving Earth's atmosphere.
   d. The increase in Nitrogen and Oxygen as a percentage of the total gases in Earth's atmosphere.
2. The difference between weather and climate is:
   a. Weather is what we expect based on years of data while climate is what is happening right now
   b. Weather is predictable but climate is not
   c. Weather is a day-to-day event while climate is a consistent pattern over many years
3. What is the current CO_2 concentration in the atmosphere, in parts per million (ppm)?
   a. 280 ppm
   b. 400 ppm
   c. 350 ppm
   d. 500 ppm
4. Do we need to increase, decrease, or maintain (keep the same) the current CO_2 concentration to stabilize the Earth's climate?
   a. Increase
   b. Decrease
   c. Maintain
5. What cause CO_2 emissions to rise?
   a. Burning fossil fuels
   b. Cutting down trees
   c. Tilling the soil (common agricultural practice)
   d. Landfills
   e. All of the above
6. What are three ways we can lower CO_2 emissions?
   a. a.
   b. b.
   c. c.
7. Over the past 50 years, CO_2 in the air has increased which has led to:
   a. Higher average global temperatures
   b. Lower average global temperatures
   c. No change in global temperature
8. What is another greenhouse gas besides CO_2?
   a. Methane (CH_4)
   b. Water vapor
   c. Nitrous Oxide (N_2O)
   d. All of the above
9. Which of the following is a natural process that removes carbon from the atmosphere?
   a. The water cycle
   b. Humans breathing
   c. Trees dying
   d. Plants (via photosynthesis)

10. Scientists and policy-makers have agreed at the Paris Conference (COP 21) to try and limit global average temperature rise to less than ___ degrees Celsius by the end of the century.
    a. 1C (1.8F)
    b. 2C (3.6F)
    c. 4C (7.2F)
    d. 10C (18F)
11. Name one thing your community could realistically do to adapt or mitigate climate changes. How and why would your plan work?

Engagement

**These questions are from the Yale Project on Climate Change Communications (YPCCC) new shortened 4-question survey for the American public to determine their level of concern and engagement with the issue of climate change. You can take the survey online here for an analysis of your results and where you fit in the 'Six Americas' spectrum.*

***Note about clarifying the difference between global warming and climate change: While the two terms are often used interchangeably by the public, Paul Hawken distinguishes between the two in his recent book Drawdown as follows:* 'Global warming refers to the surface temperature on the earth. Climate change refers to the many changes that will occur with increases in temperature and greenhouse gases'.

1. How important is the issue of global warming to you personally?
    a. Extremely important
    b. Very important
    c. Somewhat important
    d. Not too important
    e. Not at all important
2. How worried are you about global warming?
    a. Very worried
    b. Somewhat worried
    c. Not very worried
    d. Not at all worried
3. How much do you think global warming will harm you personally?
    a. A great deal
    b. A moderate amount
    c. Only a little
    d. Not at all
    e. Don't know
4. How much do you think global warming will harm future generations of people?
    a. A great deal
    b. A moderate amount
    c. Only a little
    d. Not at all
    e. Don't know
    f. I think our generation will solve climate change
5. How many times t in the past year have you looked up additional information on climate change that you did not learn in school?
    a. Never
    b. Once or twice
    c. Monthly
    d. Weekly
    e. Every day
6. How often in the past year have you talked to friends/family members about climate change?
    a. Never
    b. Once or twice
    c. Monthly
    d. Weekly
    e. Every day
7. Do you have a sibling at Lowell in the fifth, seventh, or eighth grade? Please specify:

Appendix C. Teacher/staff interview guide

1. What has your experience been like teaching a climate change curriculum for the first time in humanities?
2. What do you think about focusing the climate change curriculum around humanities?
3. Do you think middle school students are ready to learn about climate change?
4. How has the integration been between humanities and science?
5. What have parent responses been to the curriculum pilot? How do they compare with student responses? Do you think there's an intergenerational transfer effect occurring (students talking to parents more about climate change and influencing their knowledge/behavior?)
6. What suggestions do you have to improve the curriculum for next year?
7. Do you think there has been enough of a solutions focus to the curriculum this year, or is this something that could/should be strengthened?
8. What advice do you have for other humanities teachers that are considering or planning to implement a climate change curriculum with their students?
9. *[Staff only]* What motivated you to develop and implement this curriculum, with a humanities focus on teaching climate change, at Lowell?
10. *[Staff only]* Can you describe the curriculum planning and development process? Who was involved and how did that help?
11. *[Staff only]* What is your long term vision for the curriculum evolution at Lowell?
12. *[Staff only]* What advice do you have for other schools or school districts considering implementing an integrated climate change curriculum across subjects?

C. 1. Extended teacher/staff quotes:

- 'The [climate change education] train was leaving the station and I could either get on it, or be left behind, and I have two daughters who are on that train so I'm going to get on it' (S. Smith, personal communication, April 2018)
- When it comes to attracting young aspiring educators to work at a public or private school, Kavan reports hearing many job-seeking educators say they want to '"bring to life a curriculum with connections to the real world." I think we (Lowell) have an example of that'. (K. Yee, personal communication, May 2018)
- 'Teaching climate change through a humanities and civics framework fits perfectly with the new social studies standards focused on building student capacity to research *and* take action through an inquiry process' (N. Stapert, personal communication, May 7, 2018).