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A Case Study for Climate Change Teacher Professional Development in West Virginia

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Abstract: The West Virginia Climate Change Professional Development (WVCCPD) Project was developed in 2019 as an effort to engage West Virginia K-12 teachers and informal educators in climate change professional development to encourage learning and action. Started by astronomy educators who are passionate about climate change, the project has been an experiment that has iteratively grown each year. By bringing in social science experts, communication specialists, community activists, master teachers, and learning how to best support teachers and their students through misconceptions and empowering action, we have engaged over 130 W.Va. educators. WVCCPD represents a promising case study for how educators can come together across disciplines and institutions to build an engaging climate change learning community, even in West Virginia, an area that is known for fossil fuel extraction. We hope this paper informs other teacher education practitioners.

Keywords: *Climate Change, Teacher Professional Development, K-12 Education, Community Engagement*

Introduction

Taking action to solve climate change is perhaps the greatest challenge of our time. The extreme urgency is detailed in a variety of reports, most notably the recently released sixth assessment reports from the UN's Intergovernmental Panel on Climate Change (IPCC),

which says that we "will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all (IPCC, 2022)." One of the key areas to make the necessary changes is through engagement with K-12 schools through teacher professional development. Most public school students hear the words "climate change" in a classroom at some point, but the way climate change is taught in schools can vary widely, leading to a range of knowledge gaps and skewed information often entangled with the sociopolitical landscape of a community (Worth, 2021).

Research indicates that climate change instruction can be effective for empowering learning and action. For example, students show positive pre to post-instruction changes in content knowledge related to climate change causes and effects (Bodzin & Fu, 2013; Varma & Linn, 2011). It takes more than one brief climate change unit to build persistent and accurate knowledge. In order for us to expect students to take action, they must have a sustained and accurate understanding of climate change (Chang & Pascua, 2016). For example, students who have taken an environmental science course that includes climate change make more environmentally friendly decisions at least a year afterwards (Worth, 2021). While promising, Varela et al. (2020) found that some misconceptions can remain after a course, which the authors attributed to their teachers teaching multiple environmental issues together rather than focusing instruction on a single issue, blurring the lines between topics. In addition, misleading images provided in textbooks were cited as a possible source of misconceptions. Shephardson (2014) found that students may think of climate change as unidirectional, simple

cause-effect phenomenon, or linear with no feedback mechanism. A variety of alternate conceptions of the greenhouse effect, a core idea for understanding global warming, have also been identified (Boyes & Stanisstreet, 1993), such as: misidentification of greenhouse gasses (Bofferding & Kloser, 2015; Cartwright et al., 2021), overgeneralization of pollution as the cause for climate change (Bofferding & Kloser, 2015), the reduction in ozone layer's contribution to climate change (Bostrom et al. 1994; Rye et al., 1997; Cartwright et al., 2021), and no clear understanding of preventive measures (Bodzin et al., 2014).

Climate change education can also be influenced by teachers' beliefs and values. Mirroring some actors in the societal debate over climate change, many teachers repeat scientifically unsupported claims in class and have their students "debate" climate science, when scientists themselves are having no such debate (M. Lynas et al., 2021). As noted by Plutzer et al. (2016), "only about half of U.S. adults believe that human activity is the predominant cause, which is the lowest among 20 nations polled in 2014." The beliefs of the adults in students' lives, including both their teachers and their parents, can have a profound impact on their willingness to learn about climate change. However, Lawson et al. (2019) notes that the reverse is also true – kids can influence their parents' beliefs about climate change. As climate scientist Michael Mann and colleagues suggest, "Science alone is clearly insufficient to reverse the climate crisis. But widespread civic climate change engagement – with climate educators playing a key role – might do it" (Buckland et al., 2020). Civic engagement is integral to American democracy and

responsible citizenship (Ehrlich, 2000), and it is a key component of many social studies and government education standards. Especially when teaching climate change, we must engage with teachers' and students' values and help them become civically engaged decision-makers (USGCRP, 2009). In addition to the benefits it offers teachers and students, it has the potential to increase public understanding, change behavior, build political will, and encourage collective action to address climate change (Buckland et al. 2020; Wibeck, 2014).

Teachers teach the way they have been taught, so, to get to the heart of addressing climate change learning and engagement in schools, we must ensure teachers have accessible, relevant, and engaging Professional Development (PD). Effective professional development models like the Climate Academy (Shea et al., 2016), which work across face-to-face and online spaces, match to science standards, and engage a range of grades and types of educators, have been shown to improve teachers' knowledge and pedagogy related to climate change instruction and to have impacts on student belief and increased awareness of climate change. The Climate Change Education in Formal Settings, K-14 (NRC, 2012b) workshop stressed the importance of identifying successful "replicable and scalable" programs to be shared with other states. One example of this is the Maryland and Delaware Climate Change Education Assessment and Research (MADE CLEAR) project, which, thanks to shared leadership that includes both teacher and community members, has been able to persist beyond NSF grant funding (Stylinski et al. 2020). Additionally, PD must include, but move beyond, climate science, best practices in climate instruction, climate

communication, and community engagement and help re-orient participants toward transforming the mainstream status quo (Wise, 2010; Drewes et al., 2020). In sharing examples of climate change educational programs, we can all learn how to navigate this uncertain territory so we can move toward positive socio-cultural action on climate change in our schools and communities.

The West Virginia Climate Change Professional Development Project (WVCCPD)

West Virginia is well-known for its fossil fuel industry's extractive practices that contribute to global warming and climate change. Coal has brought and continues to bring jobs and income for many communities, and it is deeply intertwined with the culture of the state. However, West Virginia is also at risk from climate change, including extreme precipitation events that lead to increases in flooding, landslides, and other natural hazards (Butler et al., 2014; Jay et al., 2018). According to new flood risk data for the United States, which incorporates climate projection in its assessments, West Virginia is at or near the top of the list in nearly every risk category, including potential impacts of flooding on utilities, roads, fire and police stations, schools, and commercial properties (Flood Factor, 2021). We have had several floods in the recent decade, including a particularly devastating one in 2016, which hit several small towns and led to years of recovery (Shinn & Caretta, 2020), and another flood event as of the writing of this article. Yet, according to the Yale Climate Opinion studies in 2021, only 57% of West Virginians believe that global warming is happening, compared to the national average of 72%. Furthermore, only 28% of West

Virginians report discussing global warming at least occasionally, even though, as climate scientist Katharine Hayhoe says, we know "the most important thing you can do to fight climate change is to talk about it."

While some residents of our state may doubt climate science, 66% of West Virginians believe that schools should teach about global warming. While West Virginia was a lead state in the development of Next Generation Science Standards (NGSS Lead States, 2013), and supported the inclusion of climate change standards in Earth Systems and environmental sciences, during the adoption process, the state Board of Education expressed concerns regarding the language of the climate change performance expectations. All NGSS climate change performance expectations are present in the WV standards, but ultimately the wording was changed to discourage teachers from teaching climate change as a "foregone conclusion" (Speciale, 2015). As of the writing of this article, NGSS has been again "adapted" in the now-second iteration of state standards known as the "WV College and Career Readiness Standards" and went into effect academic year 2022-23. Despite the inclusion of the standards, teachers have received little preparation to teach them. There is clearly both a need and a desire to engage schools in climate change learning and action, even in a state whose economy has traditionally depended on fossil fuels.

To help address this need and desire for climate change engagement through schools in West Virginia, the West Virginia Climate Change Professional Development (WVCCPD) project was created in 2019. WVCCPD has become a dynamic collaboration between physical and

social scientists, science communicators, media consultants, social activists, and educators, with the aim of empowering teachers and their students toward climate learning and action. The goals of the WVCCPD project are to: (1) increase collaboration and collective impact of West Virginia physical science experts, social science experts, community activists, and teachers to address climate change in the state; (2) empower West Virginia teachers in a range of disciplines to work together in data-driven investigations; and (3) highlight, reward, and promote climate change engagement of WV teachers and students through civic action and public media campaigns. The project website is: sites.google.com/view/wvclimatechangepd. To date, we have engaged over 130 teachers in at least one event, whether that be through a workshop, networking session, or full-semester course, as our project evolved over the last four years.

2019-2020 Pilot Workshop:

The WVCCPD began in 2019 as a collaboration between two of us who are primarily astronomy educators – one professor from West Virginia University (WVU) and one informal educator from the NASA Independent Validation & Verification Facility Education Resource Center in Fairmont, WV. We had previously worked together on teacher professional development focusing on Earth and Space Science (see the Earth and Space Science (ESS) Passport program through Fairmont State University). The ESS Passport training included NASA GLOBE activities, which empowers classrooms to record and report local measures of land cover, cloud cover, rain depth, and temperatures to contribute to world-wide datasets.

However, we noticed a lack of specific climate change lessons that were both scientifically focused and grounded in community action. We were eager to improve climate change education at the middle and high school levels and applied for seed funding from the WV Space Grant Consortium to pilot an in-person climate change teacher professional development workshop in Morgantown, WV, in February 2020. We had 34 educators express interest, and with our grant funding we were able to support 11 middle and high school science teachers to attend, hailing from all over the state. The focus was largely on physical science issues (e.g., greenhouse gasses and the carbon cycle, and the planetarium film, "Dynamic Earth"), but we also included a letter-writing social action component, inspired by the "Climate Generation" organization. In an effort to connect participants to additional local change agents, we also heard from local climate activists and a state delegate. Results from the teachers were overwhelmingly positive, but it became clear that teachers were struggling with moving their students from science to action, and there were no formal incentives for teachers to follow through and implement the climate lessons with students. As far as we know, only one teacher implemented a climate change lesson with students – a lesson on mosquitos and the spread of disease as the result of warming temperatures. We presented at the West Virginia Science Teachers Association (WVSTA) annual meeting to generate more interest. We also realized that focusing on physical science meant we were missing a large number of teachers who could implement climate change lessons. We determined that the project needed an additional social science emphasis moving forward.

2020-2021 Expansion to Social Science and Action:

In 2020, the WVCCPD team expanded to include a social scientist from WVU and a climate activist and media/communication specialist from Morgantown, WV, and social studies teachers were encouraged to participate in professional development activities. With a new grant from the WV Space Grant Consortium, we aimed to pair science teachers and social studies teachers to work together across the curriculum, and plans were made for the second in-person workshop, but this was moved online due to COVID-19. Instead, three virtual professional development webinars were offered, each with physical science, social science, and climate action related components on topics related to carbon, water, and climate solutions. Key social science components included Carbon Footprint Calculators and Story Maps of flooded towns. To better incentivize follow-through, we assigned optional "homework" after each webinar for teachers to go through the activities themselves, and those that did received Amazon gift cards supported by the grant. A total of 93 teachers from across the state signed up to attend one or more workshops, 40 (or 43%) actually attended, and 38 (or 41%) followed through on the homework to receive a gift card.

In the spirit of the Youth Climate Movement, we wanted to encourage teachers to mobilize their students to action. To this end, we hosted a "Public Service Announcement" (PSA) competition surrounding Earth Day 2021, inspired by a similar effort by Mid-Ohio Valley Climate Action, a West Virginia-based civic organization. In contrast to a traditional commercial, the goal of a PSA is to inform, raise awareness, and influence attitudes or behaviors about a social

issue rather than to sell a product. Through their teachers, students from across the state were invited to submit 30- or 60-second audio and video PSAs focusing on climate change along the themes of "water" or "carbon." The PSA goals were to (a) communicate a scientific fact the students learned about climate change, (b) incorporate effective messaging techniques, and (c) encourage the audience to take action. To prepare teachers for engaging students in this project we offered media production recommendations, including those from the "Climate Education in an Age of Media" (CAM) project (Rooney-Varga et al., 2014), and presented strategies for crafting effective messages (Krajewski et al., 2019; Roser-Renouf et al., 2015; Markowitz et al., 2014; Wibeck, 2014). In total, we received 30 PSA submissions from WV teachers and students, and grant funds were used to award first, second, and third place prizes in each category, which our team judged based on use of effective messaging techniques, creativity, accuracy, and quality. These were featured on our website, and most importantly, the PSAs were broadcast across WV TV and radio outlets. Several local newspapers also ran stories on the student winners and their PSAs. It was exciting to see students being celebrated by their schools, teachers, and peers for engaging with climate change. The PSA competition facilitated students' civic engagement by allowing them to apply their work beyond the classroom and add their voices to the public climate discussion.

2021-2022 Formalizing a Continuing Education Course for Teachers

In 2021, our team expanded further to include a science education expert from Fairmont State University and an expert science teacher

from Huntington, WV, and the team received another award from WV Space Grant Consortium, as well as an additional award from the Appalachian Stewardship Foundation (ASF). Together, this diverse group of collaborators took the lessons learned from the first two years of the project and updated and expanded the suite of WVCCPD featured activities, which are featured on the Resources page of the project website. While most professional development is for teachers who teach a certain grade or subject, the WVCCPD course now takes the stance that climate change can be incorporated into any grade and subject, and includes activities that span a variety of grades and disciplines and meet state and national educational standards. For example, an activity that analyzes water mass concentration with NASA's GRACE satellite helps meet the the WV Science Standard S.9.ESS.14: Students will analyze geoscience data and the results from the global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. The Impacts of Flooding story maps activity helps meet the WV Social Studies Standard: SS.CS.17: Hypothesize how human and environmental interactions pose a threat to mankind and the environment. Additionally, the Public Service Announcement component helps meet the WV English Language Arts Standard: ELA.6.15: Integrate information presented in different media or formats and in words to develop a coherent understanding of a topic or issue. We continue to identify new connections to standards and have created an ongoing list, which currently includes 123 standards (52 Science, 57 Social Studies, and 14 English & Language Arts (ELA) standards), which we have coded

as a searchable database, linked from the project website and matched to each activity and grade level.

In Spring 2022, our team formalized a semester-long curriculum to offer three-credit Continuing Education Units (CEUs) to teachers through Fairmont State University (syllabus available in Appendix A). CEUs are a critical component of teachers' repertoires for continued employment, recertification, and promotion. Because these credits are often costly, and this cost often falls to teachers to pay out-of-pocket, our grants covered the costs so the course would be free to teachers. If teachers did not need the credit, our grant funds would pay an equivalent amount as a gift card at the conclusion of the course. We also hoped the accountability of a formal course would help with teacher follow through and the semester-long exposure would enhance retention of any new content knowledge. Course modules were delivered online asynchronously through Google Classroom, with only 3 mandatory virtual meetings, so as to remain accessible and accommodating of teachers' busy schedules. Content included climate science (both physical and social science), climate communication, and action. The syllabus (Appendix A) schedule was roughly divided into three parts. The first third of the course was focused primarily on climate science, including physical science (ex: the carbon cycle, such as through a "Carbon Journey Game," climate change evidence, such as through "Build Your Own Ice Core" activity from Byrd Polar and Climate Research Center at The Ohio State University, and precipitation data using NASA satellite data from the GRACE mission) and social science (ex: flood risks and human impacts, particularly in West Virginia). The second third of the course

focused on climate change solutions and communication. To learn about solutions, teachers explore the Project Drawdown solutions library for a variety of sectors, such as energy and transportation, food and agriculture, and health and education. They can then choose an activity – either the En-ROADS online solutions simulator, which involves sliding scales to understand how different policies impact projected temperature rise, or the Stabilization Wedge activity, originally produced by the Princeton Environmental Institute Carbon Mitigation Initiative, where learners choose solutions that will remove 8 billion tons of carbon emissions to help stabilize emissions. Activities that focus on solutions include resources from the Yale Climate Opinion maps, such as the Six Americas Role Playing Activity to understand which climate communication strategies impact people with different levels of climate concern, and the Cranky Uncle game from Monash University, which is an app that teaches about different types of misinformation techniques through interactive examples. The Cranky Uncle developer even called in for one of our networking events. The final third of the course required teachers to implement a climate change lesson plan with their students and create a 5-7-minute video presentation to share at the conclusion of the course. Again, all of these activities are linked from our website, and educators can email us to request WVCCPD teachers' lesson plans and video presentations.

Concurrently with the course, we ran our second annual PSA competition. While all teachers enrolled in the course were required to practice creating PSAs as part of the curriculum, they were not required to participate in the contest. However, one of the teachers

created an audio PSA with his students that went on to become a second place winner in the contest. Out of the other 46 entries, additional video and audio winners were selected. Again, the winning PSAs were featured on our project website and broadcast and streamed across state media, thanks to Appalachian Stewardship Foundation grant funds. We received PSA viewership data from one audio/radio streaming source indicating a 32.13 percent completion rate, meaning that people listened to that particular PSA 6,982 times across four metropolitan areas in the state. This percentage is several points higher than the traditional completion rate and suggests that our combined broadcast/streaming efforts may have resulted in 20,000 or more views across the state. While we do not have concrete data on how many people heard and/or watched these PSAs, the combined reach of the broadcast stations is in the tens of thousands, so we are hopeful that a large number West Virginia residents received the messages.

Assessment

Each year of the project included informal assessment measures, such as Google Forms after each webinar, which allowed us to iterate and ultimately led to our full 3-credit course for teachers. The focus on this paper is the impact of the Spring 2022 CEU climate change professional development course for teachers. In total, 25 teachers enrolled. Teachers taught a variety of age ranges (1 Elementary, 9 Middle, 11 High school, 3 informal educators) and a variety of subjects (Earth & Space Science, English, Special Education). Seventeen enrolled for credit through Fairmont State University (15 passed, and 1 dropped the course, average course grade 88%), 5 for

an e-Gift Card (1 passed, average course grade 45%), and 3 as volunteers, i.e. informal educators who wanted to learn but were not eligible for our funding (0 passed, average course grade 29%). Therefore, we had a total of 16 teachers who completed the course requirements, including our assessment surveys, for a follow-through rate of 64%, our highest rate for any component of the WVCCPD project. Through their climate change lessons, these teachers engaged 513 K-12 students and created 16 video presentations sharing their lessons learned in implementing climate change lessons with their students.

We implemented both qualitative and quantitative methods to understand the impact of the WVCCPD Spring 2022 Course on the 16 teachers who engaged. Qualitative methods included review of a variety of artifacts collected during the course, including teacher comments during online meetings, in the Google Classroom Discussion Forums, and in their final project presentations. We also documented unexpected connections and outcomes, ex: new collaborations that arose through networking events, and news and media stories that resulted from the work we were doing. Quantitative assessment methods include a pre and post-course survey, which was assigned through the Google Classroom as a Google form, such that responses were tied to teacher names for participation credit and to match responses for analysis. This assessment form had 3 components. The first component was a Climate Change Hope Scale adapted from Li & Monroe (2017) that included 11 items scored on a 7-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = neutral, 5 =

slightly agree, 6 = agree, 7 = strongly agree) plus an option to select, "I do not think climate is changing." When the latter option was chosen, we did not include those responses in the average score calculations. Three items were reverse-coded (ex: "Climate change is so complex we will not be able to solve problems that it causes"). The second part of the survey included 13 content questions related to the greenhouse effect, carbon footprint, scientific consensus vs public opinion, and weather vs climate. Nine of these questions were multiple choice, including 1 that had multiple correct answers ("Which of these processes add significant carbon to the atmosphere?"), making it a particularly challenging question, 2 were "True/False" ("Weather and Climate are different words for the same thing" and"WV has had a flood-related disaster declared nearly every year in recent decades"), and 2 were "Yes/No" or "I don't know" ("Is the current climate change caused primarily by human activity?" and "Are there natural cycles to the climate?"). Because these questions were only developed for our project and not formally validated, we only use them as a basic assessment of teacher understanding. The final component to the assessment survey included self-perceived knowledge about climate change and preparation to teach climate change, as well as course-related opinions and practices, such as interest in teaching about climate change (pre-course only) and the impact of the course on their learning, what they enjoyed, and what could be improved (post-course only).

Impacts on Confidence & Content Knowledge:

Teachers' pre to post-course self perceptions about their climate change knowledge and preparedness to teach climate change is

shown in Figure 1. All 16 teachers showed positive gains and both questions showed large effect sizes: "How much do you know about climate change?" (pre avg=4.93, SD=1.98; post avg=7.38, SD=0.72, Cohen's d =1.63) and "How prepared are you to teach climate change lessons?" (pre avg=4.44, SD=2.50; post avg=8.50, SD=1.21, Cohen's d =2.07).

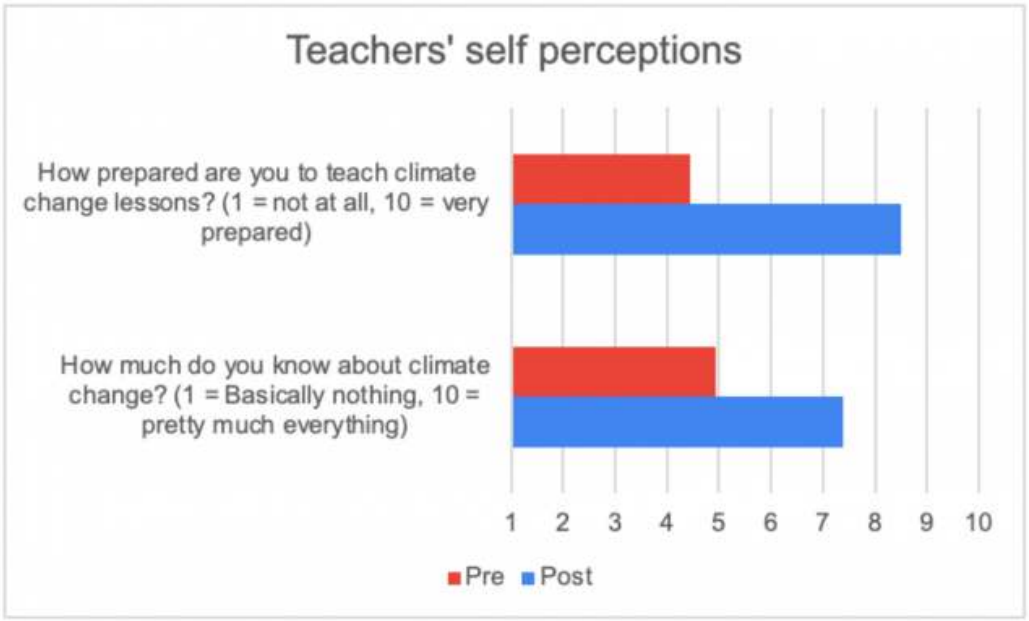

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Figure 1: Gains in teachers' self-perceptions in knowledge about climate change and preparation levels in teaching climate change lessons. N=16

Results for the content knowledge subset of questions is shown in Figure 2. The average pre-course score was 75% and the average post-course score was 90%, with all 16 participants showing gains. The highest gains were from the questions about public opinion, and the lowest gains, both negative, were about the purpose of two of the activities (the Stabilization Wedge game and the En-ROADS

climate simulator, which focus on climate solutions) and the processes that add significant carbon to the atmosphere (again, this was the most challenging question with multiple correct answers). Additionally, the question "Which of the following is NOT a greenhouse gas?" shows the lowest correct scores both pre and post-instruction. The choices were "Water, Carbon Dioxide, Methane, and Nitrogen," with the correct answer being "Nitrogen." All teachers who got this wrong selected "Water," pointing to a need to clarify that not all greenhouse gasses are carbon-based and to discuss the importance of feedback loops, ex: carbon emissions can raise temperatures, which causes increased evaporation and water vapor in the atmosphere, which leads to additional temperature increases, and so on. On the pre-survey, 3 (out of 16) teachers marked "I don't know" on the question asking if the current climate change is caused primarily by human activity and 2 marked this on the question asking if there are natural cycles to the climate; whereas on the post-survey, all 16 teachers correctly marked "Yes" to both questions.

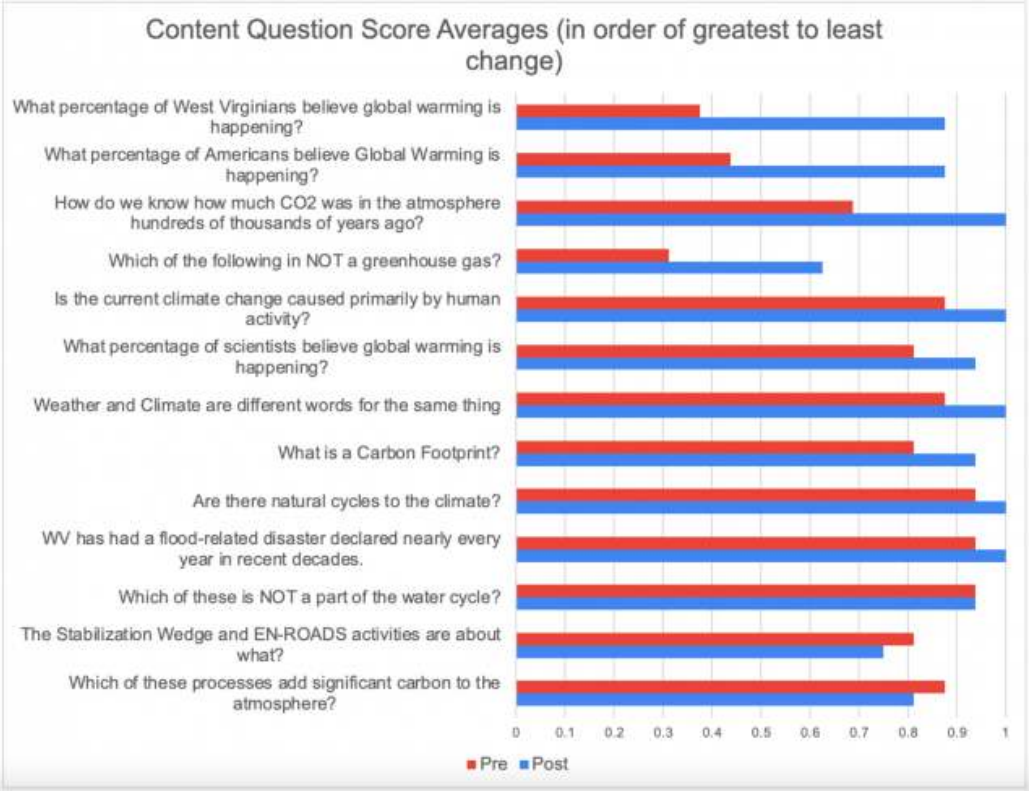

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Figure 2: Content Question Results for the N=16 matched pre and post results.

Impacts on Climate Change Hope:

The Climate Change Hope scale pre- to post-course changes showed that 14 teachers increased their overall Climate Change Hope score and 2 decreased (see Figure 3). The greatest gains in hope were from the statements, "I know what to do to help solve problems caused by climate change," and "I believe more people are willing to take actions to help solve problems caused by climate change." The smallest gains were from the items, "Climate change is so complex we will not be able to solve problems that it causes," and "I am willing to take actions to help solve problems caused by climate change." Though small, these changes are still positive. There was

one item that showed a small decrease in hope: “Even when some people give up, I know there will be others who will continue to try to solve problems caused by climate change.” With such a small sample size, more data is needed to say whether this is significant. Again, the overall Hope scale shows notable improvement in climate change hope, indicating that teachers learned concrete solutions to climate change and came to view themselves as change agents for the future.

Additionally, we were also surprised to see that two teachers marked that they do not think climate change is happening on the post-assessment but not on the pre-assessment. We did not hear doubts from them throughout the course, so perhaps they were just going along with the assignments to get the credit without revising their belief systems. This indicates that there is still important work to do in understanding and improving teachers’ beliefs about the scientific consensus and connecting to teachers through their values. As we move forward with the project, we are reaching out to climate change communication experts to explore options for better achieving our goals.

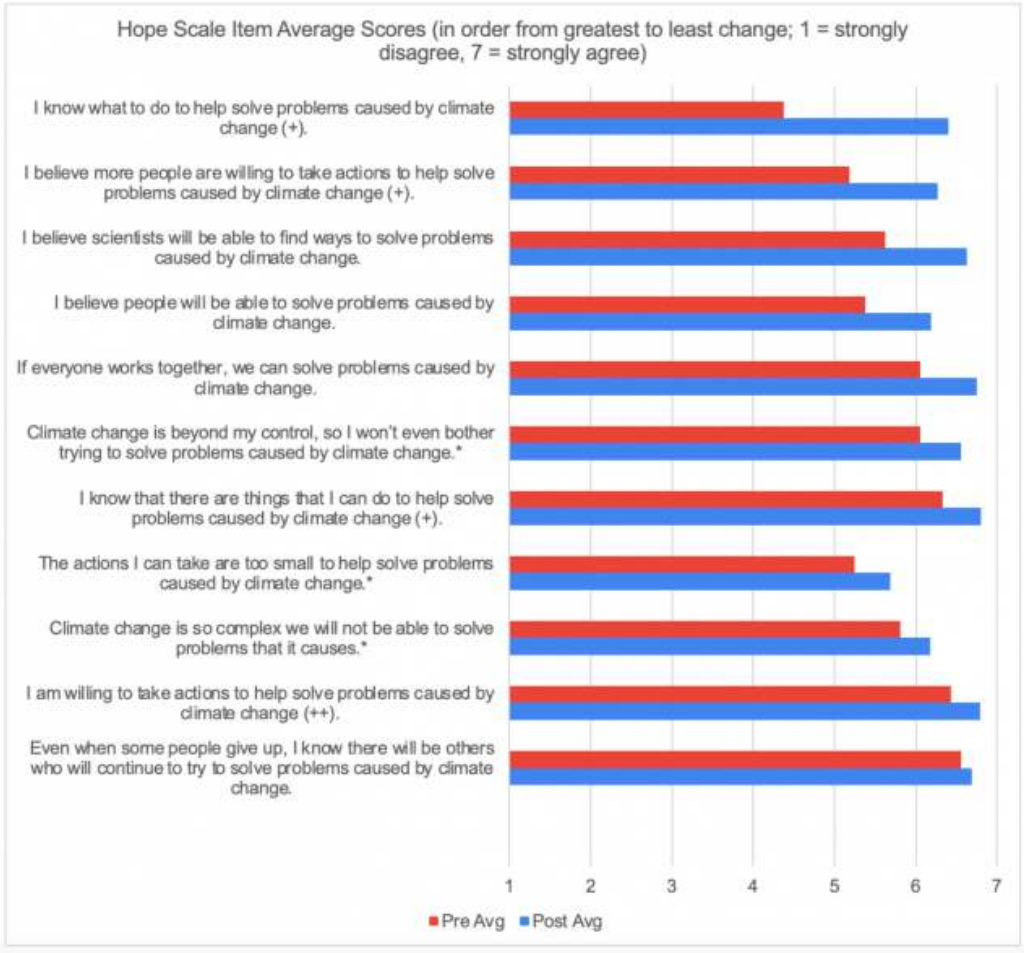

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Figure 3: Hope Scale Results for the N=16 matched pre and post results. Where participants marked "I do not think climate is changing," we made a notation and calculated averages without their responses. (* = reverse coded; + = 1 person marked ""I do not think climate is changing" on the post survey; ++ = 2 people marked "I do not think climate is changing" on the post survey)

Perceptions of Overall Course Effectiveness:

From the pre-course survey question that asked what teachers hoped to learn from the course, they reported that they wanted data-driven and hands-on activities to engage students in convincing

and impactful ways, both through local examples of climate change and attention to global climate issues. Several teachers commented that they wanted to learn how to incorporate climate education into their non-science classes (e.g. English and Social Studies), as well as in middle school classrooms. There was also a desire to learn how to overcome skepticism and engage students in what can be a controversial topic in WV classrooms. Anecdotally, from our conversations at our first synchronous meeting, we also sensed some trepidation from the teachers – worry that their students would be hopeless and it would just be demotivating to everyone. Ultimately, most teachers had the goal of increasing student awareness of, knowledge about, and belief in climate change in a way that felt hopeful and empowering.

In the post-course survey, we asked what teachers most enjoyed about the class. Teachers seemed to enjoy the course overall. As one said, “The assignments were extremely relevant, well-paced, and enjoyable. The program as a whole is better than my expectations by far. I can only hope there are more courses like this offered soon.” Teachers also commented on specific course units that they enjoyed, including the carbon footprint calculator and ice core activities. Several also enjoyed the opportunities to network with and learn from one another, as well as with our guest experts. Some particularly enjoyed the PSA component of the class. Perhaps most importantly, teachers reported success in implementing course material into their classrooms and an increased confidence in teaching their students about climate change, as is supported by our quantitative results above. In their final projects, all 16 teachers

indicated some sort of feelings of success and were pleased with their students' engagement, as indicated by the variety of quotes shown in Figure 4.

"I was not really sure of the response from the students when I told them that we would be conducting…the climate change project. But the very first day when I started it…every student loved it. And to my surprise the whole week was successful."
"Students really do want their voices heard [in reference to PSAs]. They want their thoughts out there and they do have a lot of thoughts when it comes to climate change… I was surprised [that] the class clown, usually goofing off, actually had quite good thoughts and ideas he wanted to put out there. The class sleeper, the one who's always sleeping and rarely participates in anything, was actually up and joined things during this class. It was exciting to see that."
"The students were extremely engaged the whole time, they asked me a lot of questions, I heard them talking amongst themselves saying they were interested in this topic. They had a really good time creating their PSAs and playing them for the class… I think that the overall takeaway is that I gave them some awareness that they now know there is evidence for climate change."
"We calculated carbon footprints for students and their families and looked at WV flood maps so students could see flooding risks for where we live and where we go to school and where our community is... At the end of the lesson I had the students take another informal poll so that we could see if their opinions had changed. Most students were at the 'yes' end of the scale as to whether or not climate change was affecting West Virginia."
"Students…were really intrigued about how much trees are important to us and how we were able to show how the different levels of carbon affects things. Now every time they hear of somebody wanting to cut a tree down they get very upset."
"[After the course], I feel completely ready and willing to teach and do lessons about climate change. The tough part is getting the students themselves to be engaged and interested. I however believe that this course helps better prepare teachers to do so."

[7]

Figure 4: WVCCPD Spring 2022 teacher quotes from final project presentations.

Teachers also had ideas for how to improve future versions of the class. These included hearing from additional experts, as well as increasing the number of synchronous meetings to facilitate more discussion and debate with one another. Some suggested expanding or adapting activities for younger classrooms. Finally, a few

requested additional instructions on how to complete assignments, as well as increased feedback.

Reflections & Next Steps

A major outcome of the West Virginia Climate Change Professional Development project is that teachers feel more knowledgeable, confident, hopeful, and capable in engaging their students in climate change! Our assessment results show a notable increase in self-perceptions in understanding and teaching climate change – this can have profound impact on teachers' willingness and follow through to incorporate climate change into their curriculum, which in turn can have a big impact on students' knowledge and confidence, and even their families and communities. It seems that WVCCPD was able to provide content knowledge, and more importantly, a framework for how to talk about climate change in a productive way. Additionally, our teacher participants were connected with a variety of climate contacts and other experts around the state and beyond. Now, if they have a technical question or want a guest speaker for their class, they have a wide array of people they can ask. Our project also connected teachers with climate communication researchers; for example, one teacher was invited to write a blog post for the Cranky Uncle game, and teachers were invited to participate in a research project with Mom's Clean Air Force. The PSAs, and the project in general, have garnered news attention from local and national outlets. This is the kind of attention that climate change deserves, and we are proud to see it stem from some of WVCCPD's efforts.

With continued funding from WV Space Grant Consortium, we offered a second iteration of our course in Fall 2022, and saw an even higher

completion rate of 85% (i.e. 17 out of 20 teachers completed the Fall 2022 course), which we attribute to four upgrades to the project: (1) four "Teacher Leaders" from the Spring course served as mentors to new teachers in the Fall course, offering one-on-one encouragement and advice from personal experience; (2) we required all participants to officially register for course credit, i.e. rather than receive a Gift Card, increasing accountability; (3) we broadened the course assignments with a "choose your own adventure" format each week, adding in resources about youth activism (ex: "Youth v Gov" documentary), climate justice, and climate emotions, allowing teachers from different grades and subjects to select what feels most relevant to them; (4) Networking sessions with a broader range of experts both within and beyond the state (ex: an expert on Climate Justice from the Presidio Graduate School). To mimic the action component that surrounded Earth Day in the Spring, we encouraged a "Day of Action" for a Friday in the Fall, inspired by the Fridays for Future movement. Fall 2022 cohort teachers engaged 671 K-12 WV students in their own climate lesson plans inspired around this Day of Action. The qualitative outcomes of the teachers' final projects and Lesson Plans for the Day of Action showcase the most impressive impacts of the WVCCPD course. These include: a special education teacher whose students became leaders in recycling for the school, a kindergarten teacher whose students read the Lorax and recited, "unless someone like you cares a whole awful lot, nothing's ever going to change, it's not," a high school English teacher whose students "revolted" against her essay assignment and said they wanted to write letters to their legislators instead, and a middle school teacher whose school is now designing a composting system.

Finally, our third annual PSA competition is scheduled for Earth Day 2023, again supported by the Appalachian Stewardship Foundation. We hope to improve on some of the common messaging issues we saw in our previous two PSA competitions. For example, we saw some persistent misconceptions ex: too much focus on tornadoes as a risk of the expected extreme weather events (over flooding or fires), saying that a particular flood is the direct result of climate change (rather than the severity and frequency as a trend), that reducing plastic pollution, or recycling more, will solve global warming, (rather than as a reduction of greenhouse gas emission). We also saw many "doom and gloom" communication strategies, but we would like to encourage more creative examples that use humor and/or empowering language that focuses on solutions, consistent with what the climate communication literature suggests.

Conclusion

We continue to be proud of what we have accomplished with the West Virginia Climate Change Professional Development project. When we started this project, we felt some trepidation about engaging with climate change in our fossil fuel-focused state. We wondered if we would have resistance, either from teachers or students or communities, especially those who rely on coal, but we were pleasantly surprised that we have not had one incident, at least to our knowledge, of anyone expressing anger toward our project or trying to thwart our efforts. One reason is that we likely have a participation bias – signing up for our PD was optional to teachers, so we likely reached those who were already interested. While the rhetoric paints a polarizing picture, most people know climate change

is happening, they are just afraid to talk about it, so having a supportive environment to do so feels welcoming. While we have had two teachers in our course who remain unconvinced that the climate is changing, they were still respectful and active members of the course, so perhaps they simply wanted the CEU credit and/or wanted to avoid contention. One teacher said her family members pushed back on her for engaging with climate change, but she was able to recognize their comments as part of the misinformation techniques she had learned about and let them go. Working with a receptive audience, rather than spinning wheels with naysayers, is also an effective climate communication strategy. Additionally, we have noticed that some leaders in our state have kept a distance from the project; perhaps they do not feel like they are in a position to publicly promote climate change education amidst some of the powerful forces at play. Others might not feel a direct connection between climate change and their content standards. We hypothesize that this project works because it is a grassroots effort; we are reaching teachers and students directly. Either way, these overall positive outcomes have given us, as professional development providers, confidence and hope in the future of tackling climate change in an extractive state. Additionally, we note again that our project started with astronomy and space science educators, not climate scientists. From physical science to social science, climate communication, and activism, none of us alone is an expert on what will best serve our teachers, students, and communities in engaging with climate change. We continue to remain committed to exploring ideas, trying new things, learning from our mistakes, connecting with people who are experts, and empowering teachers and students to

become leaders in this effort. We hope that WVCCPD serves as a case study of what is possible when educators come together and connect climate science to action.

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